CHARACTERIZATION OF GROUNDNUT (*Arachis hypogaea* L.) GERMPLASM IN RELATION TO MAJOR FOLIAR PESTS AND DISEASES

THESIS

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BY

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CERTIFICATE

I have pleasure in forwarding this thesis of Mr. Joshi Nilesh Hemantkumar, entitled, “Characterization of groundnut (*Arachis hypogaea* L.) germplasm in relation to major foliar pest and diseases” for acceptance for the degree of Ph.D in Plant Science. The results embodied in this thesis are original and have not been submitted for the award of any degree of any University.

Mr. Joshi Nilesh Hemantkumar has put in more than six terms of research work in this department under my supervision.

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ABBREVIATIONS AND SYMBOLS

%	Percentage
µg/kg	micro gram per kilogram
µl	micro liter
AICORPO	All India Coordinated Research Project
^{o}C	Degree Centigrade
cm	centimeter
CV	co efficient of variance
ELS	Early leaf spot
g	gram
h	hour
ha	hector
ICRISAT	International Crop Research Institute for Semi Arid and Tropics
Kg/ha	kilogram per hector
LLS	Late leaf spot
mm	millimeter
NBPGR	National Bearo of Plant Genetic Resource
NRCG	National Research Centre for Groundnut
RH	Relative humidity
SD	Standard deviation
t	tons
t/ha	tons per hector
WTO	World Trade Organization

Chapter 1 *Introduction*

Groundnut (*Arachis hypogaea* L.) is one of the world's major food legume crop. It belongs to the sub tribe *Stylosanthinae* of the tribe *Aeschynomenae*. It originated in South America, where the genus *Arachis* is widely distributed. The natural distribution of all the *Arachis* species is confined to Argentina, Bolivia, Brazil, Paraguay and Uruguay (Krapovickas, 1973; Krapovickas and Rigoni, 1960). *Arachis hypogaea* L. is not known to occur in the wild state. The first species described was *Arachis hypogaea* by Linneaus in 1753. Five wild diploid species were described nearly a century later. Since then, a total of 23 species and one interspecific hybrid have been validly named. Although the exact number of species in the genus is unknown, estimates of 70 or more are common (Valls *et al.*1985; Stalker and Moss 1987; Krapovickas *et al.* 1990).

Groundnut (*Arachis hypogaea* L.)

Groundnut (*Arachis hypogaea* L) is presently cultivated in more than 80 countries from 40^o N to 40^o S in tropical and warm temperate regions of the world.

Botanically, cultivated groundnut can be classified into two sub-species, which mainly differ in their branching pattern; sub-species *hypogaea* with alternate branching and sub-species *fastigiata* with sequential branching. Each sub-species is again divided into two botanical varieties; sub-sp. *hypogaea* into var. *hypogaea* (virginia) and var. *hirsuta* and sub-sp. *fastigiata* into var. *fastigiata* (valencia), var. *vulgaris* (spanish), var. *peruviana*, and var. *aequatoriana*.

The flowers are borne in the axils of the leaves mostly near the base of plant and have generally orange petals. It is a self-pollinated crop. After fertilization, stalk of ovary elongates and forms peg, which contains fertilized ovules at the tip. The growth of peg is positively geotropic until it penetrates soil to some depth (7 cm). The tip then becomes diageotropic and ovary starts developing into a fruit called pod, which contains seeds. Generally, it takes about 60 days from fertilization to full pod maturity.

Known as **poor man's almond,** groundnut is a crop of global economic significance due to its use as a source of diverse food products. The seed is most important part, which is utilized for the production of edible oil and also eaten as snack food. Groundnut contains about 35-54 per cent oil, 6-24 per cent carbohydrate and 21-36 per cent proteins and therefore it forms a high-energy source (Cobb and Johnson, 1973).

Commercially, Groundnut is the world's fourth most important source of edible oil and third most important source of vegetable protein. Groundnut oil is considered as stable and nutritive as it contains right proportions of saturated fatty acid namely, Oleic acid (40-50%) and unsaturated fatty acid like linoleic acid (25-35%). The higher ratio of Oleic/linoleic acid in groundnut oil, which ranges from 0.76 to 5.5 imparts stability and improves shelf-life and cooking quality. In addition, a higher linoleic acid content of groundnut oil, in nutritional terms, is more desirable because of its "hypocholosterolameic effect" (Cholesterol scavenging). Groundnut oil also contains 0.93-mg/g of tocopherol, an anti oxidant that prevents the oil from rancidity and increases its shelf life.

Recently, the use of groundnut meal has became more recognized, not only as a dietary supplement for children on protein-poor, cereal based diets in economically under developed countries, but also as an effective treatment for children with protein energy malnutrition (PEM). The nutritional value of groundnut meal can further be improved by fortifying it with animal proteins such as skim milk powder or other plant proteins, which can complement/supplement it. Groundnut cake (defatted meal) contains 44 to 69% of protein, which is extensively used in livestock feed concentrates and mixtures.

Raw groundnuts are excellent source of vitamins especially E, K, and B groups. It is also one of the richest sources of thiamine (B_1) and niacin. This is important, as diets in semi-arid regions contain limited amounts of the essential amino acids like tryptophan and niacin, which can be substituted by thiamine. Roasted groundnuts are a desirable food product with a pleasant and unique flavour. The characteristic nutty flavour of roasted groundnuts largely results from the interaction between reducing sugars liberated from sucrose and free amino acids. In the International market, Indian groundnuts are highly valued for this very characteristic flavour and aroma.

Groundnut shells are cheap source of fuel, bedding material for the poultry and also find a place in cardboard manufacture. The potentials of shells in industrial applications like enzyme production and alcohol extraction is becoming increasingly popular.

1.1. Global scenario

Groundnut is an annual legume native to South America. The Portuguese apparently introduced it to West Africa and then to southwestern India in the 16th century from Brazil.

Currently, groundnut is grown in nearly 25 million ha around the world with an annual production of 34 million tons of nuts-in-shell. The major producers are China, India, Indonesia, and the USA which together account for two-thirds of the world output. Other important producers are Nigeria, Senegal, Sudan and Argentina.

Developing countries, account for 82 percent of total groundnut area and 79 percent of production of the world. Among the developing countries, production is mainly concentrated in Asia and Africa, with Asia accounting for 51% of global area and 60% of production. India occupies 30% of global area (7.6 million ha) and 22% (7.8 million tons) of total groundnut production.

Conversely, China with 66% of India's area, shares about 42% of total groundnut production of the world and ranks first. Africa accounts for 19% of global groundnut area with only 19% of the total world output. The productivities of different countries are India (1040 kg/ha), Indonesia (1550 kg/ha), Argentina (2100 kg/ha), China (2897 kg/ha) and the USA (2800 kg/ha). The world average productivity of the crop is about 1.3 tons/ha (Table 1.1).

Table 1.1 World groundnut production scenario

Countries	Area ('000 ha)	Production ('000 t)	Yield (t /ha)
Africa	7,923	6, 401	800
Asia	13,374	20,871	1600
a. India	7,600	7,800	1040
b. China	5,025	14,556	2897
c. Indonesia	650	1,000	--
Latin America and Caribbean	466	806	1700
Australia	21	41	1952
South Africa	94	158	1300
USA	550	1591	2800
World	**25,863**	**34,499**	**1,339**

(Source: FAO database, 2003)

Wide variation in production and productivity across and within regions is a regular feature associated with the crop. The major reasons being the growing conditions, which may be, grouped as low-input and high input systems in addition to biotic and abiotic factors. Low-input system is predominant in Asia and Africa, which are characterized by rainfed cultivation with no or little inputs and hence the yield varies between 700 to 1000 kg/ha. While the high input system of cultivation most prevalent in USA, Australia, Argentina, Brazil, China and South Africa, involves commercial production coupled with mechanization. Hence, the average yield levels in these regions are around 2-4 tons/ha.

1.2. Indian groundnut scenario

1.2.1. Distribution and Ecology

In India, groundnut is grown in about 8.0 million ha with an annual production of 7.8 million tons nuts-in shell. The major groundnut area (6.0 million ha) in India comprises marginal lands where the crop is grown under rainfed conditions. Eighty per cent (6.0 million ha) of the total groundnut area is confined to five states viz., Gujarat, Andhra Pradesh, Tamil Nadu, Karnataka and Maharashtra, which account for 84% (6.5 million tones) of the total production (Fig 1.1). The rest of the area and production is distributed mainly in the states of Rajasthan, Uttar Pradesh, Madhya Pradesh, Punjab and Orissa. Groundnut is also grown in few pockets of Jharkhand, Uttaranchal,Chattisgarh, Goa, Haryana, Kerala, West Bengal and NE states (Table 1.2).

Groundnut is cultivated during *kharif* season (June-July to September–October) mostly under rainfed conditions with a few protective irrigations. The crop is also grown during *rabi* season (October-November to February-March) under residual moisture/ minimal irrigation situation. In summer (January - February to April-May), groundnut is grown as an irrigated crop. The spring groundnut is grown from March-April to July-August. The crop can be grown successfully in places receiving a rainfall of 500 to 1250 mm and performs better in the sandy loam and loamy soils and also in black soils with good drainage.

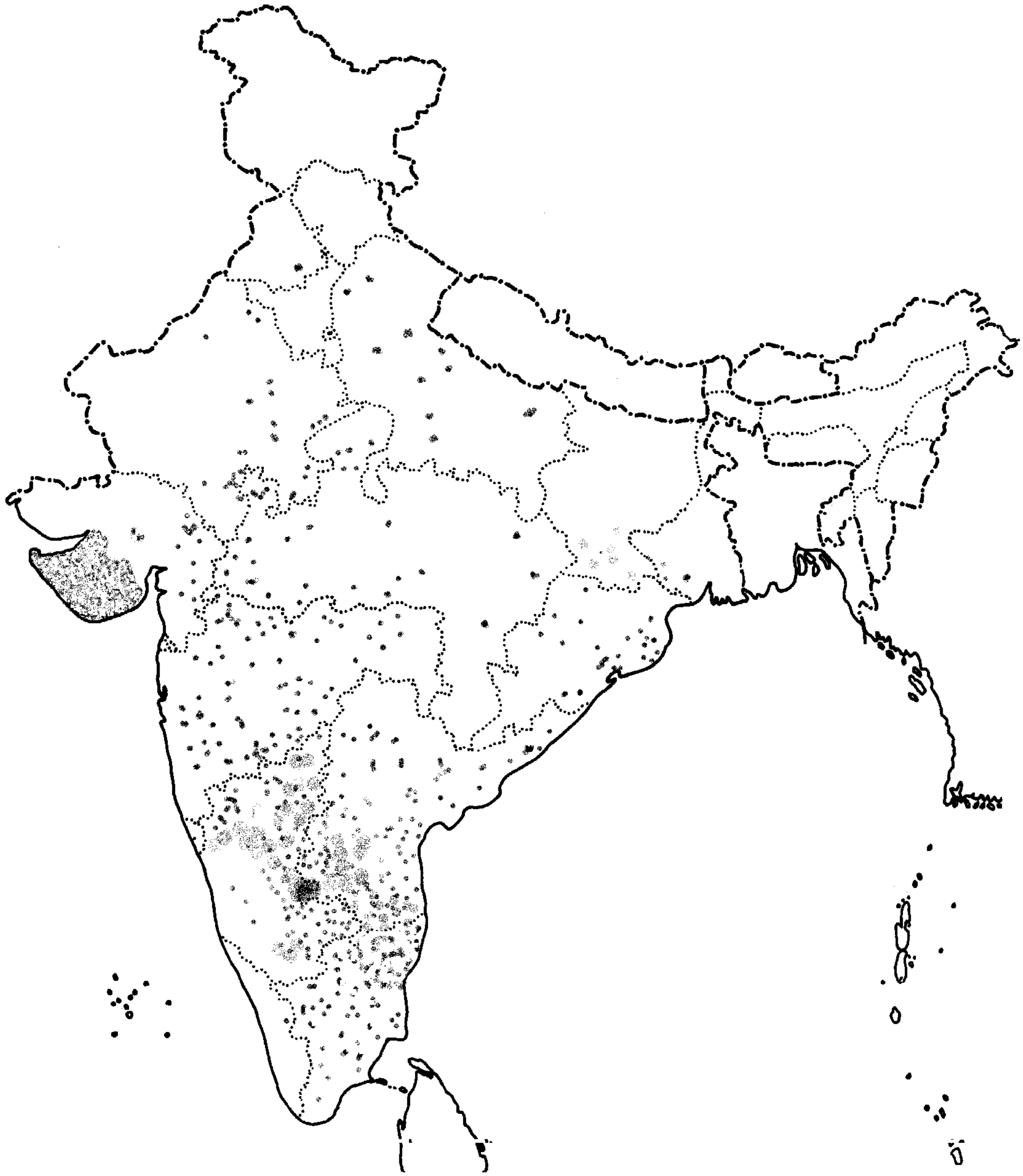


Figure. 1.1 Distribution of groundnut in India

(The dots depict approximate spread and density)

Table 1.2 Area, production and productivity of groundnut in major states of India

States		2000-01			2001-02			2002-03		
		A	P	Y	A	P	Y	A	P	Y
Andhra Pradesh	K	1.60	1.70	1060	1.44	0.82	568	1.27	0.54	427
	R/S	0.27	0.45	1636	0.25	0.43	1714	0.20	0.28	1397
Gujarat	K	1.71	0.63	368	1.85	2.59	1401	1.97	1.00	508
	R/S	0.33	0.59	1788	0.37	0.55	1473	0.57	0.93	1641
Tamil Nadu	K	0.49	0.77	1557	0.46	0.70	1511	0.38	0.54	1430
	R/S	0.21	0.59	2836	0.19	0.54	2753	0.16	0.43	2605
Maharastra	K	0.40	0.36	894	0.35	0.38	1081	0.35	0.33	958
	R/S	-	-	-	-	-	-	-	-	-
Karnataka	K	0.88	0.88	998	0.71	0.42	592	0.71	0.40	563
	R/S	0.18	0.19	1108	0.14	0.16	1142	0.13	0.14	1127
All India	**K**	**5.7**	**4.91**	**861**	**5.5**	**5.62**	**1030**	**5.3**	**3.24**	**614**
	R/S	**0.85**	**1.49**	**1756**	**0.77**	**1.41**	**1808**	**0.68**	**1.12**	**1660**

K=*Kharif*; R/S =*Rabi*/summer, A= Area (Million ha); P= Production (Million tons); Y= Yield (kg/ha) (Source: Basu and Singh, 2004)

1.2.2. Trends of area, production and productivity

Groundnut, which was mainly grown in the rainy season (*Kharif*) in India, faced a sea-change and was being grown in winter (*rabi*) and summer also from 1970-71 in Andhra Pradesh, Tamil Nadu and Karnataka, where it exhibited a higher yield potential (1500 kg/ha) than in *kharif* (1000 kg/ha). Since then, the area under *rabi*/summer groundnut has increased and spread to Gujarat and Maharastra and reached up to 1.5 million ha in India.

The area under groundnut in India which was only 0.23 million ha during 1900-01 to 1909-10 has increased to 7.68 million ha during the past century. The decennial annual compound growth rate (Table 1.3) during different periods explicitly depicts that the growth in area (17.2%) was the major factor for the increase in groundnut production during 1951-1960. After 1970's, the productivity growth (2.5% during 1971-80; 8.2% during 1981-90 and 6.64% during 1991-2000) contributed more towards augmenting groundnut production than the area increase.

Table 1.3 Decadal annual compound growth rates (%) of groundnut in India (1950-2000).

Years	Area	Production	Productivity
1951-60	17.21	21.60	3.72
1961-70	4.77	0.17	-4.38
1971-80	-1.07	1.41	2.51
1981-90	5.86	14.58	8.22
1991-00	-4.06	-1.98	6.64

(Source: Basu and Singh, 2004)

The quinquennial average area, production and productivity in India (Table 1.4) further indicate that the average groundnut area increased from 4.79 million ha (1951-55) to an all time high of 8.27 million ha during 1991-95. The productivity levels were fluctuating between 660-760 kg/ha before 1970's and thereafter exhibited a steady increase. This may mainly be attributed to release of several high yielding and improved groundnut varieties with matching technological innovations under different cropping systems, and to a certain extent, growing of groundnut under assured irrigation and high input conditions during summer.

Table 1.4 Quinquennial average area, production and productivity of groundnut in India

Years	Area ('000 ha)	Production ('000 t)	Productivity (kg/ha)
1951-55	47987.8	3458.4	722.4
1956-60	5947.6	4524.0	761.2
1961-65	6979.4	5234.4	749.4
1966-70	7298.6	4826.6	661.0
1971-75	7182.6	5485.4	762.2
1976-80	7178.2	6016.4	837.6
1981-85	7230.2	6206.4	855.6
1986-90	7638.0	6921.8	895.4
1991-95	8277.4	7851.8	950.8
1996-00	7733.4	7603.4	1032.6

(Source: www.fao.org)

1.2.3. Regional trends

The five major groundnut growing states, Gujarat, Andhra Pradesh, Tamil Nadu, Karnataka and Maharashtra contributes around 80% groundnut area and nearly 84% of production. Though the trend remained same for more than three decades (1960-1990), the area and production within and between each state varied considerably during the last few years (Table 1.2). Among the major groundnut growing states, Gujarat is the most important one accounting for 32% of area followed by Andhra Pradesh (26%), Tamil Nadu (10%), Karnataka (12%) and Maharastra (6%).

Critical analysis of the groundnut area in India showed a declining trend especially in traditional northern belts comprising Uttar Pradesh, Punjab and Haryana where the reduction in area was 26%, 83% and 71% in just a span of 15 years. In Gujarat also, the total area, which was around 2.04 million ha during 1993-94, came down to 1.84 million ha during 1996-97 and reached 2.54 million ha during 2002-03. While the production rose from 0.68 million tons in 1993-94 to 1.97 million tons in 1994-95 and from 1.02 million tons (1995-96) to 1.93 million tons (2002-03).

Conversely, in Andhra Pradesh, the production reduced from 2.54 million tons (1993-94) to 1.67 million tons (1994-95) and again rose to 2.08 million tons (1996-97) and reached an all time low of 0.82 million tons (2002-03). Such a year-to-year fluctuation in area and production and the commercial risk associated with groundnut not only lowers the export opportunities but also costs heavily on the exchequer due to heavy import of groundnut oils. This is true for other major edible oils also.

1.3. Major production constraints

The groundnut cultivation is unique in that it is being cultivated under four different production systems/seasons like rainy (*kharif*), winter/post rainy (r*abi*), summer and spring fitted into different cropping pattern/sequences. Hence, the problems and constraints are multi-varied and multi-faceted according to the production system involved.

However, the major production constraint of this crop has been the confinement mainly to dry or rain dependent areas (~ 6.0-6.5 million ha). Groundnut is energy rich C_3 crop, yielding about 50% of oil but grown under “energy starved conditions” in the dry and marginal lands. From 1 g of carbohydrate, 0.66 g of starch can be obtained as against 0.33 g of fats. Hence the crop requires almost double the nutritional and irrigation requirement as compared to cereals, which is totally on the contrary, in reality.

The biotic and abiotic stresses also limit the production during the rainy season. Among the abiotic stress, soil moisture deficit stress at various stages of crop growth during rainy season and low temperature during germination and vegetative stage but high temperature during the pod filling and maturation stage during summer, hampers the productivity. In addition, salinity and acidity build-up and micronutrient deficiency in selected pockets of the country further limit the production.

Among the biotic stresses, the foliar fungal diseases (Early Leaf Spot, Late Leaf Spot, Rust, Alternaria), viral (Peanut Bud Necrosis, Stem Necrosis) soil borne (Stem rot, collar rot and pod rot complexes) diseases and the insect pests like defoliators (*Spodoptera, Helicoverpa*, Red hairy caterpillar and Leaf miner) and sucking pests (Jassids, Aphids, Thrips) are the major ones that limit groundnut production and productivity (Fig. 1.2). In addition, the pre and post harvest aflatoxin contamination in the kernels and meal also reduces the quality as well as export value.

Of the foliar fungal diseases, the two leaf spots together are popularly known as “*Tikka*” disease in India. Both early and late leaf spot are commonly present wherever groundnut is grown. However, the incidence and severity of each disease varies between locality and seasons.

Reduction in the yield due to leaf spots is largely due to damage caused to the leaves as a result of intense spotting and consequent loss in the photosynthetic area (Gerlagh and Bokdman, 1974). Premature leaf fall due to the disease is also a factor contributing to the lower yield. In India, losses in the yield of groundnut crop due to the leaf spots have been estimated to be in the range of 15 to 50% (Sundaram, 1965). In semi-arid tropics, where chemical control is rare, average losses exceeding 50% are quite usual (Garren and Jackson, 1973).

Apart from yield losses, the value of the haulms, which is mostly used as fodder for cattle, is also adversely affected (Cummins and Smith, 1973). Normally, early leafspot is more prevalent in northern groundnut growing states. However, recently, it has been assuming a serious status in southern and central states of India also. However, the incidence and severity varies among localities and over seasons.

Early leaf spot symptoms first appear as pale areas on the upper surface of lower leaves about 10 to 28 days after emergence. The spots later turn yellow, and necrose from the centre of the lesion, and later the entire spot becomes necrotic. The large, circular to irregular spots measure to 1 to 10 mm in diameter, characterized by a yellow halo of variable width. At maturity the spots turn reddish brown to black (Subrahmanyam *et al.,* 1995).

A

B

C

Figure 1.2 A. Early (*Cercospora arachidicola* Hori.) and late (*Phaeoisariopsis personata* Berk. & Curt) leaf spot of groundnut. B. Rust (*Puccinia arachidis* Speg.) on groundnut. C. *Spodoptera litura* (F).

The source of inoculum is presumably from conidia or ascospores produced in or on groundnut debris in the field. However, Frezzi (1960) demonstrated that conidia have sufficient longevity to carry over from one crop to another. The source of inoculum is mostly in the soil since early season (Boyle, 1964). Inoculum from these possible sources is blown or splashed on leaves giving rise to primary infections. Subsequent sporulation provides conidia to be carried by wind, rain, insects (Higgins, 1956) or machinery, thus leading to secondary infection cycles. Lyle (1964) found that the greatest number of conidia was detected during a period of abundant rainfall and minimum (22ºC) and maximum (35ºC) temperatures. Infection was correlated directly with inoculum production during this period. The intercellular mycelium of *C. arachidicola* kills the cells while advancing and then becomes intracellular (Jenkins, 1938), whereas, late leafspot pathogen produces haustoria within host cell without killing cells while advancing, (Woodruff, 1933 and Jenkins, 1938).

Although, the groundnut production in India suffers from proverbial instability and low yield, cultivated groundnut, a relatively recent introduction to this country, may be considered as a crop of remarkable adaptability. Such a rapid spread to almost all part of the country in a period of about 80 years account for its wider adaptability. The cultivation of the crop was under low levels of management and was generally relegated to marginal and sub-marginal holdings from the inception. One result flowing out of this situation is that genes for high yield have been generally eroded in the populations and have given way to the genes conferring adaptability. So there is an urgent need to develop new strategies to put back genes for higher productivity and to introduce gene for pest and disease resistance in cultivars of groundnut apart from developing low cost and efficient means of crop husbandry (Reddy, 1988). Hence, new source of variability for yield and other economic attributes are to be identified from the large genetic resource available in groundnut.

Natural variability in the cultivated groundnut (*Arachis hypogaea* L.) is substantial and has provided ample resources for the development by selection and hybridization of cultivars adapted to different environments (Hammons, 1973). According to Banks (1976) collection of groundnut germplasm in the USA is extensive. In addition to the collection in the USA, there are some important major collections in Argentina, Senegal, Israel, Taiwan, India, Venezuela, South Africa, Nigeria, Malawi, Rhodesia, Madagascar and other countries.

Most of the Indian germplasm has been collected by the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT) mainly from the centers of the All India Co-ordinate Research Projects on Oil seeds. By the end of 1983, a total of 10,209 germplasm lines from 81 countries had been assembled at the ICRISAT. They include 2,558 accessions from 36 countries of Asia, 2,423 accessions from 17 countries of Africa, 75 accessions from 7 countries of Europe, 2,769 accessions from 19 countries of America and 54 accessions from two countries of Australia and Oceania. The remaining 2,330 accessions were of unknown origin. The accessions at the ICRISAT represent the largest collection assembled and conserved at any single centre (Reddy and McDonald, 1984) especially of groundnut. Another important groundnut germplasm repository in India is the National Research Centre for Groundnut (NRCG) located at Junagadh in Gujarat. Till December 2004, groundnut genetic resources numbering 13902 were assembled from various organization of Central and State Research Institute, ICRISAT, States Agricultural Universities (SAU's) as well as private agencies (NRCG annual report, 1981). Besides the ICRISAT and the NRCG a few of the AICORPO groundnut centres also maintain working collections of groundnut germplasm.

At present in National Gene Bank (NBPGR) and at National repository 13902 collections are available. The repatriation programme between NRCG and ICRISAT which was aims at accessing those germplasm which were currently not available either at NBPGR or at NRCG but available with the ICRISAT, so that the entire set of collections are available in National Gene Bank and NRCG. Under this programme during *Kharif* 2001, 367 groundnut germplasm were supplied to NRCG. Those valuable genetic resources hitherto unavailable and undescribed formed the basic materials of the present study.

The objective of management of germplasm remains incomplete until and unless the collection is evaluated for various desirable traits to assess the genetic potential of the resources, to identify the duplicates in the collection and to create core collection. It is also equally important to permeate the information generated to user agencies to identify and select the specific accessions for utilization. The successful utilization of the germplasm depends on the access of desired information by the breeders.

So the study was aimed at characterizing these germplasm accessions for 19 qualitative and 26 quantitative characters, to know the extent of genetic variability present in them and to evaluate their resistance to three major foliar fungal diseases [late leaf spot (*Phaeoisariopsis personata* Berk. & Curt) early leaf spot (*Cercospora arachidicola* Hori.) and rust (*Puccinia arachidis* Speg.) and a serious pest of groundnut namely the *Spodoptrera litura* (F), so that new sources of variability can be effectively utilized in the groundnut improvement programme.

In addition, a preliminary inquiry into biochemical features associated with the resistance to the above biotic stresses are also attempted. Although few studies pertaining to anatomical and biochemical features associated with resistance of groundnut to various biotic stresses are available, studies related to germplasm resources are very scanty. Hence, the present study was also aimed at elucidating information on biochemical parameters like, total phenol, *Ortho-dihydroxy* phenol, total sugars, reducing sugars, free amino acids and epicuticular wax content associated with resistance of groundnut to the leaf spots and rust despite *spodoptera.*

In addition, 9 leaf anatomical features were also studied in relation to its reaction to the three biotic stresses namely early leaf spot, late leaf spot and rust were also studied so that a better insight about the resistance could be obtained.

1.4. Aflatoxin contamination

Aflatoxin contamination of groundnut is a serious food quality problem especially in kernels consumed as food in many tropical and sub-tropical countries in the world. India is not an exception to this as groundnut is cultivated under varied environmental conditions in different states of the country.

India earns substantial foreign exchange with the export of HPS (Hand Picked Selected) groundnut and groundnut meal. The USA contributes more than 33 % of the world export market of groundnut followed by China (about 30 %). Till seventies, India was a leading exporter of groundnut in the world. The exports figures of groundnut in shell were 575 and 2137 metric tonnes in the year

1987-88 and 1996-97, respectively and for kernel it ranged from 4090 metric tons (1987-88) to 150000 metric tons (1996-97) (www. IOPEA. org).

With the increasing thrust on export and diversified uses of groundnut for value added products and liberalization of the Indian economy since 1995-96, again there has been an increasing trend in the export of kernels. But the higher aflatoxin load in the exportable commodities like Hand Picked Selected (HPS) grade kernels and de-oiled cake and the strict tolerance limits for aflatoxin imposed in these products by the importing countries have seriously jeopardized the export earning, there by depriving the country of valuable foreign exchange (Jhaveri. 1984).

Hence, there is an urgent need to address the problem of aflatoxin contamination in groundnut kernels, cakes and meal to capitalize the 'free trade gate' under WTO regime.

Aflatoxin is a toxic metabolites produced primarily by some strains of *Aspergillus flavus and Aspergillus parasiticus.* These fungi are wide spread in light sandy soils, which are most suitable for groundnut cultivation. These fungi can invade the seed before or after harvest or during the storage of produce. As a result of infection, accumulation of aflatoxin occurs in the kernels. Infected kernels look discolored and shriveled. On the pods, kernels or in culture

Groundnut seeds infected by *A. flavus*

the fungus produces olive green coloured colonies with abundant sporulation.

Aflatoxin production in the field is favored by high seed moisture, temperature in the range of 25-30 ^{0}C and relative humidity of 85 per cent. Aflatoxin production in storage condition takes place when kernels are stored above 7% seed moisture content. *Aspergillus flavus* also causes the aflaroot disease of groundnut leading to death of seedlings in the field.

Hence, it is not possible to control this problem by any single method. Integrated management involving genetic resistance and identifying the suitable resistant genotypes against the fungus appears to be the best possible solution in reducing this mycotoxin problem.

Although, very few sources have been identified (Utomo *et al.,* 1990) very little information is available on the germplasm resistant to *A.flavus* contamination. Hence, evaluation of groundnut genetic resources to identify potential germplasm having resistance/tolerant to aflatoxin contamination is very essential. Hence, an effort was made to evaluate the groundnut germplasm, to identify aflatoxin resistant/tolerance genotypes through *in vitro* seed colonization and aflatoxin production through ELISA technique.

Keeping the above facts in mind, the present experiments were taken up with the following objectives.

i. **To characterize 367 accessions of cultivated groundnut germplasm assembled from centres of diversity (19 Qualitative characters and 26 quantitative characters)**

ii. **To screen for the pest (*Spodoptera litura*) and diseases (Early leaf spot, late leaf spot and rust) resistance in natural epiphytotic conditions**

iii. **To identify resistant/susceptible genotype**

iv. **To study comparative leaf anatomy of resistant and susceptible genotypes**

v. **To study the relationship of the specific anatomical characters with resistance/tolerance to pest and diseases**

vi. **To analyze biochemicaly the resistant and susceptible genotype for total phenol, OD phenol, total sugars, reducing sugars, free amino acids and wax content**

vii. **To identify the resistant genotypes against aflatoxin contamination through seed colonization and aflatoxin production by ELISA technique.**

Chapter 2 Review of literature

Diseases and pests are the most serious yield-reducing constraints of groundnut in the tropics and semi-arid tropics. Many of these diseases and pests can be controlled effectively by the application of chemicals. However, host-plant resistance remains the most economical and sustainable, especially for the resource poor farmers of the semi-arid tropical region (SAT) of the world, where groundnut is predominantly grown.

Groundnut (*Arachis hypogaea* L.) is attacked by several diseases caused by fungi and bacteria. However, only some of them are economically important. Of these economically important diseases, a few are more widespread than others. Among the important diseases of groundnut, three foliar fungal disease, late leaf spot (*Phaeoisariopsis personata* Berk.& Curt), early leaf spot (*Cercospora arachidicola* Hori.) and rust (*Puccinia arachidis* Speg.) are the most widespread and destructive in India (McDonald *et al.*, 1985)

The total annual loss in groundnut due to these diseases and pests has been estimated to be about Rs.1600 million in the world (Amin, 1983). However, most of the groundnut insect pests in India are sporadic in occurrence and distribution. Among them *Spodoptera litura* (F.), commonly known as the "tobacco caterpillar" is one of the serious pests of groundnut.

Sources of genetic resistance to these fungal diseases and the pest in the germplasm collection available in the genebank at the International Crops Research Institute for the Semi-Arid Tropic (ICRISAT) have already been documented (Singh *et al.*, 1997).

New sources are being added from existing germplasm over time and space. It is important to understand the nature and extent of genetic variability present in them and to screen them against major pest and diseases so that they may be effectively used in groundnut breeding programme.

2.1. Morphological characterization

Morphological characterization still continues to be the backbone of a complete taxonomical system at any taxonomic level.

The objective of germplasm management is incomplete until and unless the collection is evaluated for various desirable traits. Hence, it is indispensable in crop improvement programme to evaluate the available germplasm to identify the superior and desirable genes and make the information to percolate the crop improvement workers to exploit the genetic potential in desired direction. A wide spectrum of variability is harbored over years for characterization and utilization in groundnut. The important objectives of morphological characterization are as under,

- To select and identify accessions having specific traits.
- To identify duplicates in the collection.
- To create core collection.
- To identify the gaps in the working collection.

Many workers have characterized and documented the groundnut (*A.hypogaea* L.) germplasm traits. The available literature pertaining to the morphological characterization is as under:

Gill and Joshi (1980) evaluated 1394 groundnut germplasm in the years 1979-1980. They found considerable variation in growth habit, stem surfaces, leaf colour and in pod constriction for two habit types Spanish and Valencia. They also documented important agro-morphological traits.

Bhagat and Lalwani characterized (1981) 1310 bunch groundnut germplasm. They found variation in seed colour from off-white to purple with white flakes. They noted the highest 11 mm seed length in NRCG 11908.

The 680 Valencia groundnut germplasm, introduced from 40 different countries were characterized by Bhagat *et al.* (1981). They have recorded 10 quantitative and 21 qualitative traits. They noted less differences in qualitative traits among the Spanish and Valencia group of germplasm, while considerable differences were observed in both qualitative and quantitative traits for Virginia bunch and Runner genotypes.

Bhagat *et al.* (1984) characterized 34 commercial groundnut varieties and found differences in seed size, pod size, pod constriction, pod reticulation, hundred seed weight, yield per plant and other yield related traits. They concluded that, among the 34 groundnut varieties, JL 24 performed the best considering the yield related traits.

Bhagat *et al.* (1985) evaluated two batch of 1314 and 2960 groundnut germplasm. They evaluated 12 qualitative and 19 quantitative traits and recorded considerable variability among them, for the traits studied.

Bhagat and Lalwani (1990) characterized 2655 groundnut germplasm and recorded considerable differences among the qualitative and quantitative traits. They have reported white testa for the first time in the national repository.

Veiga *et al.* (1996) suggested the need to change in some descriptors state like, leaflet proportion, leaf and branch, peg colour, pod constriction and reticulation for easy identification.

Rajgopal *et al.* (1997) studied morphological characterization of Valencia and Virginia bunch peanut germplasm and noted the difference in descriptors state between them. They explored the degree of similarity between and within Valencia and Virginia bunch genotypes collection with respect to three pod feature, pod beak, pod constriction, pod reticulation and testa colour. They also noted that among the Valencia accessions, the predominant characteristics were slight pod beak. While among the testa colour it ranged from off-white to blackish purple in Valencia and rose colour was most common in Virginia bunch genotypes.

Chandran and Pandya (2000) characterized the wild *Arachis* specie and checked the morphological difference in it. They found that *A. batizocoi* and *A.hypogaea* had maximum dissimilarity for morphological characters.

Rajgopal *et al.* (2001) evaluated 775-groundnut germplasm for morphological traits. They followed the descriptor's state as described by IBPGR. They found range of pod yield from 190-220 g/m^2 in NRCG 7543,11631,11693,11711,11715 and 11780. While shelling percentage ranged from 71.2-74.2 in NRCG 7543,11771,11778,11005. They also observed testa colour in these germplasm which ranged from off-white to dark purple.

Chandran *et al.* (2003) evaluated 596-groundnut germplasm and documented the results. They described 19 qualitative and 26 quantitative characters. They noted a range of 10.2-17.6 g for pod yield per plant, 103-137 g/m^2 for pod yield per meter, 120-200 g for hundred pod mass, 53-66 g for hundred seed mass and 92.3-95.6 per cent for SMK (Sound mature kernels). They also observed the range of testa colour from off-white to dark purple.

Rajgopal *et al.* (2004) studied 70 groundnut cultivars for morphological traits under the Distinctness, Uniformity and Stability (DUS) testing programme. They found that the testa colour was distinct in some of the cultivars, and suggested that it can be used as a diagnostic tool for identification of a few cultivars. They also reported that cultivars showed overlapping of descriptor states in various combination of traits. They found that branching pattern and leaf colour could distinguish up to the sub-species level.

2.2. Major foliar fungal diseases and pests

2.2.1. Diseases

Attention has chiefly been directed at wild species of *Arachis* as potential sources of disease resistance. Recent evaluation of *Arachis* spp. has shown promise and despite sterility barriers, interspecific hybridization is receiving considerable attention (Moss, 1980).

Smith *et al.* (1992) studied the nature of *Cercospora* leaf spots (*Cercospora arachidicola* Hori.) and its inheritance in groundnut, and found that, resistance to the two species was inherited independently, and plant selections resistant to one were often very susceptible to the other.

Resistance to leaf spots is associated with certain plant characters such as, maturity, plant habit and colour of foliage. Evaluation systems and screening for leaf spot resistance are fairly standardized. Longer incubation periods, reduced sporulation, less defoliation, stomatal exclusion mechanism and absence of directed growth of germ tubes towards stomata are some of the recognized components of 'resistance to penetration' by *Cercospora arachidicola* Hori. and late leaf spot *Phaeoisariopsis personata* Berk. & Curt. (Abdou *et al.*, 1974; Nevill, 1981).

A 'resistance to colonization' of the invaded host also occurs and is associated with the formation, around the site of infection, a barrier composed of a pectic deposit on the cell wall, which prevents further lesion development (Abdou *et al.*, 1974). It was also found that several components of resistance within *A. hypogaea* are inherited in a quantitative manner. It was also found that defoliation was controlled by genes with additive action (Nevill, 1981).

2.2.2. Source of resistance to LLS (Phaeoisariopsis personata Berk. & Curt), ELS (Cercospora arachidicola Hori.) and Rust (Puccinia arachdis Speg.)

Sources of resistance to rust and leaf spots have been well identified both within *A. hypogaea* and in wild *Arachis* spp. (Mazzani and Hinojosa, 1961; Bromfield and Cevario, 1970; Cook, 1972; Subrahmanyam *et al.,* 1980; Subrahmanyam and McDonald, 1983) but the expression and underlying mechanisms of resistance to fungal diseases are less understood. However, prolonged incubation periods, low infection frequency, slow rupture, less sporulation and inefficient germinability of spores produced in the uredia are the major components of resistance to rust and leaf spots. The most striking future about resistance to major groundnut diseases is it's apparent stability across environment. The known sources of resistance are effective all over the world (Mazzani and Hinojosa, 1961; Bromfield and Cevario, 1970; Subrahmanyam *et al.*, 1980).The literature pertaining to disease resistance are reviewed as under.

Subramanyan *et al.* (1978) found two germplasm lines, PI 259747 and PI 298115 having field resistance to rust and Mayee and Munde (1979) confirmed the resistance of these two lines to rust under laboratory conditions.

Mehta and Mondal (1978) screened 333 groundnut germplasm accessions against rust and tikka diseases. Two genotypes, AH-6718 and

Gondal 221-223 were found to be highly resistant to rust, 106 accessions were found to be resistant to rust while 125 were found to be resistant to LLS.

Prasad *et al.* (1979) studied twenty groundnut breeding lines, which showed a high level of resistance to ELS (*Cercospora arachidicola* Hori.) and LLS (*Phaeoisariopsis personata* Berk. & Curt) while among the wild species, two species, *A. prostrata and A. villosa* were found to be highly resistant. They also found that among cultivated genotypes, four genotypes, BHB-18, CS 01, HNG 13-3-18 and T 98 were found to be resistant to ELS and LLS.

Subramanyan *et al.* (1980) reported that the germplasm accessions, NCAc 17090 and EC 76446 (292) were found to be resistant to rust among 6000 groundnut accessions screened.

Subramanyam *et al.* (1980 and 1983) screened about 7000 groundnut germplasm lines against leaf spots and rust diseases at ICRISAT, Patancheru, Hyderabad. They found that five groundnut accessions were resistant to rust and had measurable resistance to one or other of the leaf spot.

Chen *et al.* (1981) screened 695-groundnut germplasm for resistance to rust infection. They found that only 3 accessions were resistant, and none were found to be immune. They also found that the symptoms appeared earlier on Spanish and Valencia than on Virginia genotypes. They also reported that cultivars with thin and less waxy leaves were generally attacked by the rust earlier than those with thick, waxy leaves.

Search for sources of resistance to leaf spot and rust of groundnut has led to the identification of many wild species and land races possessing varying degrees of resistance. Since then a number of workers have successfully screened many genotypes for resistance to leaf spot and rust (Mixon *et al.,*1983).

Ghewande *et al.* (1983) screened 3655 groundnut entries for leaf spot and rust disease. They observed only two genotypes namely B-613 and PI 341839 were resistant to both the diseases.

Gupta (1986) screened 253 groundnut cultivars against tikka disease resistance during 1980-82 under the natural epihytotic condition. He found that twenty-one cultivars were resistant to tikka disease.

Patel and Vaishnav (1986) screened 75 groundnut germplasm lines against rust disease and found five were moderately resistant to rust.

Sneh *et al.* (1987) screened 170 breeding lines for resistance to rust. They found that 15 breeding lines had higher yield than the resistant and susceptible standard varieties.

Jayasekhar *et al.* (1987) screened 2000 groundnut genotypes under natural and artificial infection of *P. arachidis* during 1980-85. They found that only twenty genotypes were resistant to rust.

Waliyar *et al.* (1990) evaluated groundnut germplasm lines and breeding lines for LLS resistance. They found 13 genotypes as resistance to LLS.

Eaenshaw *et al.* (1992) screened 22 groundnut germplasm lines for reistance to LLS and Rust. They found that the entries, NCAc 17132, PI 476164 and PI 476168 showed tolerance to LLS.

Rao *et al.* (1995) evaluated 89 groundnut genotypes against LLS and rust. They noted that 33 genotypes were found to be resistant and 21 genotypes were found to be moderately resistant to rust. They also observed that total of 28 genotypes recorded lower disease score, than the control.

Rao *et al.* (1995) used the laboratory screening technique for reaction of ELS (*Cercospora arachidicola* Hori.) in groundnut. They observed significant differences between the conidial concentrations for most of the disease components studied.

Rabeendran and Arulnandhy (1995) screened short and medium duration groundnut lines for LLS, ELS and rust resistance. They identified four lines, ICGV 86928, 87883, 88248, 87387 as resistant to ELS and LLS and six lines viz. ICGV 87282, 87334, 87391, 87817, 87281 and ICGV 88330 as resistant to rust.

Halbrook and Anderson (1995) have evaluated the core collections to LLS and identified several genotypes showing resistance and reported that 54 per cent of entire core collection was resistant to late leaf spot.

Mehan *et al.* (1996) screened a total of 979 groundnut germplasm for resistant to rust and late leaf spot in preliminary field trials during 1989-90. They further evaluated the selected genotypes in separate advance screening trials and found that 21 erect, 5 spreading and 12 runner genotypes were resistant to rust, while 5 erect bunch and 2 runner were found to be resistant to late leaf spot.

Rao *et al.* (1996) screened 114 groundnut genotypes at Burkina Faso against rust and leaf spot diseases. The field screening revealed that 30 genotypes had good level of resistance to rust.

Saleh and Nugrahaeni (1996) screened 46 groundnut genotypes against leaf spot and rust. They rated the disease reaction on a 1-9 scale. They found that seven genotypes, ICG 10823, ICGV 88369, ICG 10660, ICGV 86402, ICG 1015, ICG 6163 and T9 were found to be resistant to LLS. They also observed that 12 lines showed moderate levels of resistance to LLS.

Huq *et al.* (1996) screened 22 groundnut germplasm against tikka and rust diseases under natural epiphytotic conditions. They found that three accessions (ICVG 86590, ICGV 866654 and ICVG 86707) were moderately resistant. While for rust resistance, three genotypes were highly resistant and two germplasm were resistant to both the diseases.

Sahel and Trustinah (1996) screened 50 groundnut germplasm lines introduced from ICRISAT. They found that none of the genotypes were found to be resistant to rust and LLS. While 21 and 11 genotypes were moderately resistant to rust and LLS respectively and 10 were moderately resistant to both the diseases.

Adiver *et al.* (1997) screened several germplasm accessions of groundnut against on LLS and rust diseases. They found that ICG 2760, ICG 6330 and ICG 6284 were resistant to rust among 44 genotypes screened, while Singh and Singh (1997) found three advanced breeding groundnut lines namely ICGV 87820, ICGV 87310 and ICGV 87835 as resistant to both LLS and rust.

Reddy *et al.* (1997) screened 33 groundnut advanced breeding lines against leaf spot disease. They found that none of the lines were resistant to both ELS and LLS diseases, while ICGV 86252 and JL 24 were moderately resistant to LLS .

Jiang *et al.* (1998) screened 5700 groundnut germplasm accessions collected from China and other countries. They found that 92 accessions were highly resistant to rust, 77 highly resistant to ELS and LLS and 53 as highly resistant to LLS and ELS, 58 rust and LLS resistant, 49 as rust and LLS resistant and 45 were resistant to all the three diseases. They also found that different botanical types and different origins showed great difference in their botanical characters and disease resistance.

Naidu *et al.* (1999) screened 42 groundnut genotypes against late leaf spot. Based on 1-9 scale severity rating at 90 days after sowing and found that all the genotypes were susceptible to LLS.

2.2.3. Pest

2.2.3.1. Tobacco caterpillar - Spodoptera litura (F)

Spodoptera litura (F.) commonly known as the “Tobacco caterpillar” is one of the serious pest of groundnut. In India, it is considered as a pest of national importance since it is polyphagous attacking several agricultural and horticultural crops. The pest has been reported from 51 countries causing damage to more than 120 species of plants belonging to 44 families. In India, it feeds on 74 species of cultivated crops and some wild plants. Besides groundnut, it also attacks tobacco, cotton, pulses and several vegetables crops (Singh and Jalali, 1997). It has been reported that an infestation level of one larva/plant during the seedling or flowering stage can result in 20% yield loss in groundnut. Severe outbreak of the pest can result in 30-40% loss in pod formation. The incidence of

S. litura varies greatly, primarily depending upon the availability of food plants in large area and the favorable climatic conditions rather than a varietal phenomenon.

Tiwari *et al.* (1988) classified the released groundnut varieties for their susceptibility to *S. litura* (F) based on the larval growth, pupal period and weight and the total longevity of the adult. The variety, “dwarf mutant” registered a lowest larval period of 15 days, while, M-13 and C 501 had prolonged larval period up to 19 days.

Rajgopal *et al.* (1988) reported significant varietal differences both in larval orientation as well as percentage of leaf damage due to *Spodoptera* in the extraction studies. The varieties having less damage were V40 and AH629 of Virginia bunch type and NCAC17840, NFG79, EC21989 in Virginia runner.

At Dharwad, the pod loss to the extent of 66.6% due to *S. litura* has been reported (Kulkarni, 1989). Two germplasm lines, ICGV 87264 and ICGV 86590 recorded the least damage to foliage (< 17.5%) compared to control (65%) in Dh 3-30 (Patil *et al.,* 1991).

Stevenson *et al.* (1993) identified and characterized some of the wild species of the *Arachis* resistant to *S. litura*, when they excised and detached the leaves of wild species and were allowed for feeding for 5 days in the case of former method and 48 hours for the later. Among the wild species studied, the mortality of the 1st instars ranged from 47 to 100% when compared to TMV-2 recording only 19% mortality. Similar trend was also recorded, when the larvae were allowed to feed on the attached leaves. This was confirmed further by the weight gain by third instars exposed for 24 hours for feeding. The weight of the larvae fed on the wild species recorded 1 to 25% gain when attached leaves are exposed. While it was 42% weight gain when fed on TMV-2. The *A. major* and *A. kemphmercadoi*, were rejected by the larvae for feeding.

Nandagopal *et al.* (1996) studied about 300 groundnut accessions in field as well as under laboratory conditions to identify the stable source of resistance to *S. litura* (F). They observed that 21 genotypes (ICGs, 2271, 7016, 7034, 7050, 7141, 7449, 7552, 7737, 8978, 8994, 9065, 9067, 9094, 9116, 9897 and GBFDS 272, 273, ICGVs 87165, 87264, 86699 and 91166) were resistant to *S. litura*.

Dharne and Patel (2000) have screened 32 groundnut genotypes against *S. litura*, during 1996-97. They found that the lowest damage (5 per cent) was recorded by the genotypes ICGVs 86156, 86400, 86528, 87128, 87141, 87290, 87411 and 91214.

2.3. Anatomical basis of resistance to biotic stresses

The Anatomical characters were used for the first time to delimit taxa of various levels within the family *Bignoniaceae* by Bureau in 1864. Bailey (1951), Metcalfe (1954 and 1961) and Dickinson (1975) have dealt on the use of anatomical evidences in the study of phylogeny and classification of plants. Hickey (1973) proposed terminology to describe the various anatomical features of dicotyledonous leaf. Since then, anatomical traits like nature and thickness of epidermis, stomatal types and its ontogeny, frequency and distribution;

distribution of mesophyll tissues and presence of crystals and tannin sacs in leaves were frequently been used to describe and delimit various taxa.

Anatomical characters especially of leaf were utilized in correlating with the important metabolic functions in the plant. Halma (1929) found a positive correlation between lamina thickness and height of palisade tissue layer, whereas Wilson and Cooper (1967, 1969a, 1969b and 1970) has gone through a great detail on the correlation between assimilation, seedling growth and mesophyll cell size among an array of populations, and also on photosynthetic activity and cell size among individual genotypes in *Loleum perenne*.

In cultivated plants resistant to biotic and abiotic stresses were often correlated with their anatomical features. Dobrenz *et al.* (1969) reported association of low stomatal frequency with drought tolerance in *Panicum antidotale* and a positive correlation with the winter hardiness and low stomatal frequency in *Opeca* sp. by Knecht *et al.*, (1970).

In the genus *Arachis* the preliminary studies on leaf anatomy was done (cf: Reed, 1924; Yarbrough, 1957; D'Cruz and Upadhyaya, 1961; Kothari and Shah, 1975), where the emphasis was given on the structure and development.

Suryakumari *et al.* (1983 and 1989) studied comparative leaf anatomy of wild species, cultivars and interspecific hybrids and suggested the need to use anatomical features with considerable weightage in systematic studies.

Siddaramaiah and Hegde (1979) studied the mode of penetration of *Puccicia arachidis* and its development on groundnut leaf. They found that uridiospores started to germinate within three days in water medium and penetration of host was either through the stomata or directly through the epidermis.

Brahmachari and Kolte (1983) studied the leaf anatomy of groundnut cultivars resistant to *Cercospora arachidicola* and *Cercosporidium personata*. They found fewer stomata/unit leaf area and a thicker palisade layer in resistant cultivar than susceptible cultivars. At all stages of plant growth resistant plants had more total chlorophyll and a higher total phenol content.

Suryakumari *et al.* (1984) reported strong correlation of number of tannin sacs in leaves with rust resistance in groundnut genotypes.

Sokhi *et al*. (1985) studied the comparative leaf anatomy in three rust susceptible and three rust resistant groundnut genotypes. They concluded that susceptible genotypes had more stomata/unit and larger length of leaflet area than resistant genotypes. Palisade tissue was more compact and thicker in the resistant genotypes.

Dwivedi *et al.* (1986) established the association of trichome density and length with the jasssid resistance. Mayee and Surayawanshi (1995) found correlation of structural characters to resistance to late leaf spot diseases in groundnut.

Jasbir *et al*. (1988) studied the pre-inflectional anatomical defense mechanism of two resistant genotypes, PI 259747,PI 381622 and two susceptible genotypes, M 13 and Faizpur to ELS. They found that the size, frequency, and index of stomata were significantly higher in susceptible genotypes. While palisade index values were higher in resistant genotypes. They also found that the most resistant genotype, PI 259747 had the highest frequency of tricomes, calcium oxalate crystals and the thickest epidermis, cuticle and palisade layers than the susceptible ones.

Kaur *et al.* (1988) studied 33 groundnut varieties differing in reaction to ELS. They found negative correlations between infection severity and palisade index, palisade cell number/mm and cell width. They also found that palisade cells were arranged more compactly in leaflets of resistant than in those of susceptible ones.

Kaur and Dhillon (1988) studied histological and histochemical characteristics of leaves from resistant and susceptible groundnut genotypes. They observed that after inoculation with *C. arachidicola* and *C. personatum* [*M. berkeleyi*]. both the pathogens induced almost similar anatomical responses in the inoculated leaves. The epidermal and mesophyll cells were shrunken or collapsed; damage to protoplasts was more obvious than damage to cell walls. The histochemical localizations revealed a gradual depletion of polysaccharides, proteins, ascorbic acid and nucleic acids from the diseased host tissue at the site of contact with the pathogen and their subsequent accumulation in the pathogen in the later stages of disease development. Differential staining for these metabolites was not observed in healthy tissues of these genotypes.

Sukhwinder *et al.* (1989) studied the groundnut genotypes with resistance to *Cercosporidium personatum*, and found that lowest mean stomatal frequency 16854/cm^2 and stomatal size 17 µm, in resistant genotypes compared with moderately susceptible (17810 cm^2 and 25 µm) and susceptible (18739 cm^2 and

26.1 μm) genotypes. A positive and significant correlation between the stomatal frequency and disease reaction indicated the importance of stomatal characteristics in determining the degree of resistance or susceptibility to infection.

Camacho *et al.* (1991) conducted field and laboratory trials on groundnut cultivars Tarapoto, Bolivia Pintado and Red Star. The cultivars were artificially inoculated with *Cercospora arachidicola* [*Mycosphaerella arachidis*]. They found that Tarapoto and Bolivia Pintado had higher cuticle and outer epidermal wall width, stomatic index and trichome density in the upper leaf surface, and greater palisade parenchyma cell length than the cultivar Red Star.

Sukhwinder *et al.* (1992) compared various anatomical characteristics in 24 cultivars, out of these 8 were resistant, 8 were moderately susceptible and 8 were susceptible to leaf spot. They found that thickness of the epidermis, including the cuticle, palisade tissue and the middle part of the lamina, was greater in the resistant cultivars whereas that of the spongy parenchyma was greater in moderately susceptible or susceptible plants.

Arruda *et al.* (1994) studied the leaf morphology of groundnut genotype SO 53 which is susceptible to all the most important foliar diseases and SO 909 a resistant genotype. They concluded that the thickness of the leaflet and the epidermis of the abaxial surface could be associated with susceptibility to some foliar diseases.

The static structural features of potential importance for entry and spread of LLS were studied in the leaflet of resistant and susceptible groundnut genotypes by Suryawanshi *et al.* (1994). They found that the leaflets of the resistant genotypes had thicker epidermis-cuticle, palisade and spongy tissues. They also noted that size, frequency and index of stomata were significantly lower in the resistant genotypes. In addition, the resistant genotypes had the highest frequency of trichomes and significantly higher palisade index.

Mayee and Apte (1995) studied the structural defense mechanism in groundnut rust pathogen. They studied five genotypes namely EC 76446, NcAc 927, NcAc 17090, PI 215696 and PI 350680. By using the sequential section cutting and whole mount technique they found that the resistant genotypes had smaller and fewer stomata, a compact palisade layer, thicker epidermis-cum cuticular layer and the presence of trichomes on abaxial surfaces of the leaves. They also concluded that resistance was characterized by intense callose depositions around the infection loci, while the deformities in sub-epidermal urediospores suggested an obstruction to visible pustule appearance on the leaves of resistant genotypes.

Rao *et al.* (1996) studied the electron microscopy in rust resistant groundnut genotypes. They found that in susceptible genotype, TS 32-1, infection pegs developed from appressoria over stomata and enter the substomatal cavity through the openings between guard cells. While in the resistant genotype, PI 259747, the infection peg either failed to enter through the stomata or the infection structure disintegrated in the substomatal cavity. It was also suggested that phytoalexins may be involved in disease resistance. They found that the response of phytoalexin was similar in both resistant and susceptible genotypes but the rate of accumulation was faster in the resistant genotype.

Bera *et al*. (1997) examined structural variation in different leaf characters in uninfected and diseased leaves of four groundnut genotypes. They found that total leaf area per plant and leaf hair density were higher in resistant genotypes. The susceptible genotypes, possessed larger stomata with wider apparatuses than resistant genotypes. They also found that, in case of leaf spot infection, stomatal frequency, stomatal size and apparatuses increased on the resistant genotypes.

Prabhpreet *et.al*. (1999) studied Pre-penetration anatomical barriers of 22 muskmelon genotypes against downy mildew (*Pseudoperonospora cubensis*). They found that thickness of epidermis and cuticle on both adaxial and abaxial leaf surfaces was significantly greater in the resistant genotypes than in the susceptible genotypes. The significant correlation of disease resistance with stomatal and trichome size and frequency indicated their importance in determining resistance.

Grewal *et al.* (1999) studied 15 genotypes of tomatoes with known levels of resistance/susceptibility to *Phytophthora* infections. It was found that resistant genotypes had a higher average trichome frequency, but this difference was not significant. Susceptible genotypes possessed higher numbers of glandular trichomes. They also confined that spongy parenchyma tissue in resistant genotypes was thicker than in susceptible genotypes, but again this difference was not significant. Finally there were significantly more calcium oxalate crystals in the spongy parenchyma of resistant genotypes.

Mahajan and Dhillon (2002) studied the anatomical characteristics of leaves of 220 muskmelon (*Cucumis melo*) genotypes exhibiting variable degree of resistance/susceptibility to downy mildew caused by *Pseudoperonospora cubensis.* They noted that mean thickness of the epidermis-cum-cuticle and cuticle, thickness of palisade tissue, breadth of palisade cells, palisade index and palisade proportion were significantly higher in resistant genotypes. On the other hand, thickness of spongy tissue was significantly higher in susceptible genotypes.

Mahajan *et al.* (2003) studied the leaf anatomy of 42 genotypes of muskmelon showing variable degree of resistance/susceptibility to downy mildew. They found that the size and frequency of the stomata and the stomatal index were significantly higher in susceptible genotypes than in resistant genotypes. On the other hand, the average frequency and size of the trichomes were significantly higher in resistant genotypes. It appears that these leaf anatomical characteristics act as structural barriers against penetration by the downy mildew pathogen.

Monica *et al.* (2003) examined the leaf epidermal characteristics of four potato (*Solanum tuberosum*) cultivars differing in their resistance or susceptibility to late blight disease (*Phytophthora infestans*). The cuticle was significantly thicker in the resistant cultivars. On the other hand, in resistant cultivars both the adaxial (5.8 and 6.9 microns) and the abaxial (5.2 and 5.4 microns) surfaces of the leaf was thicker than that of the susceptible cultivars. The epidermis thickness also showed a similar trend. The size (23.2 and 23.8 microns, abaxial surface), frequency (83.2 and 62.8/mm^2, adaxial surface) and index of stomata (17.0 and 18.5 on adaxial and 38.0 and 38.9 on abaxial surfaces) were significantly higher in the susceptible cultivars. The resistant cultivars had significantly higher values for size of trichomes on both leaf surfaces (588.0 and 735.6 mm on the adaxial and 667.8 and 600.0 mm on the abaxial surface).

Monica *et al.* (2003) studied structural variability amongst potato cultivars carrying varying grades of resistance to late blight in four potato cultivars namely Kyoti Jyoti, Kufri Badshah, Kufri Ashoka and Kufri Chandramukhi. They found that the ratio of palisade proportion (i.e. thickness of palisade tissue in comparison with the total thickness of lamina) was higher in resistant cultivars compared to susceptible cultivars. They also concluded that the values of palisade index indicated that the palisade cell arrangement was more compact in the resistant cultivars, whereas these were loosely arranged in the susceptible cultivars and had large intracellular spaces.

2.4. Biochemical characterization

Infected plant tissues often have increased activity of several enzymes; particularly those associated with generation of energy (respiration) or with the production of oxidation of various phenolics compounds. Some of which may be involved in defense reactions to infection, although few enzyme (proteins) may be constitutively present in cell, at the time of infection, or may be produced during host-pathogen interaction (Gupta *et al.* 1985).

Literature pertaining to biochemical and physiological alterations associated with diseases and pest resistant in groundnut are very limited.

However, systematic studies reported in the literature pertaining to the induction of antimicrobial compounds such as phenol, and the enzymes involved in the phenol metabolism among susceptible and resistant genotypes are reviewed hereunder.

2.4.1. Carbohydrates

Siddaramaih *et al*. (1979) observed water soluble sugar content on dry weight basis in rust infected leaves of groundnut caused by Puccinia arachidis and reported that higher amount of soluble sugars were present in the susceptible leaves.

Mahapatra (1982) reported that leaves of groundnut infected by C. personata contained higher quantity of reducing sugars than the healthy ones. He also observed that there was a sharp depletion in non-reducing sugars, immediately after infection, while the total sugars increased as the disease progressed.

Patel and Vaishnav (1986) reported higher amount of soluble sugars in leaf spot infected leaves of groundnut plants.

Gupta *et al*. (1985) reported that the reducing sugars may be considered to be responsible for disease resistance in groundnut leaves infected with tikka disease.

Sujathamma and Reddy (1986) observed changes in sugar contents associated with *Rhizoctinia solani* infection of groundnut hypocotyls and reported gradual demolition of sugars in infected parts.

Li *et al*. (1995) observed that the soluble sugar content was generally high in susceptible cultivars than in resistant ones of groundnut plant infected with rust disease. But after infection, the soluble sugar content in infected plants was lower than that in healthy plants.

Sindhan and Parashar (1996) studied changes in the carbohydrate content in groundnut leaves infected by early and late leaf spots. They stated that there were lower levels of reducing and non-reducing sugars in the resistant cultivars as compared to susceptible ones.

Reddy and Khare (1998) studied the changes in total sugars content of groundnut leaf infected with rust disease. They reported higher levels of total sugars in both highly susceptible and resistant cultivars of groundnut.

2.4.2. Amino acids and protein contents

Siddaramaiah *et al*. (1979) observed that amino acid content increased (dry weight bases) in infected leaves of groundnut caused by *Puccinia arachidis*. Similar results were also obtained by Patel and Vaishnav (1986) in groundnut.

It has been found that amino acids were highest in PI 269747, a leaf spot resistant groundnut variety. It was also found that total free amino acids were high in susceptible varieties (Jasbir *et al.,* 1987).

Li *et al.* (1995) studied protein ratio in groundnut plants after rust infection and their findings showed that the ratio of protein content in diseased plant was the lowest and the amino acids namely cystein and tyrosine were observed in early stages of infection and then disappeared subsequently.

2.4.3. Phenols

Phenols have been credited with an important role in groundnut disease resistance (Reddy, 1983; Mayee, 1987; Baskaran, 1988; Velazhahan and Vidhyasekaran, 1994, Rathnakumar *et al*. 2004). Reports of higher levels of phenols in resistant varieties gave support to the hypothesis that individual phenols and their oxidation products are responsible for providing resistant to fungal diseases (Gurdeep, 1998; Sindhan and Parashar 1996; Sudhagar, 2000). Although, phenols were found to increase in both resistant and susceptible varieties during infection, the magnitude of increase was less in susceptible varieties (Hiramath and Savanpur, 1990)

Brahmachari and Kolte (1983), studied morphological and biochemical differences in leafspot resistant and susceptible varieties. They found more total chlorophyll and total phenol contents in resistant varieties than in susceptible ones.

The study carried out by Reddy and Khare (1988) on groundnut plant infected with rust indicated that phenol contents in leaves increased after the inoculation of urediospore suspension on groundnut cultivar on the variety Jyoti (highly susceptible) and ICG 1697 (Resistant) cultivar.

Gupta *et al.* (1985) reported that total phenols were markedly higher in tolerant than in susceptible cultivars of groundnut to leaf spot.

Singh and Sachan (1992) observed higher phenolic acid content in all the genotypes resistant to *S.litura,* while lower phenol content was found in susceptible genotypes, TMV 2 and M 13.

Stevenson (1993) studied biochemical resistance in groundut to *S. litura.* He found that resistance was associated with the presence of several foliar quercetin diglycosides and caffeoylquinic acids. The analogues compound 'hutin' and chlorogenic acids were found to be toxic to the larve of S.litura.

Velazhan and Vidhyasekaran (1994) studied the alteration in phenolics contents of groundnut leaves infected by *Puccinia arachidis* (rust) and revealed that there was higher phenol and ortho-dihydroxy phenol contents in resistant varieties as compared with susceptible varieties. These contents also increased after infection in both susceptible and resistant varieties.

Bera *et al.* (1999) found that *Cercospora* resistant groundnut genotypes were capable of maintaining a higher levels of chlorophyll, soluble sugars, protein and phenol contents. Selection of varieties with increased amount of phenols in the leaves was suggested for development of Tikka disease resistant genotypes.

Sudhagar *et al*. (2000) observed changes in phenolics in groundnut genotypes infected with the rust pathogen at 80th and 90th day in resistant (ICG 1697) and susceptible genotypes (TMV-1, VRI 2). They observed an increase in total phenol and ortho-dihydroxy phenol contents in resistant genotypes.

However, the susceptible genotypes showed initial increase in total phenol content which subsequently decreased.

Rathnakumar *et al.* (2004), found greater amount of epicuticular wax content in rust resistant and susceptible genotypes of groundnut. They also found higher total phenol in resistant genotypes.

2.4.4. Epicuticular wax

The role of epicuticular wax content under various stresses have been well documented in various crop species except for groundnut. However, available literature pertaining to oilseed crops is reviewed hereunder.

Plants of *B. napus* spp. *oleifera* is very waxy compared to those of *B. rapa* spp *oleifera* which is more susceptible than to *B. Juncea.* The leaves of the cultivar Mida and Tower resistant to Alternaria had appreciable amounts of epicuticular wax (Skoropad and Tewari, 1977).

Gupta *et al.* (1985) reported that waxes on the leaf surface of plants have been shown to confer resistance to fungal disease by their antifungal properties. They found that the wax content at initial growth stages of plant (25 days old) was maximum, where as the amount decline gradually up to 55 days growth stage and at least wax content become constant.

2.5. Aflatoxin resistance

The aflatoxin problem was first recognized following outbreaks of Turkey 'X' disease in the United Kingdom in 1960, when one lakh turkey-pouts died due to feeding contaminated groundnut meal from Brazil (Blount, 1961). Later, researches revealed that the disease was due to the toxins produced by strains of fungus, *Aspergillus flavus* that had grown in the groundnuts. The toxin was named 'Aflatoxin' (Sargent *et al.,*1961).

Aflatoxins are the toxic metabolites produced primarily by some strains of *Aspergillus flavus* Link ex Fries and *Aspergillus parasiticus* Speare. It also produced by other fungi viz., *A. niger, A.ruber, Penicillium citrinum*, *P. puberulum* (Hodges *et al.*, 1964; Kulik and Holady,1966), *A. oryzae* (Basappa *et al.*, 1967), *A. ostianus* (Scott *et al.*, 1967), *A. glaucus, P. glaucum*, *P. digitatum, Mucor mucedo* (Hansen, 1968), *A. fumigatus* (Tilden *et al.*,1968), *A. ochraceus*, *Rhizopus* sp.(Van wakbeek et a/., 1968) and *Streptomyces* Sp. (Misra and Murthy, 1968). Many other fungi were also reported as aflatoxins producers but they all need confirmation except *A.flavus* and *A. parasiticus* (Hesseltine *et al.,*1966; Murakami *et al.,*1967).

These toxins have a profound effect on the health of animals and plants. There are four major aflatoxin B_1, B_2, G_1 and G_2 based on their structure and chromatographic fluorescent characteristics, which give blue and green fluorescence under U.V. light (Delongh *et al.,* 1962; Nesbitt *et al.,* 1962). Both aflatoxins were further sub-divided into two related compounds viz., B into B_1 and B_2 and G into G_1 and G_2 according to their R_f values (Patterson, 1977). There are many derivatives of these aflatoxin viz., B_{2a}, G_{2a}, M_1, M_2, M_{2a}, GM_1, GM_2, B_3, P_1 and Q_1 and R_0 have been reported. Out of these B_1 is the most occurring and acutely toxic followed by G_1, B_2 and G_2 (Moss, 1972).

Aflatoxin can cause serious animal and human health problems and when present in groundnut it reduces its quality and value. Aflatoxins are now known to be hepatotoxinc, carcinogenic and teratogenic in many animal species.

2.5.1. Aflatoxin in groundnut and groundnut product in India

Aflatoxin is a serious problem in groundnut kernels, groundnut oil, groundnut cake, peanut butter etc. Limited survey has been conducted to determine aflatoxin levels in groundnut and its products in several groundnut producing states of India. Srinivasamurthy *et al.*, (1967) reported the association of toxigenic strains of *A. flavus* with the samples of peanut kernels obtained from the market of Mysore. Whereas, Rao *et al.*, (1965) collected the samples from six coastal districts of Andhra Pradesh and showed that 36 of the 288 samples i.e.12.5 % were contaminated with aflatoxins. Nearly 50 per cent of the 500 groundnut kernel samples collected from west coast areas in 1967-68 had 100250 µg/kg levels of aflatoxins (Wagle, 1970). In Uttar Pradesh also, the level of aflatoxin B_1 rang from 33-440 µg/kg in raw groundnut and from 10-85 µg/kg In roasted groundnut has been reported by Singh *et al.* (1982). Only 5 of 26 samples of groundnut collected from local market in Maharashtra showed aflatoxin contamination (Patil and Shinde, 1985), Nagaraj and Kumar (1986) reported the highest levels of aflatoxin B_1 ranging from 0,8 to 65.8 µg/kg in

Junagadh and Chintamani samples of groundnut, where as Kshemkalyani and Patel (1988) found that 75 samples collected from nearby villages of Ahmednagar city were contaminated with aflatoxin B_1.

Various survey conducted in different parts of India (Ghewande *et al*.,1989; Sahay and Rajan, 1990 and Kolhe *et al*., 1994) have revealed that groundnut and its products are high-risk commodities for aflatoxins contamination. Levels of aflatoxin contamination varied from 0.8 to 220 mg per kg in groundnut kernels, traces to 200 µg/kg in edible flour, 786 µg/kg in unrefined oil and 27 to 1122 µg/kg in cake.

Aflatoxins were found in the range of 1400-3600 µg/kg in groundnut cake samples (Choudhary and Rao, 1982). Balasubramanian (1985) reported aflatoxins B_1 in 66 % of the samples, among them only groundnut oil cake was contaminated with aflatoxin B_1 (330-2670 µg/kg).

2.5.2. Factors influencing Aspergillus flavus infection

Environmental factors such as soil moisture, soil temperature in the pod zone and soil type influence the degree of groundnut seed infection by *Aspergilus flavus* and other fungi which complicates resistance screening as level of infection vary considerably within a genotype over seasons and locations (Surekha and Reddy, 1989).

Aspergilus flavus infection and aflatoxin contamination was much lower in the seeds of all genotypes from vertisols than from alfisols and light sandy soils (Ghewande and Nagaraj, 1987). Irrespective of soil types, resistant genotypes showed lower level of seed infection than susceptible ones and seed infection in the storage is more in wet season than in dry seasons (Mehan *et al.,*1991).

High level of seed colonization observed in the late sown crop was attributed to higher seed testa damage resulted from greater drought stress (Patil and Shinde, 1985).

2.5.3. Genetic resistance to Aspergillus flavus invasion and aflatoxin contamination

The aflatoxin problem could be solved, if the groundnut cultivar possess resistance or immunity to seed infection by the aflatoxin producing fungi or once infected, did not support aflatoxin production. Several studies have shown the presence of field resistance to seed infection by *A.flavus* in some cultivars. Resistance to pre-harvest field infection is particularly important in areas where late season drought stress is of common occurrence (Zambettakis *et al.*, 1981; Mixon, 1983 and Mehan *et al.*, 1987). Some cultivars such as J-11 and PI 337394 F have shown stable resistance to *A. flavus* across locations (Mehan *et al.,*1991).

Pettit *et al.* (1989) screened five genotypes for resistance to *Aspergillus flavus* infection of kernels, pods and pegs and noticed differences among genotypes. The genotype, PI337409 was highly infected while SN 55-437 had less infection.

Desai *et al.* (1991) observed that high yielding lines were susceptible to invasion by *A. flavus* and aflatoxin contamination. The variety, OG-53-1 showed the highest resistance among the 53 cultivars tested but had low yield potential.

Ghewande *et al.* (1993) screened 38 bold seeded genotypes for dry seed resistance to *Aspergillus flavus* and aflatoxin production. Infection and colonization were the lowest in ICG-239 (14.71 %) followed by B-95, B-88, B-99-1 and 2946. While, aflatoxin production was the lowest in B-99-1(3900 µg/kg) followed by B-95 (5805 µg/kg). Maximum aflatoxin production (90,000 µg/kg) was observed in BG 2. A strong relationship has been established by them between *Aspergillus flavus* infection and colonization and colonization and aflatoxin content.

Rao *et al.* (1965) evaluated the genotypes, ICGV 88145 and ICGV 89104 for natural seed infection by aflatoxin producing fungus, *A. flavus*. Natural seed infection was 0.7 per cent in ICGV 88145 and 1.0 per cent in ICGV 89104 as compared to 1.3 per cent of the best resistant one.

Varma *et al.* (1996) found that most of the cultivated varieties of Karnataka exhibited colonization comparable to the most susceptible variety, TMV 2. Three genotypes S 206, KRG-1 and GPBD-4 recorded relatively low levels of colonization indicating their tolerance to *A. flavus* (isolate, UASD-1).

The resistance of groundnut seed to *A.flavus* and aflatoxin production is associated with certain morphological and biochemical characteristics viz., structure of seed coat, size of wax layer, junction between epidermal cells, thickness of cell wall and presence of cracks etc. (Zambettakis and Bockelee morvon, 1976 and Zambettakis, 1978).

2.5.4 Genetic resistance to A.flavus invasion

Mixon and Roger (1973) developed a laboratory inoculation method for screening groundnut genotypes for resistance to *A.flavus* infection and colonization and reported that two Valencia type genotypes, PI 337394 F and PI 337409 had high levels of resistance to *in vitro* seed colonization by *A.flavus*. Where as, Zambattakis (1978) reported that out of 24 cultivars, "Dron IV" and "Shulamit" showed least pod infection by *A.flavus*. Aujla *et al.* (1978) screened 37 groundnut cultivars against *A.flavus* (L-27); Among them U-4-7-2 and U-2-1-14 were found moderately resistant. According to Bartz *et al.* (1978) groundnut variety UF-71513 has shown a resistance against toxin producing strain of *A.flavus*. Davidson *et al.* (1983) found the groundnut cultivars 'Sunbelt runner' and 'Florunner' as resistant and moderately susceptible respectively to *in vitro* seed colonization by *A.flavus*. Mixon (1983) observed groundnut varieties Ah 7223, Faizapur, Monir 240-30 and AR-1-2-3 were resistant to toxin producing strain of *A.flavus*.

Researchers at National Research Center for Groundnut, Junagadh have identified several genotypes (GRP 34, ICG-239, AH-20, NRCG 698, 8970,8972,8973), released varieties (GG-11, Koyana, RS 1, ICGS 11 and S 206) and advanced breeding line (B 99-1) as resistant to *in vitro* seed colonization and as low supporters of aflatoxin production (Desai *et al.,* 1991; Ghewande *et al.,* 1993).

Nagarajan and Bhatt (1973) found late aflatoxin production on US-26 as compared to TMV-2 using three isolates of *A.flavus* and two isolates of *A.*

paraciticus. A laboratory method to screen groundnut for resistant to aflatoxin production was used at ICRISAT (Mehan and Mc Donald, 1980) to test 502 genotypes. None was totally resistance to aflatoxin production but highly significant differences in aflatoxin production were found (Mehan *et al.,* 1987). Zambettakis *et al.* (1981) confirmed the resistance of PI 337409 and found 55-437 as resistant and PI 73-33 as tolerant to aflatoxin. Minimum producion of aflatoxin i.e below 2000 µg/kg was supported by RSB 87, TMV-12, TMV-7, S 230 and KRG-1 and maximum by BG-1 followed by JL-24 and GG 2 (Ghewande *et al.,*1993).

Desai *et al.* (1991) reported highest aflatoxin content in Kaushal (38250 ppb), while lowest aflatoxin content was recorded in Chitra (3200 ppb). Verma *et al.* (1996) also reported the highest incidence of aflatoxin in 'Dhokya white' cultivar of peanut.

2.5.5 Mechanism of resistance to A.flavus infection and colonization

The seeds from pods with damaged shells were more frequently contaminated with aflatoxin than those from undamaged pods, because groundnut shell has been considered a barrier to penetration by *A.flavus* (McDonald and Harkness, 1967). Resistance depends upon the intact and undamaged testa. So protective role of seed testa has been emphasized in case of seed colonization by aflatoxigenic fungi (Carter, 1973). Whereas, according to Laprade *et al.* (1973) and Zambettakis (1976), seed colonization has been correlated with its thickness, density of 'pallisade cell' layers, absence of fissures and cavities etc. The presence of waxy layer on the testa has been found as an important factor for resistance of genotypes to *A.flavus* (Laprade *et al.,* 1973). As per Amaya *et al.* (1977) fungistatic phenolic compound found in testa may have a role in resistance to *A.flavus* infection and colonization.

Dieckert and Dieckert (1977) reported that seeds of resistant genotypes, PI 337394 F and PI 337409 had thinner testa with tighter, more compact cell structure than the seeds of susceptible genotypes, PI 343360 and PI 343362.

Chapter 3 Materials and Methods

3.1. Experimental site

The experiment was carried out at the field of National Research Centre for Groundnut (ICAR), Junagadh. The laboratory studies were carried out at the National Research Centre for Groundnut, Junagadh and at the Department of Biosciences, Saurashtra University, Rajkot.

3.2. Location of the experimental site

Jungadh is located at a latitude of 21°3'N and 70°36'E longitude and 60 m above sea level in the Saurashtra region of the Gujarat state.

3.3. Climate

The general climate of area surrounding Junagadh is semi-arid with an average rainfall of 750 mm. Monsoon generally starts by the third week of June. However, it is often delayed until the first week of July. More than 90% of the rain is received during June to September with several intermittent dry periods. Winter spells from October to February and occurrence of frost is rare. The agro-meteorological data of Junagadh for the year 2001 to 2004 is given in Table 3.1, 3.2. and 3.3.

Table 3.1 Agro-Meteorological data of Junagadh for the year 2001-02

Months	Temp (°C)		RH (%)	Rain fall (mm)	Soil temp. (^oC)		Wind Velocity (km/h)	Sunshine (h/day)
	Max	Min			5cm	10cm		
Apirl'01	39.1	22.2	74	--	38.2	36.5	8.72	10.40
May	39.3	25.4	81	--	40.0	39.2	11.57	10.60
June	35.9	26.3	84	305.5	35.6	35.4	13.70	6.10
July	31.3	25.4	92	333.4	30.7	30.5	8.68	2.64
August	29.5	24.1	94	65.0	28.7	28.8	7.51	1.83
September	32.9	23.4	87	0.9	32.4	31.9	5.30	5.85
October	35.0	21.1	71	26.2	32.5	31.5	6.98	7.78
November	32.4	13.6	69	--	27.7	27.1	5.33	8.93
December	31.2	11.9	67	--	25.8	25.1	5.73	8.30
January'02	28.7	11.3	70	12.0	24.5	23.2	6.18	8.62
February	32.8	12.4	66	--	27.8	26.6	6.03	9.73
March	36.6	19.1	61	--	32.7	31.4	8.40	6.83

(Source: NRCG Annual Report, 2001-02)

Table 3.2 Agro-Meteorological data of Junagadh for the year 2002-03

Months	Temp (°C)		RH (%)	Rain fall (mm)	Soil temp. (^oC)		Wind Velocity (km/h)	Sunshine (h/day)
	Max.	Min.	%	Mm	5cm	10cm	Km/hour	h/day
Apirl'02	36.6	21.6	73	12.7	28.7	30.2	8.10	8.60
May	49.0	26.0	77	-	32.2	32.2	10.80	9.30
June	33.0	25.0	85	231.7	29.4	30.4	11.40	4.90
July	31.0	26.0	91	281.5	28.4	29.2	11.08	1.60
August	32.8	26.1	98	96.4	27.2	27.9	8.40	2.60
September	31.9	23.6	88	217.6	27.2	28.0	5.60	5.60
October	35.	21.2	81	39.3	26.8	28.0	5.40	9.40
November	28.6	14.8	74	-	24.6	26.0	4.80	8.60
December	25.2	11.1	68	-	18.8	21.6	8.20	8.00
January'03	29.	11.0	72	-	17.2	19.8	6.70	8.20
February	31.0	13.5	81	-	18.6	19.1	5.40	7.90
March	36.1	18.2	62	-	24.5	26.7	7.90	9.90

(Source: NRCG Annual Report, 2002-03)

Table 3.3 Agro-Meteorological data of Junagadh for the year 2003-04

Months	Temp (°C)		RH (%)	Rain fall (mm)	Soil temp. (°C)		Wind Velocity (km/h)	Sunshine (h/day)
	Max.	Min.	%	mm	5cm	10cm	km/hour	h/day
Apirl'03	38.2	22.3	70	--	20.7	28.2	7.10	10.1
May	39.2	24.3	72	--	30.2	30.2	9.80	10.2
June	37.4	25.4	79	268.2	25.1	30.4	10.40	6.8
July	31.5	26.1	90	291.0	26.4	23.2	10.08	2. 4
August	33.2	23.0	88	186.7	22.1	27.9	8.40	1.3
September	35.0	24.1	98	96.7	20.2	29.0	6.60	5.5
October	32.8	20.4	74	--	29.5	26.2	5.40	7.8
November	33.4	15.7	68	--	26.6	26.9	5.80	8.3
December	31.2	11.8	59	--	19.5	24.6	7.20	8.0
January'04	28.4	12.7	72	--	17.2	20.7	7.70	8.6
February	31.6	11.1	66	--	18.6	19.4	6.40	9.8
March	37.2	18.2	60	--	24.5	24.2	6.90	6.3

(Source: NRCG Annual Report, 2003-04)

3.4. Soil

The soil is calcareous and medium black vertisol. The following physical and chemical analyses were carried out to assess the properties of the soil as per the procedure detailed below.

3.4.1. pH

The pH was measured in 1:2.5 (W/V) soil: water suspension by using Beckman Zeromatic ph meter (Jackson, 1968)

3.4.2 Electrical Conductivity (EC)

The EC was measured by mixing soil and water in 1:2 (W/V) proportion using an EC meter.

3.4.3. Total Nitrogen

The total nitrogen was estimated in soil by salicylic acid-sodium thiosulphate, a modification of Kjeldahl method to include nitrate. Suitable quantity of air-dried and sieved soil sample was taken in a micro kjeldahl flask and 4 ml of salycilic acid-H_2SO_4 mixture was added and allowed to stand overnight. To the mixture 500 mg of $Na_2S_2O_3$ was added and heated till frothing ceased. After cooling, 1.1 g of K_2SO_4-$CuSO_4$ catalyst mixture was added and heated cautiously until the content turned clear. This digest was used to determine nitrogen by Micro-Kjeldahl method (Jackson, 1968).

3.5. Experimental materials

Three hundred and sixty seven groundnut germplasm accessions received from the International Crops Research Institute for Semi-Arid And Tropic (ICRISAT) under the repatriation programme were evaluated and characterized. Out of these 367 groundnut germplasm, 103 germplasm accessions belonged to Spanish (VUL) habit type; 135 were Valencia (FST); 92 were Virginia Bunch (HYB); and 37 were of Virginia runner (HYR). The passport information of all the germplasm accessions are provided in Annexure-I

3.6. Morphological characterization

The groundnut germplasm was characterized morphologically for 19 qualitative and 26 quantitative traits using the Descriptor for groundnut (IBPGR/ICRISAT, 1992).

Morphological characterization was done for two consecutive years under the field conditions. Sowing was done in the month of June in 2001 and 2002 after the onset of monsoon in a single replication, in an augmented block design (ABD) with grid plot check. The sowing was done in a row of 4 m length, with a row-to-row spacing of 75 cm and a plant-to-plant spacing of 10 cm during both the years. Recommended agronomic practices were followed to raise a successful crop.

The observations were recorded after 105-110 days old plants using Descriptors for groundnut (IBPGR/ICRISAT, 1992). Methuen handbook of colour (Kornerup, 1978) was used for describing colour of the flower.

Nineteen Qualitative characters and 26 quantitative characters were recorded (Table 3.5 and 3.6). Additional descriptor states were also used wherever necessary. The qualitative traits included both binary (present or absent), ordinal (absent, slight, moderate, prominent) parameters. Leaf characters were recorded from third fully opened leaf of main stem to get full expression of the character. Floral characters were recorded on 30 flowers of each accession. Pod and seed characters were observed from 10 mature pods. Observations were taken from five plants at random for each accession for two years and the data were pooled over the years for the analysis of quantitative characters.

3.6.1. Descriptors used and methods followed

The passport information on each accession has been provided for easy identification of the material and procurement. The passport information is classified in to six categories as detailed below (Table 3.4).

Table. 3.4 Passport Information

Column	Information	Description
1	Sr no	Serial number of accession
2	NRCG	Number assigned by the NRCG at the time of incorporation of the material in the gene bank
3	ICG	Number assigned by the ICRISAT for the accessions maintained in the world collection
4	Variety	Identity of the accession by collector number, name etc
5	ORG	Country of origin, country code as given by IPGRI, Rome
6	HBT	Habit type; Virginia bunch (HYB), Virginia runner (HYR), Spanish (VUL) and Valencia (FST)

3.6.2 Qualitative traits

Nineteen qualitative traits were recorded and the following descriptor states were used (Table 3.5).

3.6.3. Quantitative traits

The quantitative traits were recorded to check the genetic potential of the accessions for various yield related traits which may be of use to breeders for further utilization through hybridization and selection. The following 26-descriptor traits were recorded for the quantitative traits (Table 3.6).

Table 3.5 Qualitative traits (19) and its descriptors state

Trait no	Descriptors	Descriptors state	Code
1	Growth habit (Plate- 1)	Decumbent-1	1
		Decumbent –2	2
		Decumbent –3	3
		Erect	4
2	Branching pattern determined on n and n+1 cotyledonary lateral branches (Plate- 2)	Alternate	1
		Sequential with flowers on main stem	2
		Irregular with flowers on main stem	3
		Irregular without flowers on main stem	4
3	Stem pigmentation scored at pod filling stage (Plate- 3)	Absent	0
		Present	+
4	Stem surface observed on main axis (Plate- 4)	Glabrous	1
		Sub-glabrous hairs in one or two rows along the main stem	3
		Moderately hairy	5
		Hairy	7
		Very hairy	9
5	Type of inflorescence (Plate- 3)	Simple	1
		Compound (more than one peg/node)	2
6*	Standard petal colour (Colour of the front face of the standard petal) (Plate- 5)	Yellow	1
		Orange (5 A 7)	2
		Dark orange (5 A 8)	3
		Garnet, Deep orange with garnet marking on petals (9 D 8)	4

Trait no	Descriptors	Descriptors state	Code
7	Peg pigmentation	Absent	0
		Present	+
8*	Leaflet colour (colour of fully expanded leaf) (Plate- 6)	Yellowish green	1
		Light green (29 C 8)	2
		Green (28 D 8)	3
		Dark green (28 F 8)	4
9	Leaflet shape (Shape of third apical leaflet on n)	Oblong	1
		Lanceolate	2
10	Leaflet surface	Almost glabrous	1
		Almost glabrous above, hairs below	3
		Almost glabrous above, hairs and bristles below	5
		Hairy	7
		Very hairy	9
11	Leaflet tip	Obtuse	1
		Acute	2
12	Pod beak (Plate- 7)	Absent	0
		Slight	3
		Moderate	5
		Prominent	7
		Very prominent	9
13	Pod constriction (Plate- 7)	None	0
		Slight	3
		Moderate	5
		Deep	7
		Very deep	9
14	Pod reticulation (Plate- 7)	None	0
		Slight	3
		Moderate	5
		Prominent	7
		Very prominent	9
15*	Testa colour (one month after harvest) (Plate- 8)	White	1
		Off white (1 A 2)	2

Trait no	Descriptors	Descriptors state	Code
		Rose, Grayish red (8 B 3)	10
		Rose with white flecks	10+1
		Salmon (6 A 4)	11
		Salmon with dark purple flecks	11+17
		Red (10 B 7)	13
		Red with white flecks	13+1
		Dark red (11 C 8)	14
		Purple (14 F 4)	16
		Dark purple (14 F 7)	17
		Dark purple with salmon flecks	17+11
		White with light Red	1+12
		Rose with white flecks	10+2
16	Pod size**	Small	1
		Medium	2
		Large	3
17	Shell thickness**	Thin	1
		Moderate	2
		Thick	3
18	Seed shape**	Round	1
		Fusiform	2
		Elongated	3
19	Seed size**	Small	1
		Medium	2
		Large	3

Plate- 1-7, courtesy NRCG.

* The code number in the parenthesis indicate matching colour code as per Methuen Handbook of colour.

** The last four traits have not been suggested in the descriptors but were recorded for additional information.

Table 3.6 Quantitative traits (26) and its descriptors state.

Trait no.	Trait	Description
1.	Days to germination	Number of days to 50% field emergence from the date of sowing
2.	Days to initial flowering	Number of days to initial flowering from the date of germination
3.	Days to 50% flowering	Number of days for flowering in 50% of plants from the date of germination
4.	Days to maturity	Number of days from the date of sowing to maturity
5.	Height of main axis (cm)	Mean of height of main axis of five plants at maturity
6.	Length of n+1 (cm)	Mean length of n+1 measured from main axis to the tip of n+1 of five plants
7.	No. of n+1 branches	Number of primary branches
8.	No. of n+2 branches	Number of secondary branches
9.	Leaflet length (cm)	Mean of 10 leaflets from different plants of third leaflet on main axis
10.	Leaflet width (cm)	Mean of 10 leaflets from different plants of third leaflet on main axis
11.	Leaflet length/width	Length/width ratio of leaflet
12.	Immature pods/ plant	Mean number of immature pods present at the time of harvest in five plants
13.	Pod mass (g/plant)	Weight of dry and mature pods
14.	Pod yield m^{-2} (g)	Weight of mature dry pods calculated m^{-2}
15.	100 pod mass (g)	Weight of 100 pods selected at random
16.	One seeded pods (%)	Percentage of one-seeded pods from a random sample of 100 pods
17.	Two seeded pods (%)	Percentage of two-seeded pods from a random sample of 100 pods
18.	Three seeded pods (%)	Percentage of three-seeded pods from a random sample of 100 pods
19.	Four seeded pods (%)	Percentage of four-seeded pods from a random sample of 100 pods
20.	Pod length (cm)	Mean of 10 mature pods
21.	Pod width (cm)	Mean of 10 mature pods at the widest point
22.	Seed length (cm)	Mean of 10 mature seeds
23.	Seed width (cm)	Mean of 10 mature seeds at the widest point
24.	Shelling outturn (%)	(Weight of dry seeds/total weight of pods) X 100
25.	Sound mature seeds (%)	(Weight of marketable seeds/total weight of seeds) X 100
26.	Hundred seed mass (g)	Weight of 100 marketable seeds selected at random

3.7. Screening against major foliar diseases and pest.

The 367 groundnut germplasm received from the International Crop Research Institute for the Semi-Arid and Tropics (ICRISAT), Patancheru, Andhra Pradesh were used as base material for the screening of three major foliar fungal diseases namely early leaf spot (ELS), late leaf spot (LLS) rust and a major pest, across India, i.e. *Spodoptera litura* (F.).

3.7.1 Preliminary screening against major diseases and pest

The 367-groundnut germplasm accessions were sown in *kharif* 2001 in the first week of June after the onset of monsoon in a single replicate of augmented block design (ABD) with grid check and infector susceptible row (GG 2) for every 10 germplasm rows. The sowing was done in a row of 4 meter length, with a row to row spacing of 75 cm and a plant to plant spacing of 10 cm. Recommended agronomic practices were followed except for the spay of fungicides and insecticides. The spray of disease inoculum was done after 15 days of sowing.

3.7.2. Production of inoculum

3.7.2.1 For early and late leaf spot

The leaf spot pathogen can survive from season to season in infected leaves. Infected leaf debris from the field were collected and stored in jute/cloth bags in farm sheds for the use in following season. (Subrahmanyam and Mcdonald 1983).

The spore suspention of leaf spot disease (50 000 spores /ml) was prepared and sprayed 15 days after sowing. After 20 days, infected leaf debris (collected from the susceptible groundnut crop) were scattered around the infector rows.

3.7.2.2. For rust

The rust spores were collected from the severely infected groundnut crop with the help of low power vacuum cleaner and stored in a deep freezer at -15 ^{o}C. The urediniospore suspension (approximately 100,000 sproes/ml) in tap water containing a small quantity (10 drops/ml) of Tween 80 was made and sprayed on each infector rows. The leaf infected by the rust was also scattered around the infector rows.

3.7.3. Disease assessment

Adequate and uniform disease pressure was ensured by checking the development of disease on susceptible check (GG 2). Screening was done at the pod filling stage and 5 days before harvest. The mean value of the screening for each genotype was considered. The 1 to 9 scale (Table 3.7 and 3.8) visual screening method was followed (Subrahmanyam *et al.,* 1982 and 1995) (Plate- 9 and 10).

10 leaves randomly selected from one row from each accession was used for screening and the mean score was considered for the disease assessment in each screening.

The groundnut germplasm which scored 1 to 3 on 1-9 disease scale were considered as resistant, 3-5 as moderately resistant and 5-9 as susceptible.

Table 3.7 1- 9 point scale used for field screening groundnut genotypes for resistance to late and early leaf spot diseases (Subrahmanyam *et al*. 1982).

Disease score	Description	Disease severity (%)
1	No disease	0
2	Lesions present largely on lower leaves; no defoliation	1-5
3	Lesions present largely on lower leaves, very few on middle leaves; defoliation of some leaflets evident on lower leaves	6-10
4	Lesions on lower and middle leaves but severe on lower leaves; defoliation of some leaflets evident on lower leaves	11-20
5	Lesions present on all lower and middle leaves; over 50% defoliation of lower leaves	21-30
6	Severe lesions on lower and middle leaves; lesions present but less severe on top leaves; extensive defoliation of lower leaves; defoliation of some leaflet evident on middle leaves	31-40
7	Lesions on all leaves but less severe on top leaves; defoliation of all lower and some middle leaves	41-60
8	Defoliation of all lower and middle leaves; severe lesions on top leaves; some defoliation of top leaves evident	61-80
9	Almost all leaves defoliated, leaving bare stems, some leaflets may remain, but show severe leaf spots.	81-100

Table 3.8 1- 9 point scale used for field screening groundnut genotypes for resistance to rust diseases (Subrahmanyam *et al*. 1995).

Rust score	Description	Disease severity (%)
1	No disease	0
2	Pustules sparsely distributed, largely on lower leaves	1-5
3	Many pustules on lower leaves; necrosis evident; very few pustules on middle leaves	6-10
4	Numerous pustules on lower and middle leaves; severe necrosis on lower leaves	11-20
5	Severe necrosis of lower and middle leaves; pustules may be present on top leaves, but less severe	21-30
6	Extensive damage to lower leaves; middle leaves necrotic, with dense distribution of pustules; pustules on top leaves	31-40
7	Severe damage to lower and middle leaves; pustules densely distributed on top leaves	41-60
8	100% damage to lower and middle leaves; pustules on top leaves, which are severely necrotic	61-80
9	Almost all leaves withered; bare stems seen	81-100

3.7.4 screening for pest

The 367-groundnut germplasm were also screened for the *Spodoptera litura* leaf damage during *kharif* season, 2001 (Preliminary screening). The screening was carried out under the natural epipytotic condition. The visual score as described by Ranga Rao and Wightman (1997) were followed (Table 3.9) (Plate- 11).

Table 3.9 0 to 9 Scale for visual scoring of *Spodoptera litura* (F).

Pest score	Percentage damage
0	No damage
1	1- 10
2	10-20
3	20-30
4	30-40
5	40-50
6	50-60
7	60-70
8	70-80
9	80 and above

3.7.5. Confirmative screening

To confirm the resistance in groundnut germplasm which were found resistant in the preliminary screening, a confirmative screening was done for two consecutive years (*kharif* season 2002 and 2003). The sowing of all the 75 groundnut germplasm which showed resistance during preliminary screening during *kharif* 2001 were done in *kharif* 2002 and 2003, in three replications. The sowing was done in a row of 4-meter length, with a row-to row spacing of 75 cm and a plant-to-plant spacing of 10 cm. The susceptible check, GG 2 was sown between every two rows. Recommended agronomic practices were followed except for the spay of fungicides and insecticides. The spray of disease inoculum was done after 15 days of sowing. The screening was done as per the method of Subrahmanyam *et al*., 1995. The yield per plant was also recorded with diseases and pest assessment.

3.8. *Anatomical basis of resistance to ELS, LLS, rust and Spodoptera litura (F.)*

Nine anatomical characteristics were recorded in the seventy-five groundnut germplasm which were found as resistant to either ELS, LLS, rust or the *Spodoptera* or combination of the three diseases and *Spodoptera* during preliminary screening. All the leaf anatomical characters were recorded on the 3rd leaf from the apex on the main stem of 110 days old plants. The middle region of the lamina of a leaflet (leaving about one cm, from the base and from apex) was fixed in FAA (methanol:glacial acitic acid: and formaldehyde) in a ratio of 9:05:05 solution diluted to 70 per cent with water prior to use. Paraffin embedding method as described by Johansen (1940) was used to obtain permanent serial section with help of a hand rotary microtome at 10-µ thickness. The sections were subjected to safranine/ fast green double staining. Representative samples were examined under microscope and the observations were recorded with the help of a ocular micrometer.

3.9. *Biochemical characterization of resistant and susceptible germplasm accessions*

The germplasm accessions which exhibited resistance (1 to 3 disease score) and susceptibility to either of the three diseases or their combination and *Spodoptera* during the preliminary screening were selected for biochemical characterization.

The leaf samples were collected from fully opened fresh young leaves (third from apical node) and old leaves (fifth from the lower most node) were collected from five plants at random at 60 days after sowing.

3.9.1. Leaf extraction

2.5 g of leaf tissue was taken in about 20 ml of boiling alcohol, and allowed for extraction under reflux for one hour. Then the supernatant was transferred through a whatman filter paper no.1 to a 50 ml volumetric flask. Again the extraction of residue was done with 80% alcohol on reflux for one hour. The extract was transferred into the same volumetric flask through whatman filter paper no.1. The volume was made up to 50 ml with 80% alcohol and store separately. This leaf extract was used to estimate the different biochemical parameters.

3.9.2. Estimation

Among 75 resistant germplasm accessions identified during preliminary screening, the total and *Ortho*-dihydroxy phenols were estimated by adopting the methods of Maliek and Singh (1980) and Michael *et al.* (1978) respectively. Total sugars (Hegde and Hofreiter, 1962) and reducing sugars (Millar, 1972) were also estimated. Free amino acids were estimated following the method of Moore and Stein (1948) while epicuticular wax content was estimated adopting the method of Ebercon *et al.* (1977).

3.10. Screening against aflatoxin contamination

The seeds of 75 groundnut germplasm, found as resistant against the three diseases and *Spodoptera* in preliminary screening were also screened against *Aspergillus flavus* infection, colonization and aflatoxin production to check whether they are also resistant to *A.flavus* colonization and aflatoxin content.

Sound, healthy and mature kernels (100 g) of each germplasm was surface sterilized with 0.1% aqueous solution of mercuric chloride for 1 min. and immediately washed thoroughly with sterile distilled water for three times. The seeds of each germplasm were then re-hydrated in sterile distilled water for 20 min. Later, water was decanted and seeds were aseptically placed in sterilized petriplates. The kernels were uniformly inoculated with the spore suspension of *A.flavus* ($4x10^6$ spores ml^{-1}) @ 1ml per 10 g kernels. Ten seeds were placed aseptically in each sterile petriplates (9 cm diameter). The seeds were rolled gently around the plates to spread the inoculums evenly over their surface. The spore suspension was prepared from 7 days old culture of toxigenic strain of *A. flavus* in sterile distilled water and after calibrating the spore load with haemocytometer. Inoculated seeds were arranged at equidistance in each petriplate followed by incubation at room temperature (30-34°C and 25-28°C of maximum and minimum temperature respectively and 85 to 95% relative humidity). After 8 days of incubation, observations were recorded on per cent seed infection and per cent seed colonization (Morgan *et al*., 1986).

The germplasm with <15 per cent seed colonization with sparse growth and sporulation were regarded as resistant; 16-30 per cent seed colonization and moderate growth and sporulation were regarded as moderately resistant, 31-50 per cent seed colonization and moderate to dense growth were regarded as susceptible and >50 per cent seed colonization with dense growth were regarded as highly susceptible. Then aflatoxin content of the infected kernels was measured by Indirect ELISA procedure (Fan and Chu, 1984; Morgan *et al*., 1986).

3.10.1. Enzyme-linked immunosorbent assay (ELISA)

For estimation of aflatoxins, indirect ELISA method was used.

3.10.2. Indirect competitive ELISA

3.10.2.1. Materials employed

(a) **ELISA-plates**: The Nunc-Maxisorp ELISA plates were used. The ELISA plates contained 96 wells (8 rows of 12 wells).

(b) **Micropipettes**: The micropipettes in the range of 0.1-10 µl, 10-100 µl and 100-1000 µl were used.

(c) **Repeatable micropipette** (100 or 200 µl volume): To dispense desired volume of liquids repeatedly from a reservoir attached to a micropipette, the repeatable mocropepette was used.

(d) **Eppendorf tubes** (1 ml): It was used for making serial dilution of samples and also for aflatoxins standard preparation.

(e) **Vertex**: It was used for homogeneous mixture of test sample in PBS or in standard preparation of aflatoxins.

(d) **ELISA or microplate reader**: The automatic ELISA reader was used having several wave lengths and also print out facility of reading.

(g) **Blender**: The blender was used for homogeneous mixture of groundnut seeds.

Chemicals:

(a) Carbonate buffer (Coating buffer)

Na_2Co_3	:	1.59 g
$NaHCo_3$	:	2.93 g
Distilled water	:	1.0 l

pH of buffer should be 9.6

(b) Phosphate buffer (PBS)

Na_2HPO_4	:	2.38 g
KH_2PO_4	:	0.4 g
KCl	:	0.4 g
NaCl	:	16.0 g
Distilled water	:	2.0 l

(c) Phosphate-buffered saline with Tween (PBS-Tween)

PBS	:	1 l
Tween 20	:	0.5ml

(d) Albumin bovine serum (BSA) 0.2%:

200 mg BSA was dissolved in 100 ml PBS- Tween

(e) P-nitrophenyl phosphate (PNPP):

5 mg PNPP (tablet form) was used as substrate and stored at -20°C.

(f) 10% Dithanolamine buffer:

Dithanolamine buffer was diluted 10 times in phosphate buffer.

(g) Antiserum:

Commercially available (SIGMA) polyclonal antiserum was used.

3.10.2.2. Preparation of groundnut seed extracts

First, the seeds were powdered using a blender. Then the powder was triturated in 70% methanol containing 0.5% KCI (proportion used was 100 ml for 20 g seed) in a blender, until the seed powder was thoroughly mixed. The extract was transferred to a conical flask and shook for 30 min at 300 rpm. The extract was filtered through Whatman No 41 filter paper and diluted 1: 10 in PBS (1 ml extract and 9 ml of PBS). For reducing error, it was again diluted to 10 folds (1: 100) in PBS. Thus, the healthy seed extract was prepared.

3.10.2.3. Procedure

In the case of indirect competitive ELISA, AFB I-BSA was adsorbed to the plate surface. Competition was between enzyme-labelled or unlabelled antibody with the toxin present in the sample or in the standard.

- AFBI-BSA conjugate was prepared in carbonate coating buffer at 1 : g/ml (100 ng/ml) was prepared and dispensed with 150 µl of the diluted toxin -

BSA to each well of ELISA plate. The plate was incubated in a refrigerator overnight or at 37°C for at least 1 h (Normally 3 h).

- The plate was washed three times with PES-Tween, allowing 3 min for each wash.
- 150 µl of 0.2% BSA prepared in PES was added to each well of ELISA plates and incubated for 1 h at 37°C.
- The plates were washed three times with PES-Tween, allowing 3 min for each wash.
- In parallel, aflatoxin B1 standards were prepared as shown in Table 3.10.
- Suitable dilution of antiserum in PBS-Tween was prepared containing 0.2% BSA and incubated for 45 min at 37 °C.
- 50 µl of antiserum was added to each of the dilution of aflatoxin standards (100 µl) and groundnut seed extract (100 µl) collected in eppendorf tubes intended for the analysis. The eppendorf tubes were incubated at room temperature for 30 min to 1 h to facilitate reaction between the toxins present in the sample with antibody.
- The reaction mixtures were added to microtitre ELISA plates prepared above and incubated at 37 °C for 2h.
- The plate was washed in three changes of PBS-Tween allowing 3 min for each wash.

Table 3.10 Aflatoxin standards used in ELISA

Standard	Stand. Conc	Healthy Extrac 10^{-1}	Serial dilution	Total volume	Polyclonal Antibody
S1	80 ng/ml	992:1 +	8 µl Alf.Std. (@ 10 µg/ml)	1000 µl	200 µl
S2	60 ng/ml	100 +	300 µl S_1	400 µl	200 µl
S3	40 ng/ml	300 +	300 µl S_1	600 µl	150 µl
S4	20 ng/ml	300 +	300 µl S_3	600 µl	150 µl
S5	10 ng/ml	300 +	300 µl S_4	600 µl	150 µl
S6	5 ng/ml	300 +	300 µl S_5	600 µl	150 µl
S7	2 ng/ml	450 +	300 µl S_6	750 µl	225 µl
S8	1 ng/ml	300 +	300 µl S_7	600 µl	150 µl
S9	0.5 ng/ml	300 +	300 µl S_8	600 µl	150 µl
S10	0.2 ng/ml	450 +	300 µl S_9	750 µl	225 µl
S11	0.1 ng/ml	300 +	300 µl S_{10}	600 µl	300 µl

- Dilution of 1:1000 goat anti-rabbit IgG labeled with alkaline phospate, in PBS- Tween 0.2% BSA were prepared and added 150 µl to each well and incubated for 2 h at 37 ^oC.
- The plate was washed with three changes of PBS-Tween, allowed three min for each wash.
- 150 µl substrate was added (P-nitrophenyl phosphate @ 0.5 mg/ml prepared in 10% dithanolamine buffer, pH 9.8) to each well of plate and incubated for 2 h at room temperature (depending on the development of yellow colour)
- Absorbance at 405 nm was measured with a ELISA reader.
- Curve was prepared with the values obtained for aflatoxin B_1 standard. Taking concentration on X axis and optical density on Y axis, and with following equation aflatoxin content was calculated.

$$\text{AFB}_1\ (\mu g/Kg) = \frac{A \times D \times E}{G} \quad \text{or} \quad \frac{A \times E}{C \times G}$$

Where,

A = AFB_1 concentration in diluted concentrated sample extract
D = Times dilution with buffer
C = Times concentration after clean up
E = Extraction solvent volume used (ml)
G = Sample weight (g)

3.11. Statistical analysis

Statistical analysis was done using the software package MSTAT-C, Systat 10 and MS excel 2000.

Chapter 4 Experimental Results

The results of various experiments carried out during the course of study during 2001 to 2004 are provided below separately.

4.1. Soil physico-chemical properties

Analysis of physico-chemical properties of the soil at experimental site indicated that the clay content was high (69.8%) followed by sand (21.8%) and silt (14.8%). The water holding capacity of the soil was around 8.0%. The pH of the soil was in the alkaline range (7.89) and the electrical conductivity was 0.40 m mho/cm. The cation exchange capacity of the soil was low (5.88 meq/100 g) whereas the total nitrogen, exchangeable potassium and exchangeable sodium were adequate. The exchangeable calcium and magnesium contents were slightly high (Table 4.1).

Table 4.1 Soil physico chemical properties

Parameters	Results	Remarks
Sand	21.6%	-
Silt	14.8%	-
Clay	69.8%	-
Water holding capacity	8.0%	-
pH	7.89	Alkaline
EC	0.40 m mho/cm	-
Cation Exchange Capacity	5.88 meq/100g	Low
Total Nitrogen	137.22 ppm	Adequate
Exchangeable K	0.273 me/100g	Adequate
Exchangeable Na	1.040 me/100g	Adequate
Exchangeable Ca	2.355 me/100g	Slightly high
Exchangeable Mg	1.126 me/100g	Slightly high

4.2. Morphological characterization

The 367 groundnut germplasm accessions acquired from the ICRISAT under the repatriation programme were evaluated and characterized for 19 qualitative and 26 quantitative characters using standard Descriptors for Groundnut (IBPGRI/ICRISAT, 1990). The passport data of the 367 groundnut germplasm accessions which contain the information of their identity (both ICRISAT and NRCG's) along with the country of origin and habit group are provided in the Annexure I.

The two years pooled results on characterization of the 367 germplasm for their qualitative and quantitative traits are provided in Annexure II and the results are described below separately.

4.2.1. Morphological characterization for 19 qualitative traits

The 19 qualitative traits were evaluated using the standard descriptor. The habit group-wise descriptor state of the qualitative traits is presented in Table 4.2.

4.2.1.1. Growth habit

Among the germplasm studied, the growth habit was mostly (303) of decumbent type and the rest (64) were erect type.

Among the germplasm accessions which exhibited decumbent forms, decumbent-1 is completely absent in all the four botanical varieties, whereas few germplasm accessions exhibited documbent-2 form under HYB (5); HYR (19); VUL (2) and FST (18). Whereas decumbent-3 was the most predominant form among the 4 botanical varieties except for HYR which had very few (18 out of 259 germplasm) number of accessions with decumbent-3 growth form.

4.2.1.2. Branching pattern

Branching pattern was defined on the sequence of vegetative and reproductive nodes. Among the germplasm accessions studied, number of accessions with alternate branching pattern were 70, sequential with flowers on main stem were 173, irregular with flowers on main stem were 68 and irregular without flowers on main stem were 56. Normally, HYB and HYR have alternate and irregular without flower s main stem. While, VUL and FST have sequential or/and irregular flower on main stem.

4.2.1.3. Stem pigmentation

The pigmentation on the main stem was recorded as presence or absence of anthocyanin pigment. Number of accessions with pigmentation were 56 and without pigmentation were 311.

4.2.1.4. Stem surface

Stem surface ranged from glabrous to very hairy among the accessions studied. Number of accessions with glabrous stem surface was 7; 223 was sub-glabrous; 113 were moderately hairy; 20 were hairy and 4 were very hairy. Majority of accessions irrespective of habit had sub-glabrous hairyness.

4.2.1.5. Type of inflorescence

Type of inflorescence was characterized as simple and compound. Number of accessions with simple inflorescence were 122 while those with compound inflorescence were 245.

4.2.1.6. Standard petal colour

The petal colour ranged from yellow to garnet (deep orange with garnet marking on petals). The different petal colours observed among the material studied were yellow (1), orange (339), dark orange (15) and garnet (12). Presence of garnet colour in most in Valencia habit group.

Table 4.2 Habit group wise descriptor state of 19 Qualitative traits

NO	Descriptors	Descriptors state	Habit type				
			HYB	HYR	VUL	FST	Total
1	Growth habit	Decumbent-1	0	0	0	0	0
		Decumbent –2	5	19	2	18	44
		Decumbent –3	76	18	96	69	259
		Erect	11	0	5	4	64
2	Branching pattern	Alternate	48	22	0	0	70
		Sequential with flowers on main stem	1	1	68	103	173
		Irregular with flowers on main stem	2	2	32	32	68
		Irregular without flowers on main stem	41	12	3	0	56
3	Stem pigmentation	Absent	18	5	10	23	56
		Present	74	32	93	112	311
4	Stem surface	Glabrous	2	5	0	0	7
		Sub-glabrous hairs in one or two rows along the main stem	76	23	51	73	223
		Moderately hairy	14	6	49	44	113
		Hairy	0	0	3	17	20
		Very hairy	0	3	0	1	4
5	Type of inflorescence	Simple	44	13	24	41	122
		Compound (more than one peg/node)	48	24	79	94	245
6	Standard petal colour	Yellow	0	0	0	1	1
		Orange (5 A 7)	92	35	101	111	339
		Dark orange (5 A 8)	0	0	0	15	15
		Garnet,	0	2	2	8	12
7	Peg pigmentation	Absent	2	3	99	23	127
		Present	90	34	4	112	240
8	Leaflet colour	Yellowish green	0	0	0	0	0
		Light green (29 C 8)	25	16	74	78	193
		Green (28 D 8)	58	19	26	54	157
		Dark green (28 F 8)	9	2	3	3	17
9	Leaflet shape	Oblong	91	37	98	129	355
		Lanceolate	1	0	5	6	12
10	Leaflet surface	Almost glabrous	4	1	0	0	5
		Almost glabrous above, hairs below	68	27	27	24	146
		Almost glabrous above, hairs and bristles below	24	7	72	90	193
		Hairy	0	1	4	20	25
		Very hairy	0	1	0	1	2
11	Leaflet tip	Obtuse	91	37	99	129	356
		Acute	1	0	4	6	11

Table 4.2 Habit group wise descriptor state of 19 Qualitative traits cont…

NO	Descriptors	Descriptors state	Habit type				
			HYB	HYR	VUL	FST	Total
12	Pod beak	Absent	9	3	21	7	40
		Slight	35	14	52	67	168
		Moderate	44	17	28	52	141
		Prominent	4	3	2	5	14
		Very prominent	0	0	0	4	4
13	Pod constriction	None	5	2	4	1	12
		Slight	24	13	31	10	78
		Moderate	58	21	59	122	260
		Deep	5	1	8	2	16
		Very deep	0	0	1	0	1
14	Pod reticulation	None	0	0	0	0	0
		Slight	40	16	34	58	148
		Moderate	34	12	65	20	131
		Prominent	18	8	3	12	41
		Very prominent	0	1	1	45	47
15	Testa colour	White	0	0	1	0	1
		Off white (1 A 2)	4	1	1	1	7
		Rose, (8 B 3)	58	25	5	2	90
		Rose with white flecks	2	0	0	0	2
		Salmon (6 A 4)	17	6	85	28	136
		Salmon with dark purple flecks	0	0	0	9	9
		Red (10 B 7)	1	0	6	54	61
		Red with white flecks	3	0	0	1	4
		Dark red (11 C 8)	5	2	0	1	8
		Purple (14 F 4)	1	0	1	10	12
		Dark purple (14 F 7)	0	2	4	28	34
		Dark purple with salmon flecks	0	0	0	1	1
		White with light Red	1	0	0	0	1
		Rose with white flecks	0	1	0	0	1
16	Pod size	Small	1	0	3	0	4
		Medium	71	31	98	133	333
		Large	20	6	2	2	30
17	Shell thickness	Thin	9	3	41	2	55
		Moderate	41	26	47	11	125
		Thick	42	8	15	22	187
18	Seed shape	Round	12	6	35	10	63
		Fusiform	51	18	61	81	211
		Elongated	29	13	7	44	93
19	Seed size	Small	1	0	3		4
		Medium	69	32	98	134	333
		Large	22	5	2	1	30

4.2.1.7 Peg pigmentation

The peg pigmentation was recorded as present or absent of pigment on peg. Number of accessions with peg pigmentation were 240 and without pigmentation were 127. Peg pigmentation was absent in majority of VUL (99) types but present in all other habit types.

4.2.1.8. Leaflet colour

The leaflet colour ranged from light green to dark green. The number of accessions with light green leaflet were 193, green were 157 and dark green were 17. Light green colour was present in habit types, VUL and FST , where as HYB and HYR exhibited green to dark green leaf colour in all the habit types.

4.2.1.9. Leaflet shape

The leaflet shape was characterized as oblong and lanceolate. Number of accessions with oblong shape were 355 and lanceolate were 12.

4.2.1.10. Leaflet surface

Leaflet surface ranged from glabrous to very hairy. Number of accessions with glabrous leaflet surface were 5, almost glabrous were 146, almost glabrous above and hairs below, with 193, hairy were 25 and very hairy were 2.

4.2.1.11. Leaflet tip

Leaflet tip was characterized as obtuse and acute. Number of accessions with obtuse leaflet tip were 356 and acute were 11.

4.2.1.12. Pod beak

The pod beak ranged from absent to very prominent. Number of accessions without pod beak were 40, with slight beak were 168, with moderate beak were 141, with prominent beak were 14 and with very prominent beak were 4. Among the Valencia habit types maximum number of prominent habit pod beak was found.

4.2.1.13. Pod constriction

Pod constriction was characterized as no constriction to very deep constriction. Number of accessions with no constriction were 12; slight constriction were 78; moderate constriction were 260; deep constriction were 16 and very deep constriction was 1.

4.2.1.14. Pod reticulation

Reticulation on the pod was characterized as none to very prominent type. Number of accessions with slight reticulation were 148, moderate 131, prominent 41 and very prominent were 47.

4.2.1.15. Testa colour

Testa colour was characterized after one month of harvest. It ranged from white to dark purple in colour. The number of accessions with white testa colour was 1; off white 7; rose 90; rose with white flakes 2; salmon 136; salmon with dark purple flacks 9; red 61; red with white flacks 4; dark red 8; purple 12; dark purple 34; dark purple with salmon flack 1; white with light red 1 and rose with white flacks were 1.

4.2.1.16. Pod size

Pod size was characterized as small, medium and large. The number of accessions having the small size pods were 4, medium size were 333 and large size were 30.

4.2.1.17. Shell thickness

The thickness of shell was characterized as thin, moderate and thick. The number of accessions with thin, moderate and thick shells were 55,125 and 187 respectively.

4.2.1.18. Seed shape

The seed shape was characterized as round, fusiform and elongated. The number of accessions with round shape were 63, fusiform were 211 and elongated shape were 93.

4.2.1.19. Seed size

The seed size was characterized as small, medium and large. The number of accessions with small seed size were 4, medium seed size were 333 and accessions with large seed size were 30.

4.2.2. Morphological characterization for 26 quantitative traits

The quantitative traits were recorded to evaluate the genetic potential of the accessions for various yield related traits which are useful to the groundnut breeders in identification of promising accessions for further utilization. The results of two year pooled data (mean data) of the 26 quantitative traits observed are presented below. The data is presented in Annexure III.

4.2.2.1 Days to germination

Days to germination were recorded in days from date of sowing to germination of seed in field condition. Days to germination ranged from 7 to 9 days. Among the materials studied, 81 genotypes germinated within 7 days while 72 genotypes germinated in 9 days. The mean days to germination was 8 days among the material studied. The co-efficient of variation for this trait was 8.1%.

4.2.2.2. Days to initial flowering

Days to first flowering were recorded in days from date of germination to first flower appearance in selected plants in a row. The days to initial flowering ranged from 14 to 32 days. The genotype, NCAc 266 was early (14 days) while the genotype, NCAc 218 was late (32 days) in flowering. The mean days to initial flowering was 20. The co-efficient of variation was 10.8% for days to initial fowering.

4.2.2.3. Days to 50 per cent flowering

Days to 50% flowering was recorded in days from date of germination to 50% flowering. Days to 50 % flowering ranged from 16 to 33 days. Among the 367 germplasm studied, only five accessions took 16 days to 50 % flowering while one accession (NCAc 218) took 33 days for 50 % flowering. The mean days to 50 per cent flowering was 20. The co-efficient of variation for days to 50% flowering was 10.9%.

4.2.2.4. Days to maturity

Number of days to maturity were counted from the date of sowing to date of harvest of plants. It ranged from 86 to 126 days. Among the germplasm studied, one accession (Chico) matured early (86 days) while two accessions (NCAc 2214, NCAc 2240) matured late (126 days). The mean days to maturity were 97 days. The co-efficient of variation for days to maturity was 11.17%.

4.2.2.5. Height of main axis

Height of all the braches was recorded on five plants at averaged.

Mean height of the main axis was ranged from 25.0 to 76.5 cm. The height of the main axis was the shortest (25.0 cm) in M 1069-7K, while the it was the longest (76 cm) in NCAc 2308. The mean height of main axis was 47 cm among the material studied. The co-efficient of variation for height of main axis was 15.6%.

4.2.2.6. Length of n+1 branch

Mean length of primary branches from main axis to the tip of n+1 branch ranged from 32.0 to 81.8 cm. The mean length of n+1 branches was 57 cm. Two accessions showed the minimum length (32.0 cm) of n+1 branches while one accession (2293) showed the maximum length (81.8 cm) of n+1 branches. The co-efficient of variation for length of n+1 branches was 14.4%.

4.2.2.7. Number of n+1 branches

The total number of n+1 branches ranged from 2 to 5.8. Number of n+1 branches were minimum (2) in SPZ 476 DARK PU, while it was maximum (5.8) in M 6-76 M. The mean number of n+1 braches was 4 and the co-efficient of variation of n+1 branches was 11.9%.

4.2.2.8. Number of n+2 branches

The total number of n+2 branches ranged from 0 to 44.5. The mean number of n+2 branches was 7 and the co-efficient of variation was 141.7%.

4.2.2.9. Leaflet length

Mean length of 10 leaflets from different plants of third leaflet on main axis ranged from 33.7 to 76.0 mm. The leaflet length was the shortest (33.7 mm) in CUP 8, while the accession WCG 170 had maximum (76.0 mm) leaflet length. The mean leaflet length was 56 mm and co-efficient of variation for this trait was 13.5%.

4.2.2.10. Leaflet width

Mean width of 10 leaflets from different plants of third leaflet on main axis, ranged from 16 to 36 mm. The minimum leaflet width (16.3 mm) was observed in CUP 8; while the maximum (36.2 mm) leaflet width was observed in PERU NO.2. The mean leaflet width was 25 mm and the co-efficient of variation for leaflet width was 12.8%.

4.2.2.11. leaflet length/width

The ratio of length/width ranged from 1.6 to 2.9. The mean leaflet length/width ratio was 2, and co-efficient of variation was 8.4%.

4.2.2.12. Immature pods/plant

Mean number of immature pods present at the time of harvest in five random plants were counted, which ranged from 0 to 9. Twenty nine accessions were found without any immature pods, while two accessions had maximum (9) number of immature pods. The mean number of immature pods was 2 and the co-efficient of variation for immature pods was 96.7%.

4.2.2.13. Pod mass (g/Plant)

Weight of dry and mature pods was measured in gram, which raged from 3.9 (CUP 8) to 45.2 g (White's Runner). The mean pod mass was 20 g/plant, while the co-efficient of variation for pod mass was 31%.

4.2.2.14. Pod yield /m^2

Weight of mature dry pods was calculated per square meter. It ranged from 51.6 (SPZ 473 GASP) to 250.1 g (PORTO ALEGRE). The mean pod yield/m^2 was 131. 0 g and the co-efficient of variation for pod yield was 29.1%.

4.2.2.15. 100 pod mass (g)

Weigh t of 100 pods selected at random, ranged from 49.8 (Chico) to 274.5 g (PI 393527 B). The mean value of 100 pod mass was 117.0 g, while the co-efficient of variation for 100 pod mass was 27.1%.

4.2.2.16. One seeded pods (%)

The percentage of one-seeded pods from a random sample of 100 pods was counted which ranged from 0 to 79.4. The one seeded pod was absent in 30 genotypes, while the genotype GA 270-8 exhibited maximum (79.4%) number of one seeded pods. The mean number of one seeded pods was 12% while co-efficient of variation for one seeded pod was 81.9%.

4.2.2.17. Two seeded pods (%)

The percentage of two-seeded pods from a random sample of 100 pods was counted which ranged from 0 to 100. The two seeded pods were absent in 4 genotypes while RCM 596-1 exhibited maximum number (100%) of two seeded pod. The mean number of two seeded pods was 64 and the co-efficient of variation for two seeded pods was 45.2%.

4.2.2.18. Three seeded pods (%)

The percentage of three-seeded pods from a random sample of 100 pods was counted which ranged from 0 to 89.5. The three-seeded pod was absent in 195 genotypes while PI 393531 exhibited maximum (89.5%) number of three-seeded pod. The mean number of three seeded pods was 22 and the co-efficient of variation for three seeded pod was 132.1%. Three seeded pods were found maximum in Spanish habit group.

4.2.2.19. Four seeded pods (%)

The percentage of four-seeded pods from a random sample of 100 pods was counted which ranged from 0 to 54.5. The four-seeded pod was absent in 280 genotypes while SPZ 486 LIGHT P exhibited maximum (54.5%) number of four-seeded pod. The mean number of four seeded pods was 3% and the co-efficient of variation for four seeded pod was 247%.

4.2.2.20. Pod length

Mean length of 10 mature pods was measured and it ranged from 19.3 to 58.0 mm. The minimum pod length (19.3 mm) was observed in NCAc 17672, while maximum pod length (58.0 mm) was observed in NCAc 17132. The mean pod length was 31 mm. The co-efficient of variation for pod length was 19%.

4.2.2.21. Pod width

Mean width of 10 mature pod was measured and it ranged from 9.5 to 20.0 mm. The minimum (9.5 mm) pod width was observed in T-900, while maximum (20.0 mm) pod width was observed in NCAc 2172. The mean pod width was 14 mm and the co-efficient of variation for pod width was 12.6%.

4.2.2.22. Seed length

Mean length of 10 mature seeds was measured and it ranged from 7.4 to 22.2 mm. The minimum (7.4 mm) seed length was observed in the genotype, 1357-10, while maximum (22.2 mm) seed length was observed in NCAc 2763. The mean seed length was 14 mm and the co-efficient of variation for seed length was 15%.

4.2.2.23. Seed width

Mean width of 10 mature seeds was measured and it ranged from 6.5 to 12.9 mm. The minimum (6.5 mm) seed width was observed in germplasm 88/23/7, while maximum (12.9 mm) seed width was observed in NCAc 17751. The mean seed width was 8 mm and the co-efficient of variation was 18%.

4.2.2.24. Shelling outturn (%)

Shelling outturn ranged from 31.8 to 87.6%. The minimum (31.8%) shelling was found in VIRGINIA RED, while maximum (87.6%) shelling was observed in NCAc 751. The mean shelling outturn was 67%. The co-efficient of variation for shelling was 10.8%.

4.2.2.25. Sound mature seed (%)

Sound mature seeds raged from 65.3 to 98.9% among the accessions studied. The minimum (65.3%) SMK was found in NCAc 2172, while maximum (98.9%) SMK was observed in NCAc 2654. The mean sound mature seed was 93% and the co-efficient of variation for SMK was 4.6%.

4.2.2.26. Hundred seed mass (g)

Weight of 100 marketable seeds selected at random was recorded which ranged from 24.3 (Chico) to 72.0 g (KU NO.61). The mean 100 seed mass of all the germplasm was 42 g while the co-efficient of variation for this trait was 20.2%.

4.3. Screening of the germplasm accessions against diseases and pest

The 367 groundnut germplasm received from the ICRISAT, Patancheru, Andhra Pradesh were screened against three major foliar fungal diseases namely early leaf spot, late leaf spot, rust and a major pest namely *Spodoptera litura* (F.) by adopting the methods of Subrahmanyam *et al.* (1985) for early and late leaf spots and Subrahmanyam *et al.* (1980) for rust under the natural condition. While for *Spdoptera,* the method suggested by Ranga Rao and Wightman (1997) was followed. The disease score obtained for ELS, LLS and rust (on a 1-9 scale) and the damage score (on a 0-9 scale) of *Spodoptera* recorded by all the germplasm studied during preliminary and confirmative screening are presented in Table 4.3 and Table 4.4 .

Table 4.3 Diseases and *Spodoptera* damage score recorded by different germplasm

SNO	ICG	HBT	NRCG	VAR	ELS	LLS	Rust	*Spodoptera Damage Score*
1	263	FST	13005	CPI 10507	5.8	6.9	4.3	4.1
2	265	FST	1070	NCAc 405	6.7	7.8	5.2	4.5
3	266	FST	1071	NCAc 406	5.6	6.7	4.1	4.8
4	274	FST	1073	NCAc 490	5.8	6.9	4.3	5.1
5	276	FST	1074	NCAc 503	6.0	7.1	4.5	3.9
6	279	VUL	4206	NCAc 515	6.7	7.8	5.2	3.5
7	283	FST	13009	NCAC 524	6.0	7.1	4.5	3.9
8	291	FST	13012	SENEGAL 1120	6.2	7.3	4.7	3.9
9	296	FST	13013	MTUTU-A	5.7	6.8	4.2	6.7
10	301	FST	782	NCAc 583	5.9	7.0	4.4	5.6
11	320	FST	13016	NCAC 706	6.0	7.1	4.5	5.8
12	322	FST	794	NCAC 710	5.7	6.8	4.2	6.0
13	325	FST	5571	PI 152129	6.6	7.7	5.1	6.7
14	326	FST	13018	NCAC 721	5.6	6.7	4.1	6.0
15	353	FST	13025	GA 177	5.8	6.9	4.3	6.2
16	354	FST	13026	V 54	5.3	6.4	3.8	5.7
17	355	FST	13027	WHITE	2.5	2.8	3.1	3.0
18	357	FST	13028	NCAC 881	6.0	4.3	6.9	5.2
19	358	FST	13029	NCAC 884	6.7	4.5	7.1	4.0
20	362	FST	13031	ZANDI	6.0	5.2	7.8	4.9
21	364	FST	13032	CORDOFAN	6.2	4.5	7.1	3.6
22	366	FST	13034	LE 29	5.7	4.7	7.3	3.6
23	367	FST	13035	MANI GUAYCURU 1	5.9	4.2	6.8	3.5
24	368	VUL	13036	MANI NEGRO	6.0	4.4	7.0	4.9
25	370	FST	13038	DETOST ADERO	5.7	4.5	7.1	4.2
26	379	FST	13042	NCAC 1001	5.8	6.2	6.8	5.6
27	380	FST	13043	NCAC 1002	5.7	6.8	4.2	5.8
28	385	FST	13046	CPI 10496	6.6	7.7	5.1	6.0
29	389	FST	4214	NCAc 1286	5.6	6.7	4.1	5.4
30	391	FST	13049	TORO	5.5	5.9	4.4	4.8
31	392	FST	4296	NCAC 1302	3.0	4.2	2.9	5.6
32	398	FST	13052	VALENCIA	3.9	4.8	2.7	4.0
33	403	FST	4299	NCAC 2653	6.0	5.2	7.8	5.8
34	404	FST	1108	NCAc 2654	6.2	4.5	7.1	5.6
35	405	FST	1109	NCAc 2663	5.7	4.7	7.3	5.9
36	411	FST	1113	NCAc 2700	5.9	4.2	6.8	5.2
37	427	FST	13055	44-183	5.9	7.0	6.4	4.1
38	447	FST	13059	2293	5.0	6.1	5.5	4.5
39	452	FST	13060	NCAC 2927	5.6	6.7	6.1	4.8
40	460	FST	13061	RCM 462	4.8	5.9	5.3	5.1

Table 4.3 Diseases and *Spodoptera* damage score recorded by different germplasm cont….

SNO	ICG	HBT	NRCG	VAR	ELS	LLS	Rust	*Spodoptera Damage Score*
41	462	FST	13062	RCM 467	4.4	5.5	4.9	3.9
42	463	FST	4220	NCAc 17089	5.6	6.7	6.1	3.5
43	469	FST	13063	WCG 131	5.9	7.0	6.4	3.9
44	470	FST	9110	WCG 169	4.7	5.8	5.2	3.9
45	1603	FST	9125	Krapovickas 4	4.8	5.9	5.3	5.7
46	1608	FST	13066	KINORALES	5.5	6.6	6.0	4.9
47	1613	FST	13068	SP 2B	5.3	6.4	5.8	5.0
48	1615	FST	1151	NCAC 414	5.1	6.2	5.6	4.5
49	1627	FST	4290	NCAC 568	5.2	6.3	5.7	4.5
50	1660	FST	1164	NCAC 2666	4.6	5.7	5.1	5.9
51	1664	FST	9130	NCAc 2679	4.2	4.5	3	1.2
52	1665	FST	9131	Gemana	4.8	5.9	5.3	3.6
53	1679	VUL	1172	NCAc 2838	4.4	5.5	4.9	3.8
54	1683	FST	13075	G 90 A	5.6	6.7	6.1	2.7
55	1696	FST	851	NCAc 16026	5.9	7.0	6.4	4.7
56	1697	FST	1177	NCAc 17090	2.5	3.0	3.2	2.0
57	1703	FST	6663	NCAc 17127	3.4	3.0	3.0	2.5
58	1704	FST	6664	NCAc 17129	3.0	2.8	2.5	3.0
59	1707	FST	5177	NCAc 17132	2.8	2.1	4.1	2.8
60	1709	FST	1179	NCAc 17134	2.5	3.0	4.0	2.6
61	1710	FST	5178	NCAc 17135	4.1	5.2	4.5	2.8
62	1712	VUL	13079	V 109	4.1	3.4	3.8	2.5
63	1713	FST	9135	Peru No. 3	5.9	4.2	6.8	5.2
64	2338	FST	13101	KRAPOVICKAS 5	5.9	7.0	6.4	4.1
65	4764	FST	13118	KU NO.220	5.0	6.1	5.5	4.5
66	4772	FST	13124	KU NO.8	5.6	6.7	6.1	4.8
67	4783	VUL	13128	KU NO.60	2.5	2.8	3.2	5.8
68	4788	FST	13130	KU NO.189	5.9	7.0	6.4	5.7
69	4790	FST	6682	Krap strain 16	3.0	3.2	4.2	5.3
70	4791	FST	9949	ICG 4791	3.0	2.8	4.1	5.5
71	5045	FST	714	NCAC 2243	6.7	7.8	5.2	3.4
72	6090	FST	13136	NCAC 664	5.6	6.7	4.1	5.0
73	6140	FST	13138	NCAC 2209	5.8	6.9	4.3	4.7
74	6201	FST	10774	BC 119	6.0	7.1	4.5	5.3
75	6271	FST	13141	WCG 149	6.7	7.8	5.2	5.4
76	6277	FST	13142	WCG 166B	6.0	7.1	4.5	5.1
77	6280	FST	6692	NCAc 17124	6.2	7.3	4.7	5.9
78	6355	FST	13143	RCM 533	5.7	6.8	4.2	5.0
79	6691	FST	13144	ROGUE DE PLODIV	5.9	7.0	4.4	5.6
80	6709	FST	13145	PERU NO.2	6.0	7.1	4.5	4.8

Table 4.3 Diseases and *Spodoptera* damage score recorded by different germplasm cont….

SNO	ICG	HBT	NRCG	VAR	ELS	LLS	Rust (*Puccinia arachidis* Speg.)	Spodoptera *Damage Score*
81	6726	FST	11247	WCG 135	5.7	6.8	4.2	4.4
82	6775	FST	4471	PI 262058	6.6	7.7	5.1	5.6
83	6960	FST	1527	PI 262007	5.6	6.7	4.1	4.2
84	7205	FST	13148	WCG 115	5.8	6.9	4.3	4.6
85	7296	FST	13149	203/66	5.3	6.4	3.8	4.9
86	7320	FST	13150	NCAC 17656	5.7	6.8	4.2	5.0
87	7340	FST	13151	WCG 182	5.9	7.0	4.4	4.5
88	7353	FST	13152	PERU NO.9	2.5	3.0	4.5	4.5
89	7404	FST	4603	V 20	4.1	4.5	2.8	3.4
90	7433	FST	4486	NCAc 17518	4.7	5.2	5.8	4.7
91	7620	FST	9747	ICG 7620	3.3	5.1	5.6	2.4
92	7628	FST	13156	WCG 170	6.0	7.1	4.5	3.1
93	7712	FST	13159	PERU NO.9	5.7	6.8	4.2	5.6
94	7777	FST	13160	SAM COL. 186	6.6	7.7	5.1	3.2
95	7881	FST	4849	PI 215696	5.2	4.8	5.6	2.7
96	7882	FST	4850	PI 314817	6.6	7.7	5.1	5.2
97	7885	FST	6700	PI 381622	5.6	6.7	4.1	4.9
98	7886	FST	6529	PI 390593	5.8	6.9	4.3	5.0
99	7889	FST	6703	PI 393517	3.0	2.5	2.1	4.2
100	7893	FST	4859	PI 393531	2.5	2.9	4.0	5.9
101	7896	FST	4861	PI 393646	3.0	3.2	3.0	3.6
102	7897	FST	6707	PI 405132	2.7	3.0	3.9	4.9
103	7924	FST	4873	PI 268491	3.9	4.2	4.9	2.9
104	7927	FST	13161	MUBENDI	6.0	5.2	7.8	3.7
105	8000	FST	4498	PI 268492	6.2	4.5	7.1	4.6
106	8003	FST	1587	Tesa bunch	5.7	4.7	7.3	4.2
107	8047	FST	4934	PI 268525	5.9	4.2	6.8	4.4
108	8105	FST	13162	RCM 449-3	5.9	7.0	6.4	4.8
109	8257	FST	6540	NCAc 17099	5.0	6.1	5.5	5.3
110	8599	FST	13166	TYPE NO.7	5.6	6.7	6.1	4.4
111	9185	FST	13168	75-16	4.8	5.9	5.3	4.8
112	10005	FST	10995	SP 425 FLESH	4.4	5.5	4.9	3.5
113	10039	FST	11589	SPZ 482 DARK PU	5.6	6.7	6.1	3.2
114	10048	FST	11007	SPZ 487 FLESH	5.9	7.0	6.4	4.4
115	10057	FST	11594	SPZ 492 PURPLE	4.7	5.8	5.2	3.8
116	10058	FST	11009	SPZ 493 FLESH	4.8	5.9	5.3	3.4
117	10059	FST	11595	SPZ 493 PURPLE	5.5	6.6	6.0	4.9
118	10063	FST	11598	SPZ 496 PURPLE	5.3	6.4	5.8	4.0
119	10067	FST	11600	SPZ 499 PURPLE	5.1	6.2	5.6	3.4
120	10070	FST	11012	SPZ 501 PURPLE	5.2	6.3	5.7	3.8

Table 4.3 Diseases and *Spodoptera* damage score recorded by different germplasm cont….

SNO	ICG	HBT	NRCG	VAR	ELS	LLS	Rust	*Spodoptera Damage Score*
121	10450	FST	11032	TINGO MARIA	4.6	5.7	5.1	3.8
122	10890	FST	11604	SPA 406 RED	5.6	6.7	6.1	4.6
123	10918	FST	11605	SPZ 459 FLESH	4.8	5.9	5.3	3.3
124	10935	FST	11611	SPZ 476 DARK PU	4.4	5.5	4.9	4.5
125	10949	FST	11918	SPZ 486 LIGHT P	5.6	6.7	6.1	3.4
126	10966	FST	11612	SPZ 496 FLESH	5.9	7.0	6.4	5.9
127	10974	FST	9740	ICG 10974	4.7	5.8	5.2	3.8
128	10975	FST	11581	SPZ 503 DARK PU	2.5	3.5	2.5	3.6
129	11073	FST	11614	SPZ 459 PURPLE	5.5	6.6	6.0	3.8
130	11075	FST	9746	ICG 11075	5.3	6.4	5.8	2.7
131	11108	FST	11615	SPZ 503 PURPLE	3.9	4.5	5.8	2.7
132	11182	FST	13170	SP 403 TAN	5.9	7.0	6.4	3.4
133	11186	FST	11582	SPZ 488 GASP	3.0	2.9	4.2	3.9
134	11282	FST	11622	SPA 411	6.0	5.2	7.8	3.4
135	11285	FST	13172	SPZ 473 GASP	6.2	4.5	7.1	4.2
136	11485	FST	13173	P 2435	5.7	4.7	7.3	3.4
137	12112	FST	13174	SPZ 485 LPL	5.9	4.2	6.8	4.2
138	268	VUL	13006	GA 167	5.9	7.0	6.4	4.1
139	275	VUL	13007	GA 181	5.0	6.1	5.5	5.8
140	282	VUL	13008	NCAC 520	5.6	6.7	6.1	6.7
141	286	VUL	1079	NCAC 529	4.8	5.9	5.3	5.6
142	289	VUL	13010	SPANISH 2B	4.4	5.5	4.9	5.8
143	290	VUL	13011	NCAC 542	4.8	5.9	5.3	6.0
144	294	VUL	9182	MPUTU-C	4.4	5.5	4.9	6.7
145	310	VUL	13014	GA 199	5.6	6.7	6.1	6.0
146	311	VUL	4236	NCAc 608	4.8	5.9	5.3	6.2
147	316	VUL	13015	GA 163	3.0	2.8	4.2	5.1
148	323	VUL	13017	BAKU FOIRE	4.8	5.9	5.3	5.9
149	327	VUL	13019	CATETO	3.0	2.9	2.5	4.2
150	329	VUL	4238	NCAc 726	4.5	4.2	5.8	2.8
151	333	VUL	4239	NCAc 746	4.2	5.2	5.9	6.6
152	334	VUL	9185	NCAc 751	3.0	2.5	4.1	4.1
153	341	VUL	13020	ACETEIRO CHICO	3.5	4.2	2.5	3.6
154	344	VUL	13021	LE 36	4.8	5.9	5.3	5.3
155	348	VUL	13022	NCAC 821	4.4	5.5	4.9	3.8
156	350	VUL	13023	NCAC 831	5.6	6.7	6.1	5.8
157	352	VUL	13024	NCAC 845	3.0	2.5	2.7	4.1
158	359	VUL	1107	NCAC 888	4.7	5.8	5.2	5.6

Table 4.3 Diseases and *Spodoptera* damage score recorded by different germplasm cont….

SNO	ICG	HBT	NRCG	VAR	ELS	LLS	Rust	*Spodoptera Damage Score*
159	360	VUL	13030	NCAC 892	6.7	7.8	5.2	5.7
160	365	VUL	13033	MANI BLANCA 61	5.6	6.7	4.1	6.1
161	369	VUL	13037	MANI BLANCO 26A	5.8	6.9	4.3	5.9
162	374	VUL	13039	NCAC 967	6.0	7.1	4.5	5.8
163	377	VUL	13040	NCAC 990	6.7	7.8	5.2	6.5
164	378	VUL	13041	SH 130	6.0	7.1	4.5	5.6
165	381	VUL	13044	A 30	6.2	7.3	4.7	5.8
166	382	VUL	13045	A 18	5.7	6.8	4.2	4.6
167	386	VUL	13047	CPI 11996	5.9	7.0	4.4	5.0
168	388	VUL	13048	CPI 12154	6.0	7.1	4.5	4.8
169	394	VUL	13050	RED SPANISH	5.7	6.8	4.2	4.7
170	396	VUL	13051	NCAC 1333	6.6	7.7	5.1	5.1
171	400	VUL	819	NCAC 2600	6.7	7.8	5.2	6.1
172	402	VUL	13053	SP 2B	6.0	7.1	4.5	4.7
173	410	VUL	13054	NCAC 2698	6.2	7.3	4.7	4.9
174	426	VUL	9187	Mfoka-A	5.7	6.8	4.2	5.0
175	428	VUL	5573	NCAc 2816	6.0	7.1	4.5	5.2
176	431	VUL	5574	PI 152108	5.7	6.8	4.2	5.1
177	432	VUL	13056	GA 270-8	2.5	3.0	4.5	3.3
178	436	HYB	9189	4133	3.8	7.0	4.4	5.1
179	438	VUL	13057	PORTO ALEGRE	5.3	7.1	4.5	3.2
180	444	VUL	13058	MTUTU-B	5.7	6.8	4.2	4.7
181	456	VUL	9190	NCAc 2953	6.1	7.7	5.1	4.2
182	473	VUL	13064	V 26	4.5	7.8	5.2	4.6
183	476	VUL	5007	Chico	5.6	7.1	4.5	4.8
184	1605	VUL	9225	Pei-Kang-Pe-You-Don	5.2	7.3	4.7	4.1
185	1606	VUL	13065	LUNG TAN YOU DO	3.5	3.9	2.9	4.1
186	1609	VUL	13067	SCHWARZ 21	5.0	5.9	4.1	4.5
187	1612	VUL	1680	NCAC 399	4.6	5.0	4.3	4.3
188	1616	VUL	13069	GA 159	4.9	5.2	4.5	4.0
189	1617	VUL	9228	NCAc 429	4.7	4.5	5.2	4.7
190	1623	VUL	13070	DOI	4.4	4.7	4.5	4.0
191	1628	VUL	13071	BILB	4.9	4.2	4.7	4.1
192	1636	VUL	1158	NCAC 889	4.3	7.0	4.2	4.5
193	1644	VUL	9235	Maseni	4.7	6.2	4.4	4.8
194	1647	HYB	840	NCAC 2188	4.9	5.9	4.5	5.1
195	1662	VUL	9236	NCAc 2673	3.0	2.7	3.0	3.9
196	1669	VUL	9237	NCAc 2737	2.5	2.9	3.0	3.6
197	1674	VUL	1169	NCAC 2753	4.7	5.8	5.2	3.9

Table 4.3 Diseases and *Spodoptera* damage score recorded by different germplasm cont….

SNO	ICG	HBT	NRCG	VAR	ELS	LLS	Rust	*Spodoptera Damage Score*
198	1677	VUL	1688	NCAC 2820	6.7	7.8	5.2	6.2
199	1681	VUL	13074	GA 195	5.6	6.7	4.1	5.9
200	1685	VUL	13076	MTUTU-C	5.8	6.9	4.3	4.9
201	1699	VUL	13078	WCG 156	6.0	7.1	4.5	4.0
202	1705	FST	5176	NCAc 17130	6.7	7.8	5.2	4.6
203	1711	VUL	9238	DHT 191	6.0	7.1	4.5	4.8
204	2272	VUL	9344	GA 165	6.2	7.3	4.7	4.8
205	2310	VUL	13093	NCAC 2158	5.7	6.8	4.2	4.4
206	2359	VUL	9347	Clark 8	5.9	7.0	4.4	3.8
207	2364	VUL	13106	GA 198	6.0	7.1	4.5	5.1
208	2378	VUL	13111	RCM 439	5.7	6.8	4.2	5.3
209	3516	VUL	9444	US 16-B	6.6	7.7	5.1	5.1
210	4743	VUL	6677	88/23/7	6.7	7.8	5.2	4.1
211	4749	VUL	6536	PI 337394F	5.2	5.4	4.9	2.9
212	4751	VUL	7320	T-900 (krinkle leaf mut	5.0	5.9	4.1	6.1
213	4756	VUL	6681	Ku# 191	4.6	5.0	4.3	6.7
214	4758	VUL	9946	ICG 4758	4.9	5.2	4.5	5.0
215	4759	VUL	13117	KU NO.159	4.7	4.5	5.2	6.0
216	4766	VUL	13120	KU NO.235	4.4	4.7	4.5	5.1
217	4767	VUL	13121	KU NO.236	4.9	4.2	4.7	4.3
218	4768	VUL	13122	KU NO.237	4.3	7.0	4.2	4.8
219	4770	VUL	13123	KU NO.203	4.7	6.2	4.4	4.8
220	4785	VUL	13129	KU NO.134	4.9	5.9	4.5	4.9
221	4787	VUL	9540	KU No. 144	6.0	7.1	4.5	3.9
222	5100	VUL	1200	NCAc 16820	6.2	7.3	4.7	4.5
223	5144	VUL	13131	NCAC 2308	5.7	6.8	4.2	4.3
224	5156	VUL	13132	F 1-79	2.4	2.0	3.0	4.5
225	6834	HYB	1613	PI 268899	6.0	5.2	7.8	4.7
226	6903	FST	1520	PI 268988	6.2	4.5	7.1	5.3
227	7633	VUL	6696	UF 71513	5.7	4.7	7.3	5.2
228	7895	VUL	6706	PI 393643	5.9	4.2	6.8	4.1
229	7906	VUL	1657	PI 268802	5.9	7.0	6.4	4.4
230	7930	VUL	4491	PI 268741	5.0	6.1	5.5	3.7
231	8230	VUL	13163	MANYEMA TANGANY	5.6	6.7	6.1	5.8
232	8450	VUL	13164	RG 23	4.8	5.9	5.3	6.0
233	8472	VUL	13165	RG 89	4.4	5.5	4.9	6.7
234	8662	VUL	9575	Acc # 727	5.6	6.7	6.1	5.5
235	8664	VUL	9577	Acc # 731	5.9	7.0	6.4	6.1
236	8977	VUL	6407	PI 268573	4.7	5.8	5.2	6.7

Table 4.3 Diseases and *Spodoptera* damage score recorded by different germplasm cont….

SNO	ICG	HBT	NRCG	VAR	ELS	LLS	Rust	*Spodoptera Damage Score*
237	2372	HYB	13108	1357-10	4.8	5.9	5.3	5.0
238	2438	HYR	13115	88/6/7	5.5	6.6	6.0	6.0
239	5048	VUL	11676	NCAC 2313	5.3	6.4	5.8	5.1
240	361	FST	4212	NCAc 963	5.1	6.2	5.6	4.3
241	1634	HYB	9036	NC Bunch	5.2	6.3	5.7	4.8
242	1641	HYB	9038	B 33	4.6	5.7	5.1	5.2
243	1646	HYB	9039	NCAc 2187	5.6	6.7	6.1	3.9
244	1648	HYB	9040	NCAc 2189	4.8	5.9	5.3	5.0
245	1653	HYB	9042	NCAc 2562	4.4	5.5	4.9	4.6
246	1654	HYB	841	NCAC 2563	2.5	3.0	4.0	3.9
247	1655	HYB	13072	NCAC 2564	5.3	6.4	5.8	4.7
248	1671	HYB	13073	D 32	5.1	6.2	5.6	4.4
249	1691	HYB	13077	GA 61-35	5.2	6.3	5.7	4.9
250	2248	HYB	4282	NCAc 12	3.0	2.9	4.9	4.3
251	2249	HYB	9044	NCAc 23	3.8	7.0	4.4	4.7
252	2251	HYB	13080	19-Aug	5.3	7.1	4.5	4.9
253	2255	HYB	13081	NCAC 63	5.7	6.8	4.2	5.1
254	2261	HYB	9045	45185	6.1	7.7	5.1	4.3
255	2267	HYB	9047	X 5 Sel.	4.5	7.8	5.2	4.8
256	2269	HYB	13082	X 11	5.6	7.1	4.5	4.8
257	2275	HYB	13083	G 340	5.2	7.3	4.7	4.9
258	2276	HYB	9048	GA 61-42	5.8	6.9	4.3	3.9
259	2277	HYB	13084	NC 1296	6.0	7.1	4.5	4.5
260	2282	HYB	13087	CASTLE CARY SEL	6.7	7.8	5.2	4.7
261	2286	HYB	13089	NCAC 819	6.0	7.1	4.5	5.2
262	2289	HYB	13090	SAMARU 38 SEL 4	6.2	7.3	4.7	4.9
263	2297	HYB	13092	C 39	5.7	6.8	4.2	5.0
264	2304	HYB	9052	NCAc 1826	5.9	7.0	4.4	6.2
265	2308	HYB	882	NCAC 2145	6.0	7.1	4.5	5.9
266	2312	HYB	885	NCAC 2172	5.7	6.8	4.2	4.9
267	2315	HYB	13094	NCAC 2277	6.6	7.7	5.1	4.0
268	2316	HYB	13095	NCAC 2279	6.2	7.3	4.7	4.6
269	2317	HYB	13096	NCAC 2316	5.7	6.8	4.2	4.8
270	2319	HYB	888	NCAC 2377	5.9	7.0	4.4	4.8
271	2320	HYB	889	NCAc 2462	4.5	7.8	5.2	4.4
272	2327	HYB	894	NCAC 2479	2.2	3.0	5.2	3.8
273	2328	HYB	13098	NCAC 2480	5.5	5.9	5.2	6.0
274	2331	HYB	13099	VIRGINIA RED	2.5	3.0	4.9	5.2
275	2333	HYB	897	NCAC 2556	5.0	5.9	4.1	5.5

Table 4.3 Diseases and *Spodoptera* damage score recorded by different germplasm cont….

SNO	ICG	HBT	NRCG	VAR	ELS	LLS	Rust	*Spodoptera Damage Score*
276	2335	HYB	13100	NCAC 2561	4.6	5.0	4.3	6.1
277	2337	HYB	9059	NCAc 2569	4.9	5.2	4.5	6.7
278	2339	HYB	900	NCAc 2690	4.7	4.5	5.2	5.0
279	2343	VUL	9062	FLA 76-10	4.4	4.7	4.5	6.0
280	2345	HYB	13102	V 45	4.9	4.2	4.7	5.1
281	2353	HYB	9065	White's Runner	4.3	7.0	4.2	4.3
282	2354	HYB	9066	Carolina bunch	4.7	6.2	4.4	4.8
283	2358	VUL	13103	NCAC 2836	4.9	5.9	4.5	5.2
284	2374	HYB	13109	GA 119072	5.0	5.9	4.1	3.8
285	2376	HYB	13110	3303	4.6	5.0	4.3	3.8
286	2380	HYB	9069	A. monticola	4.9	5.2	4.5	4.6
287	2383	HYB	9070	DHT 190	4.7	4.5	5.2	3.0
288	2385	HYB	13112	DHT 193	4.3	4.9	2.7	4.9
289	2404	HYB	13114	RCM 596-1	4.5	7.8	5.2	3.4
290	2741	HYB	6673	G.Narrow leaf	5.6	7.1	4.5	5.9
291	4746	HYB	6678	PI 298115	5.2	7.3	4.7	3.8
292	4753	HYB	13116	G 153	5.8	6.9	4.3	3.6
293	4757	HYB	9945	ICG 4757	6.0	7.1	4.5	3.8
294	4777	HYB	13126	KU NO.61	6.7	7.8	5.2	2.7
295	4778	HYB	9947	ICG 4778	6.0	7.1	4.5	2.7
296	4780	HYB	13127	KU NO.11	6.2	7.3	4.7	3.4
297	5013	HYB	927	NCAc 784	5.7	6.8	4.2	3.2
298	5030	HYB	6683	NCAc 1741	5.9	7.0	4.4	3.4
299	5037	HYB	6684	NCAc 2154	6.0	7.1	4.5	4.2
300	5129	HYB	952	NCAc 17892	4.2	3.5	3.0	3.1
301	5164	HYB	13133	NCAC 17587	3.0	3.0	4.5	4.1
302	5725	HYB	988	NCAC 17751	6.0	7.1	4.5	4.7
303	5932	HYB	13134	NCAC 1715	6.2	7.3	4.7	4.9
304	5967	HYB	13135	KANYOMA	2.8	3.0	4.0	5.0
305	6121	HYB	9519	NCAc 1455	3.5	2.9	3.6	4.2
306	6135	HYB	13137	CUP 8	5.7	6.8	4.2	4.3
307	6183	HYB	13139	S 183	3.0	3.1	4.1	3.5
308	6229	HYB	13140	RCM 596-1	6.0	7.1	4.5	4.0
309	6764	HYB	1022	NCAC 1705	6.2	7.3	4.7	4.3
310	6826	HYB	13146	C 35	5.7	6.8	4.2	5.0
311	6862	HYB	13147	NCAC 2491	3.0	2.5	4.9	5.3
312	7237	HYB	9507	ICG 7237	6.0	7.1	4.5	4.9
313	7360	VUL	4559	101/66/1	3.9	4.5	4.2	2.9
314	7446	HYB	13153	M 6-76 M	4.7	4.5	5.2	3.9
315	7454	HYB	13154	M 399-72 K	4.4	4.7	4.5	3.5

Table 4.3 Diseases and *Spodoptera* damage score recorded by different germplasm cont….

SNO	ICG	HBT	NRCG	VAR	ELS	LLS	Rust	*Spodoptera Damage Score*
316	7490	HYB	13155	M 57-72 K	4.9	4.2	4.7	3.9
317	7621	HYB	4734	NCAc 17718	4.3	7.0	4.2	3.9
318	7637	HYB	13157	M 107-74 K	2.5	3.0	3.1	5.7
319	7664	HYB	4751	NCAc 17672	2.9	3.1	4.5	5.6
320	7676	HYB	9790	ICG 7676	2.6	3.0	4.0	5.8
321	7696	HYB	13158	EGRET	3.5	3.0	2.8	3.3
322	7749	HYB	4802	M 380-72	2.7	2.9	4.0	4.5
323	7883	HYB	6699	PI 315608	5.7	6.8	4.2	3.4
324	7892	HYB	6705	PI 393527 B	3.0	2.9	3.2	5.9
325	7900	HYB	6708	PI 414332	2.5	3.9	3.0	3.8
326	8030	HYB	4921	NCAc 17866	4.7	4.5	5.2	3.6
327	8099	HYB	4978	PI 270934	4.4	4.7	4.5	3.8
328	9116	HYB	13167	75-72	4.9	4.2	4.7	3.7
329	10756	HYB	9524	TGR 997	5.7	6.8	4.2	4.8
330	10884	HYB	8967	KSSc 399	2.9	3.2	3.9	3.9
331	11269	HYB	13171	RM 70-1	2.9	3.9	3.0	5.5
332	384	HYR	811	NCAc 1085	4.9	4.2	4.7	4.6
333	1637	HYR	676	NCAc 944	5.7	6.8	4.2	4.7
334	1656	HYR	1703	NCAC 2575	2.5	3.0	3.1	4.2
335	2271	HYR	685	NCAc 343	2.9	3.1	4.5	2.8
336	2273	HYR	869	NCAC 505	2.6	3.0	4.0	4.0
337	2278	HYR	13085	NCAC 595	4.9	4.2	4.7	4.3
338	2281	HYR	13086	BADAMI ZAMINI	3.0	2.5	4.9	4.6
339	2285	HYR	13088	NCAC 759	2.0	3.1	4.1	5.3
340	2293	HYR	13091	NCAC 886	4.7	4.5	5.2	4.9
341	2296	HYR	4281	NCAc 1107	3.0	2.9	2.5	4.2
342	2326	HYR	13097	NCAC 2475	4.5	4.2	5.8	2.8
343	2336	HYR	898	NCAC 2566	4.9	5.2	5.7	4.6
344	2352	HYR	905	NCAc 2785	2.6	3.0	4.9	5.0
345	2360	HYR	13104	G 68	3.0	3.2	4.2	4.8
346	2361	HYR	13105	GA 139	3.0	3.5	3.0	4.7
347	2363	HYR	9000	G 44	2.5	3.0	4.9	3.7
348	2370	HYR	13107	GA 124-B	3.0	3.5	2.5	6.1
349	2377	HYR	702	NCAC 2945	2.9	2.1	3.0	4.7
350	2401	HYR	13113	NCAC 2763	4.7	4.5	5.2	5.4
351	2405	HYR	4153	NCAc 2821	4.7	4.5	5.2	4.6
352	4750	HYR	5187	PI 337409	3.1	2.8	5.1	4.3
353	4765	HYR	13119	KU NO.225	2.1	2.5	4.0	4.1
354	4773	HYR	13125	KU NO.9	4.7	4.5	5.2	3.6
355	5040	HYR	9517	NCAc 2214	4.4	4.7	4.5	3.8

Table 4.3 Diseases and *Spodoptera* damage score recorded by different germplasm cont….

SNO	ICG	HBT	NRCG	VAR	ELS	LLS	Rust	*Spodoptera Damage Score*
356	5041	HYR	6686	NCAc 2230	4.9	4.2	4.7	3.7
357	5042	HYR	6532	NCAc 2232	4.1	4.2	3.0	4.8
358	5043	HYR	6687	NCAc 2240	3.8	7.0	4.4	4.7
359	5055	HYR	1699	NCAC 2477	5.3	7.1	4.5	4.9
360	6147	HYR	6691	NCAc 2326	5.7	6.8	4.2	4.1
361	6317	HYR	763	NCAc 17888	6.1	7.7	5.1	3.9
362	7625	HYR	9523	M 1069-7K	4.5	7.8	5.2	3.5
363	7803	HYR	4810	NCAc 2460	5.6	7.1	4.5	3.9
364	7891	HYR	4857	PI 393527-A	5.2	7.3	4.7	3.9
365	7899	HYR	4863	PI 414331	5.8	6.9	4.3	6.7
366	11080	HYR	9791	ICG 11080	6.0	7.1	4.5	5.6
367	11094	HYR	13169	ZFA 3186-1	6.7	7.8	5.2	5.0
				GG 2 (Susceptible check)	**6.7**	**7.5**	**6.8**	**5.2**
				Minimum score	**2.0**	**2.0**	**2.1**	**1.2**
				Maximum score	**6.7**	**7.8**	**7.8**	**6.7**
				Mean	**5.0**	**5.7**	**4.8**	**4.6**
				Standard deviation	**1.16**	**1.56**	**1.05**	**0.96**
				Coefficient of variance (%)	**23.3**	**27.4**	**21.8**	**21.0**

4.3.1. Preliminary screening (Table 4.3)

Among the germplasm studied, the disease score for ELS ranged from 2.0 to 6.7 in 1-9 scale. The genotype, NCAc 759 showed the least score (2.0) followed by KU NO. 225 (2.1). Whereas ELS score was maximum (6.7) in 12 genotypes with a mean ELS score of 5.0. The co-efficient of variation for ELS score was 23.3%. The susceptible check variety, GG 2 recorded a disease score of 6.7 for ELS.

Among all the germplasm studied, the diseases score for LLS ranged from 2.0 to 7.8. The genotype, F 1-79 showed the minimum (2.0) LLS score followed by NCAc 17123 and NCAc 2945 (2.1). Whereas LLS score was maximum (7.8) in 10 genotypes. The mean disease score of LLS was 5.7 and co-efficient of variation was 27.4%. The check variety, GG 2 recorded a disease score of 7.5.

In case of rust disease, the score ranged from 2.1 to 7.8 among the germplasm studied. The genotype, PI 393517 showed the least (2.1) score while the maximum rust score (7.8) was found in four genotypes, ZANDI, NCAc 2653, MUBENDI and PI 268899. The mean rust score was 4.8 and co-efficient of variation was 21.7%. The susceptible check, GG 2 recorded a disease score of 6.8.

In case of *Spodoptera,* the damage score ranged from 1.2 to 6.7 in a 0 to 9 scale. The least score (1.2) was found in NCAC 2679 while the maximum (6.7) score was found in MTUTU-A, PI 152129, KU 191, NCAc 2569 and PI 414331. The mean *Spodoptera* damage score was 4.6, while the co-efficient of variation for this trait was 21%. The check variety, GG 2 recorded a damage score of 5.2.

4.3.2 Confirmative screening (Table 4.4)

Among the 367 groundnut germplasm studied, the genotypes which exhibited a score range of 1-3 for all the three diseases and 0 to 3 in case of *Spodoptera* leaf damage were considered as resistant and selected for further screening to confirm the observed resistance in respect of the above biotic stresses. Out of 367 germplasm studied, 75 were either found to be resistant to ELS, LLS, rust and *Spodoptera* or to their combinations. Among the 75 resistant germplasm, 25 accessions belonged to the habit group FST; 19 were of HYB, 16 were of HYR and 15 were VUL.

The 75 germplasm which were found to be resistant during the preliminary screening were further screened for ELS, LLS, rust and Spodoptera under natural condition in the field for two consecutive years viz. 2002 and 2003. The data on year-wise of screening are presented in Table 4.4 along with the mean score for the two-years. The year-wise results are described below.

Table 4.4 Diseases and *Spodoptera* damage score of 75 germplasm in confirmative screening

SNO	NRCG	Variety	HBT	ELS			LLS			Rust			*Spodoptera* damage		
				Y 1	Y 2	Mean	Y 1	Y 2	Mean	Y 1	Y 2	Mean	Y 1	Y 2	Mean
1	13027	WHITE	FST	8.5	6.7	7.6	6.7	4.3	5.5	8.8	6.2	7.5	6.4	4.4	5.4
2	4296	NCAC 1302	FST	5.7	3.9	4.8	4.8	2.4	3.6	2.5	1.8	2.2	2.5	1.2	1.9
3	13052	VALENCIA	FST	3.7	5.5	4.6	5.7	3.3	4.5	5.1	2.8	3.8	5.3	3.3	4.3
4	9130	NCAc 2679	FST	2.9	4.7	3.8	5.3	2.9	4.1	5.8	3.2	4.5	4.8	2.8	3.8
5	1177	NCAc 17090	FST	2.1	3.9	3.0	5.1	2.7	3.9	1.6	2.4	1.9	3.3	1.3	2.3
6	6663	NCAc 17127	FST	1.6	3.4	2.5	4.2	1.8	3.0	1.3	3.1	2.2	3.4	1.4	2.4
7	6664	NCAc 17129	FST	1.2	3.0	2.1	6.4	4.0	5.2	1.0	3.0	2.0	8.9	7.2	8.2
8	5177	NCAc 17132	FST	2.9	4.7	3.8	5.0	2.6	3.8	4.1	6.7	5.4	3.8	1.8	2.8
9	1179	NCAc 17134	FST	2.4	3.2	3.2	4.7	2.3	3.5	3.7	6.3	5.0	3.9	1.9	2.9
10	5178	NCAc 17135	FST	2.2	4.0	3.1	4.8	2.4	3.6	3.6	6.2	4.9	3.9	1.9	2.9
11	13079	V 109	VUL	4.2	6.0	5.1	5.2	2.8	4.0	2.3	4.9	3.6	6.2	4.2	5.2
12	13128	KU NO.60	VUL	2.9	4.7	3.8	6.8	4.4	5.6	5.4	8.0	6.7	5.5	3.5	4.5
13	6682	Krap strain 16	FST	2.9	4.7	3.8	4.7	3.7	4.2	4.3	6.9	5.6	5.2	3.2	4.2
14	9949	ICG 4791	FST	3.4	1.6	2.5	5.4	4.4	4.9	4.3	1.7	3.0	4.0	2.0	3.0
15	13152	PERU NO.9	FST	5.8	4.0	4.9	3.9	2.9	3.4	6.8	4.2	5.5	5.9	3.9	4.9
16	4603	V 20	FST	3.9	2.1	3.0	4.7	3.7	4.2	5.9	3.3	4.6	6.2	4.2	5.2
17	9747	ICG 7620	FST	3.4	1.6	2.5	5.1	4.1	4.6	3.9	6.5	5.2	5.8	3.8	4.8
18	4849	PI 215696	FST	5.2	3.4	4.3	2.8	1.8	2.3	4.5	7.1	5.8	5.6	3.0	4.0
19	6703	PI 393517	FST	2.3	4.1	3.2	4.2	3.2	3.7	2.1	4.7	3.4	4.8	2.2	3.2
20	4859	PI 393531	FST	5.8	7.6	6.7	5.6	4.6	5.1	1.0	3.6	2.3	5.5	2.9	3.9
21	4861	PI 393646	FST	2.9	5.7	4.2	3.9	2.9	3.4	4.2	6.8	5.5	4.9	2.3	3.3
22	6707	PI 405132	FST	1.5	4.3	2.8	2.6	1.6	2.1	2.0	3.3	2.5	5.8	3.2	4.2
23	4873	PI 268491	FST	2.5	5.3	3.8	4.0	3.0	3.5	3.7	5.0	4.4	5.2	2.6	3.6
24	11581	SPZ 503 DARK PU	FST	4.3	7.1	5.6	5.8	4.8	5.3	3.0	4.3	3.7	5.3	2.7	3.7
25	11615	SPZ 503 PURPLE	FST	4.6	7.4	5.9	5.4	4.4	4.9	2.9	4.2	3.4	5.5	2.9	3.9
26	11582	SPZ 488 GASP	FST	3.6	6.4	4.9	6.2	2.6	4.3	3.4	4.7	3.9	6.5	3.9	4.9
27	13015	GA 163	VUL	2.8	5.6	4.1	5.2	1.6	3.3	4.1	5.4	4.6	5.6	3.0	4.0
28	13019	CATETO	VUL	7.7	4.9	6.2	7.4	3.8	5.5	3.8	5.1	4.3	5.6	3.0	4.0
29	4238	NCAc 726	VUL	5.4	2.6	3.9	5.2	1.6	3.3	5.9	4.6	5.1	5.6	3.0	4.0
30	9185	NCAc 751	VUL	5.4	2.6	3.9	6.0	2.4	4.1	5.4	4.1	4.6	5.6	3.0	4.0
31	13020	ACETEIRO CHICO	VUL	5.2	2.4	3.7	5.0	1.4	3.1	3.7	5.0	4.2	5.6	3.0	4.0
32	13024	NCAC 845	VUL	7.1	4.3	5.6	7.7	4.1	5.8	3.4	4.7	3.9	5.6	3.0	4.0
33	13056	GA 270-8	VUL	6.0	3.2	4.5	5.8	2.2	3.9	3.7	5.0	4.2	5.7	3.1	4.1

Table 4.4 Diseases and *Spodoptera* damage score of 75 germplasm in confirmative screening cont….

SNO	NRCG	Variety	HBT	ELS			LLS			Rust			Spodoptera damage		
				Y 1	Y 2	Mean	Y 1	Y 2	Mean	Y 1	Y 2	Mean	Y 1	Y 2	Mean
34	13065	LUNG TAN YOU DO	VUL	6.4	3.6	4.9	5.6	2.0	3.7	5.2	6.5	5.7	4.0	1.4	2.4
35	9236	NCAc 2673	VUL	4.7	3.1	3.9	6.4	2.8	4.5	3.7	5.0	4.2	5.4	2.7	4.2
36	9237	NCAc 2737	VUL	5.0	3.4	4.2	7.4	3.8	5.5	3.2	6.4	4.8	5.4	2.7	4.2
37	6536	PI 337394F	VUL	8.7	7.1	7.9	5.4	1.8	3.5	2.9	6.1	4.5	8.1	5.4	6.9
38	13132	F 1-79	VUL	4.0	2.4	3.2	5.1	1.5	3.2	6.4	3.2	4.8	5.4	2.7	4.2
39	841	NCAC 2563	HYB	2.9	4.5	3.7	7.4	3.8	5.5	6.8	3.6	5.2	5.4	2.7	4.2
40	4282	NCAc 12	HYB	3.3	4.9	4.1	5.4	1.8	3.5	5.7	2.5	4.1	5.4	2.7	4.2
41	894	NCAC 2479	HYB	3.4	5.0	4.2	5.7	2.1	3.8	7.1	3.9	5.5	5.4	2.7	4.2
42	13099	VIRGINIA RED	HYB	3.1	4.7	3.9	5.3	1.7	3.4	2.9	6.1	4.5	5.5	2.8	4.3
43	13112	DHT 193	HYB	3.4	5.0	4.2	7.1	3.5	5.2	2.3	5.5	3.9	6.0	3.3	4.8
44	952	NCAc 17892	HYB	3.0	4.6	3.8	8.2	4.6	6.3	1.9	5.1	3.5	5.6	2.9	4.4
45	13133	NCAC 17587	HYB	3.7	5.3	4.5	7.1	3.5	5.2	1.8	5.0	3.4	5.6	2.9	4.4
46	13135	KANYOMA	HYB	2.8	4.4	3.6	6.6	5.2	5.9	2.3	5.5	3.9	5.7	3.0	4.5
47	9519	NCAc 1455	HYB	2.4	4.0	3.2	6.1	4.7	5.4	2.6	5.8	4.2	5.7	3.0	4.5
48	13139	S 183	HYB	3.4	5.0	4.2	4.3	2.9	3.6	3.2	6.4	4.8	5.9	3.2	4.7
49	13147	NCAC 2491	HYB	2.8	5.0	3.9	6.2	4.8	5.5	2.7	5.9	4.3	5.9	3.2	4.7
50	4559	101/66/1	VUL	4.7	2.5	3.6	6.6	5.2	5.9	3.3	6.5	4.9	6.0	3.3	4.8
51	13157	M 107-74 K	HYB	5.0	2.8	3.9	4.4	3.0	3.7	1.4	4.6	3.0	6.0	3.3	4.8
52	4751	NCAc 17672	HYB	5.6	3.4	4.5	6.2	4.8	5.5	6.2	4.0	5.1	6.1	3.4	4.9
53	9790	ICG 7676	HYB	4.7	2.5	3.6	5.9	4.5	5.2	5.7	3.5	4.6	6.0	3.3	4.8
54	13158	EGRET	HYB	6.6	4.4	5.5	4.9	3.5	4.2	7.4	5.2	6.3	6.1	3.4	4.9
55	4802	M 380-72	HYB	5.2	3.0	4.1	5.6	4.2	4.9	3.2	5.4	4.3	6.2	3.5	5.0
56	6705	PI 393527 B	HYB	5.0	2.8	3.9	6.7	5.3	6.0	3.7	5.9	4.8	6.2	3.5	5.0
57	6708	PI 414332	HYB	5.9	3.7	4.8	5.8	4.4	5.1	4.1	6.3	5.2	6.2	3.5	5.0
58	8967	KSSc 399	HYB	6.6	4.4	5.5	6.2	4.8	5.5	4.1	6.3	5.2	6.4	3.7	5.2
59	13171	RM 70-1	HYB	5.0	2.8	3.9	5.8	4.4	5.1	4.9	7.1	6.0	6.4	3.7	5.2
60	1703	NCAC 2575	HYR	4.7	6.9	5.8	5.6	4.2	4.9	5.8	8.0	6.9	6.4	3.7	5.2
61	685	NCAc 343	HYR	3.1	5.3	4.2	4.1	2.7	3.4	6.0	3.8	4.9	6.4	3.7	5.2
62	869	NCAC 505	HYR	2.8	5.0	3.9	5.9	3.5	4.7	5.9	3.7	4.8	7.0	3.7	5.2
63	13086	BADAMI ZAMINI	HYR	2.6	4.8	3.7	5.8	3.4	4.6	6.0	3.8	4.9	7.1	3.8	5.3
64	13088	NCAC 759	HYR	2.5	4.7	3.6	5.1	2.7	3.9	4.5	6.7	5.6	7.3	4.0	5.5
65	4281	NCAc 1107	HYR	2.8	5.0	3.9	5.8	3.4	4.6	4.4	6.6	5.5	7.3	4.0	5.5
66	13097	NCAC 2475	HYR	3.2	5.4	4.3	6.5	4.1	5.3	3.6	5.8	4.7	7.3	4.0	5.5
67	905	NCAc 2785	HYR	6.4	4.2	5.3	5.5	3.1	4.3	3.7	5.9	4.8	7.5	4.2	5.7

Table 4.4 Diseases and *Spodoptera* damage score of 75 germplasm in confirmative screening cont…

SNO	NRCG	Variety	HBT	ELS			LLS			Rust			Spodoptera damage		
				Y 1	Y 2	Mean	Y 1	Y 2	Mean	Y 1	Y 2	Mean	Y 1	Y 2	Mean
68	13104	G 68	HYR	6.3	4.1	5.2	6.5	4.1	5.3	4.4	5.2	4.8	7.6	4.3	5.8
69	13105	GA 139	HYR	6.6	4.4	5.5	5.9	3.5	4.7	3.8	4.6	4.2	7.6	4.3	5.8
70	9000	G 44	HYR	2.4	4.6	3.5	5.0	2.6	3.8	3.7	4.5	4.1	7.7	4.4	5.9
71	13107	GA 124-B	HYR	3.1	5.3	4.2	6.8	4.4	5.6	4.6	3.8	4.2	8.0	4.7	6.2
72	702	NCAC 2945	HYR	3.8	6.0	4.9	5.1	2.7	3.9	6.1	5.3	5.7	8.1	4.8	6.3
73	5187	PI 337409	HYR	2.8	5.0	3.9	4.6	2.2	3.4	6.2	5.4	5.8	8.1	4.8	6.3
74	13119	KU NO.225	HYR	3.1	5.3	4.2	6.7	4.3	5.5	6.3	5.5	5.9	8.1	4.8	6.3
75	6532	NCAc 2232	HYR	5.6	3.4	4.5	5.4	3.0	4.2	4.8	4.0	4.4	8.8	5.5	7.0
		GG 2		**6.8**	**7.5**	**7.1**	**5.8**	**6.7**	**6.2**	**6.5**	**7.1**	**6.8**	**4.5**	**5.0**	**8.1**
		Minimum		**1.2**	**1.6**	**2.1**	**2.6**	**1.4**	**2.1**	**1.0**	**1.7**	**1.9**	**2.5**	**1.2**	**1.9**
		Maximum		**8.7**	**7.6**	**7.9**	**8.2**	**5.3**	**6.3**	**8.8**	**8.0**	**7.5**	**8.9**	**7.2**	**8.2**
		Mean		**4.2**	**4.4**	**4.3**	**5.6**	**3.4**	**4.5**	**4.2**	**5.0**	**4.6**	**5.9**	**3.3**	**4.6**
		SD		**1.68**	**1.38**	**1.11**	**1.05**	**1.12**	**0.96**	**1.66**	**1.42**	**1.13**	**1.25**	**1.02**	**1.19**
		CV %		**40.1**	**31.3**	**25.8**	**18.7**	**33.2**	**21.4**	**39.7**	**28.1**	**24.6**	**21.0**	**30.5**	**25.5**

Where, Y1= first year, Y2= second year

4.3.2.1. ELS score

The ELS score ranged from 1.2 (NCAc 17129) to 8.7 (PI 337394 F) during first year, while during second year, it ranged from was 1.6 (ICG 4791) to 7.6 (PI 393531). The check variety, GG 2 recorded a disease score of 6.8 and 7.5 during first and second year respectively.

The mean ELS score during the first year was the 4.2 and it was 4.4 during second year. The co-efficient of variation for ELS score was 40.1 and 31.3% during first and second year respectively.

The mean ELS score for both the years ranged from 2.1 (NCAc17129) to 7.9 (PI 33394 F), while the mean ELS score among all accessions for the both the year was 4.3 and co-efficient of variation was 25.8%.

4.3.2.2. LLS score

The LLS score ranged from 2.6 (PI 405132) to 8.2 (NCAc 17892) during first year, while the range during second year was 1.4 (ACETEIRO CHICO) to 5.3 (PI 393527 B). The check variety, GG 2 recorded a disease score of 5.8 and 6.7 during first and second year respectively.

The mean LLS score during the first year was 5.6 and it was 3.4 during second year. The co-efficient of variation for LLS score was 18.7 and 33.2% during first and second year respectively.

In case of mean LLS score of both the year, the score ranged from 2.1 (PI 405132) to 6.3 (NCAc 14892) and the mean for both the year LLS score was 4.5 and co-efficient of variation was 21.4%.

4.3.2.3. Rust score

The rust score ranged from 1.0 (PI 393531) to 8.8 (WHITE) during first year, while the values during second year were1.7 (ICG 4791) to 8.0 (KU No.60). The check variety, GG 2 recorded a rust score of 6.5 and 7.1 during first and second year respectively.

The mean rust score during the first year was 4.2 and it was 5.0 during second year. The co-efficient of variation for rust score was 39.7 and 28.1% during first and second year respectively.

In case of both the year rust score, it ranged from 1.9 (NCAc 17090) to 7.5 (WHITE) with the mean of 4.6 and co-efficient of variation was 24.6%.

4.3.2.4. Sodoptera damage score

The score for *Spodoptera* damage ranged from 2.5 (NCAc 1302) to 8.9 (NCAc 17129) during first year. While it ranged from 1.2 (NCAc 1302) to 7.2 (NCAc 17129) during second year. The check variety GG 2, recorded a damage score of 4.5 and 5.0 during the first and second year respectively.

The mean damage score during the first year was 5.9 and it was 3.3 during second year. The co-efficient of variation of *Spodoptera* damage score was 21.1 and 30.5% during first and second year respectively.

For both the years, mean *Spodoptera* damage score ranged from 1.9 (NCAc 1302) to 8.2 (NCAc 17129) while the mean for both the years were 4.6 and co-efficient of variation was 25.5%.

4.4. Anatomical basis of resistance to three foliar fungal diseases and Spodoptera

Nine anatomical characters namely trichome length, tricome density, stomatal length at abaxial and adaxial surfaces, stomatal width at abaxial and adaxial surfaces, number of stomata at adaxial and abaxial surfaces and number of tannin cells were studied in the 75 germplasm which were found to be resistant either to ELS, LLS, rust and *Spodoptera* or their combinations during preliminary field screening under three replications to understant their relationship with resistance to the above biotic stresses or otherwise. The ANOVA was worked out for all the nine characters and presented in Table 4.5. and the anatomical feature of each of the materials studied is presented in Table 4.6 (Plate 12 & 13)and results are described below.

Table 4.5 ANOVA for 9 anatomical traits

No	Traits	df	Mean of squares	F- value
1	Tricome length	74	0.55	117.92**
2	Tricome density	74	13.50	4.05**
3	Stomata length abaxial	74	19.26	14.84**
4	Stomata length adaxial	74	19.26	45.37**
5	Stomata width abaxial	74	17.25	12.59**
6	Stomata width adaxial	74	18.22	42.06**
7	Stomata abaxial	74	1087.63	10.20**
8	Stomata adaxial	74	1077.48	54.69**

9	Tannin cells	74	08.97	15.78**

*,** Significant at P= 0.05 and 0.01 respectively

From the ANOVA, it was clear that highly significant differences existed among the germplasm for all the nine anatomical characters studied.

4.4.1. Anatomical Traits

4.4.1.1. Trichome length

The trichome length on leaf margin ranged from 0.3 (PI 393517 and NCAc 17672) to 1.8 mm (ICG 7620). The mean tricome length was 1.2 mm among all the genotypes studied. The co-efficient of variation for this trait was 37.1%.

4.4.1.2. Trichome density

Trichome were uniseriate with 2-3 basal cells and an elongated apical cell in all the accessions studied. The trichome density ranged from 9.3 in NCAc 17129 to 27.1 in NCAc 1302. Mean tricome density was 18.7/mm with a co-efficient of variation of 11.3%.

4.4.1.3. Stomatal Apparatus

The stomatal type was mainly paracytic with one subsidiary cell (Plate 12) in all the accessions studied.

4.4.1.3.1. Stomatal length at abaxial surface

The average stomatal length ranged from 15.4 (NCAc 17127) to 25.2 µm (NCAc 2232). The mean stomatal length at abaxial surface among all the 75 germplasm studied was 18.9 µm and the co-efficient of variation for this trait was 13.4%.

4.4.1.3.2. Stomatal width at abaxial surface

The average stomatal width at abaxial surface ranged from 11.2 (NCAc 343) to 19.8 µm (EGRET). The mean stomatal width among the germplasm studied was 15.2 µm with a co-efficient of variation of 15.3%.

4.4.1.3.3. Stomatal length at adaxial surface

The average stomatal length at adaxial surface ranged from 12.9 (NCAc 17127) to 22.7 µm (NCAc 2232). The mean value for this character among all the 75 germplasm studied was 16.4 µm and the co- efficient of variation was 15.4%.

4.4.1.3.4. Stomatal width at adaxial surface

The average stomatal width at adaxial surface ranged from 10.8 (NCAc 17127) to 19.7 µm (NCAc 2232). The mean stomatal width at adaxial surface among the germplasm studied was 16.4 µm with a co-efficient of variation of 17.1%.

4.4.1.3.5. No. of stomata at abaxial surface

In general, the accessions having larger leaflet size showed lower stomatal frequency. The number of stomata ranged from 66.4 to 143.2/mm^2. The number of stomata was the least (66.4/mm^2) in the genotype, NCAc 751 while it was highest (143.2/mm^2) in NCAC 845. The mean stomatal frequency was 112.6 /mm^2 with a co-efficient of variation of 16.9%.

4.4.1.3.6. No. of stomata at adaxial surface

The number of stomata on adaxial surface ranged from 62.2 (CATETO) to 150.1/mm^2 (NCAc 17587). The mean stomatal frequency at adaxial surface was 117.9/mm^2 with a co-efficient of variation of 16.1%. It can be observed that stomatal frequency of abaxial and adaxial surfaces have not significant difference.

4.4.1.4. Tannin cells

Tannin cells were found in palisade layer immediately below the upper epidermis (Plate 13). The number of tannin cells /mm of leaves ranged from 2.8 to 9.8. The tannin cells were minimum (2.8/mm) in genotype, NCAc 1455 while the tannin cells were maximum (9.8/mm) in genotype, ICG 7620. The mean number of tannin cells among all the genotypes studied were 6.8/mm and co-efficient of variation for this trait was 25.4%.

Table 4.6 Anatomical features of 75 germplasm found to be resistant under preliminary screening

SNO	NRCG	TL	T D	STL ab	STW ab	STL ad	STW ad	St ab	St ad	TC
1	13027	0.4	19.1	24.3	18.4	21.8	19.4	121.2	130.2	2.8
2	4296	1.7	27.1	19.1	16.2	16.6	14.7	117.8	128.8	5.9
3	13052	0.8	18.1	20.7	17.2	18.2	16.3	121.1	130.1	3.5
4	9130	0.4	16.7	20.2	16.7	17.7	14.6	111.2	122.2	4.2
5	1177	1.2	21.4	19.4	16.8	16.9	14.1	106.4	117.4	8.8
6	6663	1.6	18.4	15.4	11.4	12.9	10.8	78.3	85.3	7.8
7	6664	0.6	9.3	21.4	17.9	18.9	17.1	125.2	134.2	8.9
8	5177	0.4	16.7	17.1	14.8	14.6	12.7	128.0	139.0	6.9
9	1179	1.3	24.2	16.3	13.4	13.8	11.7	109.8	116.8	8.8
10	5178	1.4	17.0	16.5	13.2	14.0	12.1	131.5	142.5	5.7
11	13079	1.6	20.8	16.2	12.7	13.7	11.8	86.9	97.9	5.3
12	13128	1.5	19.8	19.4	15.9	16.9	14.2	99.8	108.8	3.2
13	6682	1.6	16.3	21.4	17.9	18.9	15.6	126.2	134.2	7.6
14	9949	1.4	17.0	16.5	13.0	14.0	11.9	106.0	115.0	7.6
15	13152	0.9	19.3	16.5	12.5	14.0	11.9	116.6	123.6	3.2
16	4603	1.4	18.0	22.2	18.7	19.7	17.8	100.9	108.9	6.7
17	9747	1.8	18.8	17.1	13.6	14.6	12.7	112.2	121.2	9.8
18	4849	1.4	21.0	21.2	17.2	18.7	15.4	90.9	97.9	9.2
19	6703	0.3	18.3	16.3	12.8	13.8	11.9	111.8	122.8	7.4
20	4859	1.6	18.5	21.3	17.8	18.8	17.0	121.1	130.1	6.4
21	4861	1.6	19.7	20.4	16.4	17.9	15.8	86.5	93.5	6.3
22	6707	1.5	22.3	16.2	12.2	13.7	11.6	76.8	83.8	9.8
23	4873	1.4	16.1	22.4	18.3	19.9	17.8	71.6	78.6	5.8
24	11581	1.7	19.9	21.2	17.7	18.7	16.9	118.2	127.2	6.3
25	11615	0.7	20.0	20.3	16.8	17.8	15.7	72.8	81.8	9.4
26	11582	1.6	19.6	17.1	13.6	14.6	12.7	103.1	111.1	4.2
27	13015	1.0	19.9	17.4	13.4	14.9	12.8	112.1	119.1	7.4
28	13019	1.5	19.1	23.2	19.7	20.7	18.9	71.2	62.2	5.8
29	4238	0.9	18.4	18.2	14.2	15.7	13.6	111.1	118.1	6.9
30	9185	1.5	20.0	23.9	18.4	21.4	18.2	66.4	74.4	4.8
31	13020	1.0	19.7	16.2	12.2	13.7	11.6	103.2	110.2	8.2
32	13024	0.9	20.7	19.2	15.7	16.7	14.9	143.2	108.8	7.1
33	13056	0.7	18.3	17.5	15.4	15.0	13.1	112.1	123.1	8.4
34	13065	1.7	19.3	16.3	13.5	13.8	11.9	123.8	134.8	5.7
35	9236	1.4	17.3	19.0	15.5	16.5	14.6	112.3	121.3	9.1
36	9237	1.4	19.0	17.1	13.6	14.6	12.8	128.8	119.8	7.9

Table 4.6 Anatomical features of 75 germplasm found to be resistant under preliminary screening cont….

SNO	NRCG	TL	T D	STL ab	STW ab	STL ad	STW ad	St ab	St ad	TC
37	6536	0.4	16.4	21.8	17.4	19.3	17.4	133.2	140.2	5.4
38	13132	0.6	17.0	16.5	12.5	14.0	11.9	120.8	127.8	6.4
39	841	1.4	19.7	17.8	14.3	15.3	13.5	117.4	108.4	8.4
40	4282	0.7	16.3	18.7	15.2	16.2	14.3	128.2	139.2	6.3
41	894	1.2	20.3	16.3	13.2	13.8	11.9	129.0	140.0	8.1
42	13099	1.3	18.0	16.5	12.5	14.0	11.9	139.0	146.0	6.3
43	13112	1.5	18.6	16.7	13.2	14.2	12.4	119.2	128.2	6.2
44	952	1.7	16.7	16.2	12.7	13.7	11.9	142.5	108.8	8.9
45	13133	1.2	18.7	17.0	13.5	14.5	12.7	141.1	150.1	8.4
46	13135	1.4	16.3	19.0	15.5	16.5	14.7	116.0	108.8	8.7
47	9519	0.9	17.7	21.1	17.6	18.6	16.8	120.3	129.3	2.8
48	13139	1.7	19.0	17.0	14.2	14.5	12.6	117.0	128.0	6.9
49	13147	0.7	18.3	19.0	15.5	16.5	14.7	127.6	118.6	5.6
50	4559	1.0	17.0	17.8	14.3	15.3	13.5	102.7	108.8	4.2
51	13157	1.0	20.0	16.4	12.3	13.9	12.0	120.0	131.0	8.5
52	4751	0.3	17.9	23.2	19.7	20.7	18.9	119.2	110.2	6.2
53	9790	0.4	18.2	23.8	18.4	21.3	19.5	100.1	109.1	6.1
54	13158	1.5	19.8	23.3	19.8	20.8	18.9	124.0	132.0	6.5
55	4802	1.0	19.7	16.7	13.2	14.2	12.1	89.8	98.8	9.8
56	6705	0.9	18.9	19.6	16.1	17.1	15.3	134.2	108.8	4.8
57	6708	1.4	18.4	22.2	18.7	19.7	17.9	111.1	120.1	8.5
58	8967	0.4	17.0	16.3	12.8	13.8	12.0	123.1	114.1	7.3
59	13171	1.3	19.6	20.2	16.7	17.7	15.9	111.0	120.0	6.1
60	1703	1.4	18.7	17.8	14.3	15.3	13.2	131.3	140.3	8.1
61	685	0.7	19.7	18.7	11.2	16.2	14.1	112.0	119.0	9.8
62	869	1.2	20.2	16.3	12.8	13.8	11.7	99.8	108.8	7.5
63	13086	1.6	18.0	16.5	13.0	14.0	12.1	111.8	120.8	6.3
64	13088	1.6	19.3	18.7	15.2	16.2	14.3	125.2	136.2	6.8
65	4281	0.8	18.0	16.3	12.8	13.8	11.9	86.5	95.5	6.4
66	13097	1.2	17.3	23.2	19.7	20.7	18.9	121.4	130.4	6.3
67	905	1.2	17.7	16.5	13.0	14.0	12.1	71.6	79.6	6.3
68	13104	1.4	17.0	22.2	18.7	19.7	17.9	111.2	120.2	8.1
69	13105	1.4	20.7	17.0	13.5	14.5	12.4	72.8	81.8	6.3
70	9000	1.7	20.6	19.0	15.9	16.5	14.6	135.0	146.0	6.2
71	13107	1.6	19.3	19.1	15.6	16.6	13.8	134.1	108.8	5.1
72	702	1.5	18.3	19.4	15.9	16.9	14.5	131.1	142.1	8.4
73	5187	0.7	16.7	16.7	13.2	14.2	12.1	141.1	148.1	6.3

Table 4.6 Anatomical features of 75 germplasm found to be resistant under preliminary screening cont….

SNO	NRCG	TL	T D	STL ab	STW ab	STL ad	STW ad	St ab	St ad	TC
74	13119	0.9	16.3	19.6	16.1	17.1	15.3	116.0	131.0	8.1
75	6532	0.4	18.7	25.2	17.2	22.7	19.7	123.2	131.2	5.4
	GG 2	**0.4**	**9.5**	**24.4**	**18.4**	**20.3**	**15.4**	**125.4**	**111.3**	**4.2**
	Min	**0.3**	**9.3**	**15.4**	**11.2**	**12.9**	**10.8**	**66.4**	**62.2**	**2.8**
	Max	**1.8**	**27.1**	**25.2**	**19.8**	**22.7**	**19.7**	**143.2**	**150.1**	**9.8**
	Mean	**1.2**	**18.7**	**18.9**	**15.2**	**16.4**	**14.4**	**112.6**	**117.9**	**6.8**
	SD	**0.4**	**2.1**	**2.5**	**2.3**	**2.5**	**2.5**	**19.0**	**19.0**	**1.7**
	CV (%)	**37.1**	**11.3**	**13.4**	**15.3**	**15.4**	**17.1**	**16.9**	**16.1**	**25.4**

Where, TL= Tricome length mm, TD = Tricome density no/mm, STL ab= Stomatal length abaxial surface µm, STW ab = Stoamtal width abaxial surface µm, STL ad = Stomatal length adaxial surface µm, STW ad = Stoamtal width adaxial surface µm, St ab= No of stomata/mm^2 abaxial surface, St ad = No of stomata/mm^2 adaxial surface, TC = No. of tannin cells/mm, Min= Minimum, Max= Maximum

4.4.2. Correlation of anatomical traits with disease score

The correlation co-efficient was estimated between nine anatomical characters and yield (g)/plant with ELS, LLS, rust and *Spodoptera* damage score and are presented in Table 4.7.

Table 4.7 Correlation coefficients between anatomical traits and diseases and pest score

NO	Trait	ELS	LLS	Rust	*Spodoptera*
1	Yield/ plant	-0.18	-0.99**	-0.07	-0.29**
2	Tricome length	-0.10	-0.30	-0.08	-0.21
3	Tricome density	0.14	-0.26*	-0.04	0.42**
4	Stomata length abaxial	0.32**	0.26*	0.14	0.24*
5	Stomata width abaxial	0.30**	0.32**	0.10	0.15
6	Stomata length adaxial	0.32**	0.26*	0.14	0.24*
7	Stomata width adaxial	0.34**	0.31**	0.12	0.26*
8	Stomata abaxial	0.05	0.20	0.14	0.18
9	Stomata adaxial	0.00	-0.07	0.17	0.16
10	Tannin cells	-0.26*	-0.15	-0.23*	-0.06

*,** Significant at P= 0.05 and 0.01 respectively

The disease score of early leaf spot had highly significant and positive correlations with length of stomata at abaxial (r= 0.32) adaxial (r= 0.32) surfaces, width of stomata at abaxial (r= 0.30) and adaxial (r= 0.34) surfaces. While the relationship was negative (r= -0.26) and significant in case of number of tannin cells.

The diseases score of late leaf spot had highly significant and positive association with width of stomata at abaxial (r= 0.32), adaxial (r= 0.31) surfaces, length of stomata at abaxial (r= 0.26) and adaxial (r= 0.26) leaf surfaces. While the association was significant and negative with yield/plant (r= - 0.99) and tricome density (r= -0.26).

The only one character which exhibited significant but negative association (r= -0.23) with rust disease score was number of tannin cells/mm. While rest of the characters exhibited non-significant associations with the rust diseases score.

Spodoptera leaf damage had significant and positive correlations with width of stomata at adaxial surface (r= 0.26), length of stomata at abaxial (r= 0.24) and adaxial (r= 0.24) leaf surfaces. While it showed a significant but negative correlation with yield/plant (r= -0.29).

4.5. Biochemical changes associated with resistant and susceptible genotypes

The germplasm accessions which exhibited a diseases score of 1 to 3 on a 1-9 scale to the three foliar fungal diseases and *Spodoptera* or their combinations during the preliminary screening undertaken in *Kharif* 2001 were selected for studying the changes associated with resistance and susceptibility. The biochemical components studied included estimation of total phenols, *ortho*-dihydroxy phenols, total sugars, reducing sugars, free amino acids and epicuticular wax content which were reported to be associated with disease resistance in groundnut mainly and in other crops. The ANOVA was worked out for all the biochemical characters and presented in Table 4.8. The results on the biochemical changes associated with the materials studied are presented in Table 4.9 and the results are presented below.

Table 4.8 ANOVA for 12 Biochemical traits studied

No	Traits	Df	Mean of squares	F- value
1	Total phenols in old leaf	74	0.04	18.30**
2	Total phenols in young leaf	**74**	0.02	394.2**
3	OD phenols in old leaf	**74**	0.02	53.77**
4	OD phenols in young leaf	**74**	0.02	18.02**
5	Total sugars in old leaf	**74**	0.06	1.14 ^{NS}
6	Total sugars in young leaf	**74**	0.16	6.19**
7	Reducing sugars in old leaf	**74**	0.69	16.50**
8	Reducing sugars in young leaf	**74**	0.27	32.73**
9	Free amino acids in old leaf	**74**	0.02	16.96**
10	Free amino acids in young leaf	**74**	0.03	8.05**
11	Wax content in old leaf	**74**	0.41	135.95**
12	Wax content in young leaf	**74**	0.26	3461.9**

*,** Significant at P= 0.05 and 0.01 respectively; ^{NS} Non significant

From the ANOVA, it was clear that highly significant differences existed among the germplasm for the 12 biochemical traits studied except for total sugars in old leaf.

4.5.1. Biochemical traits

4.5.1.1. Total phenols

Among all the genotypes studied, the total phenol contents ranged from 0.21 (NCAc 505) to 0.68 mg /100mg (PI 405132) in older leaves. The mean total phenol contents in older leaves was 0.48 mg/100mg. The co-efficient of variation for total phenols was 15.8%. While total phenol in younger leaves ranged from 0.26 (DHT 193) to 0.67 (SPZ 488 GASP) mg/100mg. The value of mean total phenol in younger leaf was 0.48 mg/100mg and the co-efficient of variation was 15.6%.

4.5.1.2. ortho-dihydroxy phenols (OD-phenol)

Among the materials studied, the OD- phenols ranged from 0.19 (NCAc 505) to 0.63 mg/100mg (PI 405132) in older leaves, while it ranged from 0.15 (NCAc 505) to 0.59 mg/100mg (PI 405132) in younger leaves.

The mean OD-phenol content was 0.44 and 0.40 mg/100mg in older and younger leaves respectively. The co-efficient of variation was 16.8 and 19.2% for older and younger leaves respectively.

4.5.1.3. Total sugars

The total sugar contents ranged from 1.49 (SPZ 488 GASP) to 2.98 mg/100mg (V 109) in older leaves and 1.32 (SPZ 503 DARK PU) to 2.45 mg/100mg (LUNG TAN YOU DO) in younger leaves.

The mean total sugar content was 2.25 and 1.91 mg/100mg in older and younger leaves respectively. The co-efficient of variation for total sugar content was 17.2 and 12.0% for older and younger leaves respectively.

4.5.1.4. Reducing sugars

The reducing sugars ranged from 0.52 (NCAc 17090) to 2.41 mg/100mg (KU NO.60) in older leaves and 0.23 (SPZ 503 PURPLE) to 1.95 mg/100mg (LUNG TAN YOU DO) in younger leaves.

The mean reducing sugar content was 1.40 and 0.97 mg/100mg in older and younger leaves respectively. The co-efficient of variation was 33.4 and 30.7% for older and younger leaves respectively.

4.5.1.5. Free amino acid

The free amino acid content ranged from 0.06 (NCAc 12) to 0.21 mg/100mg (V 109) in older leaves and 0.12 (NCAc 17134) to 0.25 mg/100mg (PI 405132) in younger leaves.

The mean free amino acid content was 0.15 and 0.17 mg/100mg in older and younger leaves respectively. The co-efficient of variation was 15.2 and 21.5% for older and younger leaves respectively.

4.5.1.6. Epicuticular wax

The epicuticular wax content ranged form 0.32 (KU NO.225) to 2.13 mg/dm^2 (DHT 193) in older leaves and 0.76 (PERU NO.9) to 1.96 mg/dm^2 (PI 393531) in younger leaves.

The mean epicuticular wax content was 1.340 and 1.328 mg/dm^2 in older and younger leaves respectively. The co-efficient of variation was 27.2% and 21.9 % for older and younger leaves respectively.

Table 4.9 Biochemical features of 75 germplasm found to be resistant under preliminary screening

SNO	NRCG	TPO	TPY	ODO	ODY	TSO	TSY	RSO	RSY	FAO	FAY	WO	WY
1	13027	0.455	0.547	0.405	0.325	2.127	2.075	1.727	1.085	0.123	0.135	1.647	1.221
2	4296	0.538	0.504	0.488	0.408	2.052	1.740	0.852	1.240	0.148	0.142	1.235	1.491
3	13052	0.429	0.492	0.379	0.299	2.011	1.763	1.151	0.863	0.165	0.143	1.605	1.562
4	9130	0.547	0.501	0.497	0.417	1.642	1.815	0.782	0.915	0.141	0.132	1.392	1.250
5	1177	0.447	0.486	0.397	0.317	1.722	2.069	0.522	1.169	0.189	0.156	1.037	1.179
6	6663	0.504	0.588	0.454	0.374	1.879	1.907	0.889	0.957	0.191	0.169	1.917	1.207
7	6664	0.500	0.494	0.450	0.370	2.011	2.220	1.111	1.230	0.143	0.145	0.934	0.866
8	5177	0.495	0.373	0.445	0.365	1.728	2.006	0.528	1.506	0.152	0.123	1.123	1.363
9	1179	0.444	0.580	0.394	0.314	2.110	1.403	0.613	0.453	0.175	0.121	1.335	1.406
10	5178	0.529	0.514	0.479	0.399	2.821	1.815	1.621	1.315	0.169	0.191	1.235	1.108
11	13079	0.530	0.500	0.480	0.400	2.988	1.990	2.128	1.090	0.210	0.150	1.207	1.136
12	13128	0.470	0.383	0.420	0.340	2.815	1.728	2.415	0.738	0.163	0.143	0.937	1.292
13	6682	0.485	0.433	0.435	0.395	2.688	1.959	1.828	1.059	0.136	0.132	1.022	1.676
14	9949	0.467	0.401	0.417	0.377	2.722	2.312	1.822	1.112	0.118	0.156	1.079	1.562
15	13152	0.509	0.307	0.479	0.439	2.520	2.381	1.530	1.431	0.180	0.169	1.463	0.767
16	4603	0.530	0.296	0.500	0.460	2.306	1.913	1.446	1.013	0.172	0.214	1.193	1.235
17	9747	0.472	0.381	0.442	0.402	2.040	1.661	1.180	0.761	0.205	0.133	1.235	1.889
18	4849	0.566	0.541	0.536	0.496	1.890	2.010	0.900	1.060	0.125	0.159	1.956	1.164
19	6703	0.576	0.462	0.546	0.506	1.838	1.952	0.638	1.452	0.163	0.159	1.235	1.093
20	4859	0.632	0.543	0.602	0.562	2.283	1.873	1.383	0.673	0.145	0.145	2.101	1.963
21	4861	0.584	0.502	0.554	0.514	2.046	1.844	1.056	0.894	0.149	0.169	1.463	1.250
22	6707	0.668	0.571	0.638	0.598	1.555	1.927	1.351	0.977	0.153	0.254	2.112	1.912
23	4873	0.568	0.580	0.538	0.528	1.763	1.844	0.773	0.894	0.147	0.145	1.250	1.250
24	11581	0.483	0.455	0.453	0.443	2.306	1.324	1.406	0.334	0.144	0.190	2.016	1.051
25	11615	0.490	0.373	0.460	0.450	2.006	1.439	1.106	0.239	0.136	0.176	0.767	1.491
26	11582	0.437	0.678	0.407	0.397	1.495	1.347	0.635	0.447	0.109	0.176	1.235	1.519
27	13015	0.495	0.495	0.465	0.455	2.069	1.665	1.079	0.715	0.165	0.238	1.874	1.619
28	13019	0.547	0.477	0.517	0.507	2.647	1.821	2.247	0.831	0.171	0.186	1.164	1.448

Table 4.9 Biochemical features of 75 germplasm found to be resistant under preliminary screening cont….

SNO	NRCG	TPO	TPY	ODO	ODY	TSO	TSY	RSO	RSY	FAO	FAY	WO	WY
29	4238	0.504	0.576	0.474	0.464	2.601	1.653	1.611	0.703	0.126	0.175	1.689	1.264
30	9185	0.492	0.467	0.462	0.452	2.786	2.312	1.926	1.412	0.115	0.238	1.037	1.605
31	13020	0.501	0.477	0.441	0.431	2.878	2.000	1.888	1.050	0.118	0.238	1.889	1.548
32	13024	0.486	0.426	0.426	0.416	2.543	2.052	2.143	1.062	0.166	0.248	1.207	1.945
33	13056	0.571	0.489	0.511	0.501	2.815	2.029	1.615	1.129	0.174	0.193	0.994	1.931
34	13065	0.600	0.639	0.540	0.530	2.765	2.453	1.565	1.953	0.171	0.138	1.193	1.704
35	9236	0.598	0.404	0.538	0.528	2.358	2.035	1.498	1.135	0.157	0.208	1.150	1.590
36	9237	0.594	0.383	0.534	0.524	2.566	1.971	2.166	0.981	0.163	0.190	1.406	1.718
37	6536	0.495	0.352	0.435	0.425	2.873	1.919	1.883	1.419	0.176	0.168	1.250	1.349
38	13132	0.477	0.470	0.417	0.387	2.179	1.948	1.189	0.998	0.169	0.156	1.889	1.505
39	841	0.576	0.485	0.516	0.486	1.959	1.832	1.559	0.842	0.166	0.152	1.491	1.832
40	4282	0.467	0.467	0.407	0.377	2.826	1.665	1.626	1.165	0.066	0.188	1.250	1.690
41	894	0.477	0.509	0.417	0.387	2.584	1.474	1.384	0.574	0.142	0.169	1.108	1.278
42	13099	0.582	0.476	0.522	0.492	2.884	2.300	1.894	1.350	0.163	0.193	1.448	0.994
43	13112	0.306	0.262	0.246	0.216	2.090	1.988	1.190	0.998	0.171	0.160	2.131	1.335
44	952	0.391	0.547	0.331	0.301	2.006	2.014	1.606	0.744	0.144	0.136	1.093	1.008
45	13133	0.384	0.447	0.344	0.314	2.110	1.844	1.210	0.854	0.133	0.125	1.037	1.221
46	13135	0.561	0.504	0.521	0.491	2.073	2.121	1.673	1.131	0.118	0.136	1.250	0.994
47	9519	0.557	0.500	0.517	0.487	1.902	2.052	1.502	1.062	0.142	0.126	1.207	1.434
48	13139	0.521	0.495	0.481	0.451	1.971	1.971	0.771	1.471	0.145	0.142	1.235	1.008
49	13147	0.535	0.444	0.495	0.465	2.127	2.179	1.727	1.189	0.143	0.143	1.051	1.193
50	4559	0.473	0.529	0.433	0.413	2.052	2.081	1.652	1.091	0.150	0.127	1.250	1.079
51	13157	0.400	0.530	0.360	0.340	2.011	1.975	0.811	1.475	0.171	0.140	1.136	1.221
52	4751	0.423	0.470	0.383	0.363	2.722	1.763	2.322	0.773	0.157	0.142	0.644	0.987
53	9790	0.471	0.485	0.431	0.411	2.404	1.803	1.504	0.813	0.192	0.128	1.051	0.838
54	13158	0.436	0.470	0.396	0.376	2.780	1.850	1.920	0.950	0.183	0.190	1.122	1.193
55	4802	0.458	0.485	0.388	0.368	2.751	1.786	1.851	0.586	0.143	0.203	1.349	1.264
56	6705	0.412	0.467	0.342	0.322	2.589	2.028	2.189	0.750	0.166	0.200	1.108	1.122
57	6708	0.504	0.509	0.434	0.394	2.873	1.994	1.973	0.794	0.155	0.239	1.207	0.923

Table 4.9 Biochemical features of 75 germplasm found to be resistant under preliminary screening cont….

SNO	NRCG	TPO	TPY	ODO	ODY	TSO	TSY	RSO	RSY	FAO	FAY	WO	WY
58	8967	0.473	0.495	0.403	0.363	2.179	2.069	1.779	1.079	0.164	0.233	1.463	1.221
59	13171	0.425	0.547	0.355	0.315	1.959	1.994	1.059	0.794	0.176	0.226	1.463	0.909
60	1703	0.403	0.504	0.383	0.343	2.826	1.959	1.926	0.759	0.187	0.217	1.505	1.179
61	685	0.383	0.504	0.363	0.323	2.584	1.728	1.594	0.778	0.127	0.171	1.354	1.434
62	869	0.214	0.308	0.194	0.154	1.717	2.366	0.817	1.166	0.150	0.138	2.112	1.434
63	13086	0.376	0.598	0.356	0.316	2.006	1.844	1.146	0.644	0.140	0.166	1.110	1.250
64	13088	0.416	0.594	0.396	0.356	2.110	2.017	0.910	1.117	0.118	0.150	0.923	1.108
65	4281	0.510	0.495	0.490	0.450	2.073	1.763	1.173	0.563	0.142	0.166	1.605	1.179
66	13097	0.476	0.477	0.456	0.416	1.902	1.728	1.502	0.738	0.168	0.233	1.392	1.051
67	905	0.477	0.576	0.457	0.437	1.971	1.815	1.111	0.915	0.163	0.199	1.448	1.122
68	13104	0.402	0.467	0.382	0.362	2.127	2.069	1.727	1.079	0.158	0.169	1.235	1.349
69	13105	0.355	0.477	0.335	0.315	2.052	1.907	1.152	0.707	0.161	0.224	1.364	1.108
70	9000	0.411	0.504	0.391	0.371	2.011	2.324	0.811	1.424	0.151	0.200	1.093	0.937
71	13107	0.437	0.500	0.417	0.397	2.557	2.220	1.242	1.230	0.128	0.184	1.988	1.136
72	702	0.438	0.495	0.418	0.398	1.722	1.728	0.862	0.828	0.169	0.191	2.101	1.377
73	5187	0.478	0.444	0.458	0.438	2.115	1.838	1.125	0.888	0.160	0.251	1.349	1.860
74	13119	0.407	0.529	0.387	0.367	2.011	1.798	1.611	0.808	0.166	0.252	0.321	1.420
75	6532	0.383	0.530	0.363	0.343	2.185	1.670	1.325	0.770	0.160	0.235	1.008	1.789
	GG 2	**0.221**	**0.279**	**0.200**	**0.160**	**2.524**	**2.335**	**2.201**	**0.995**	**0.136**	**0.205**	**0.350**	**0.790**
	MIN	**0.214**	**0.262**	**0.194**	**0.154**	**1.495**	**1.324**	**0.522**	**0.239**	**0.066**	**0.121**	**0.321**	**0.767**
	MAX	**0.668**	**0.678**	**0.638**	**0.598**	**2.988**	**2.453**	**2.415**	**1.953**	**0.210**	**0.254**	**2.131**	**1.963**
	MEAN	**0.481**	**0.484**	**0.440**	**0.406**	**2.257**	**1.916**	**1.406**	**0.976**	**0.154**	**0.175**	**1.340**	**1.328**
	SD	**0.08**	**0.08**	**0.07**	**0.08**	**0.39**	**0.23**	**0.47**	**0.30**	**0.02**	**0.04**	**0.37**	**0.29**
	CV (%)	**15.8**	**15.6**	**16.9**	**19.3**	**17.2**	**12.1**	**33.4**	**30.7**	**15.3**	**21.5**	**27.3**	**22.0**

Where, TPO= Total phenol old leaf (mg/100mg), TPY= Total phenol young leaf (mg/100mg), ODO= OD phenol old leaf (mg/100mg), ODY= OD phenol young leaf (mg/100mg), TSO= Total sugar old leaf (mg/100mg), TSY= Total sugar young leaf (mg/100mg), RSO= Reducing sugar old leaf (mg/100mg), RSY= Reducing sugar young leaf (mg/100mg), FAO= Free amino acid old leaf (mg/100mg), FAY= Free amino acid young leaf (mg/100mg), WO= Wax content old leaf (mg/dm2), WY= Wax content young leaf (mg/dm^2)

4.5.2. Correlation of biochemical traits with diseases and pest damage score

The correlation coefficients were estimated among nine biochemical characters with ELS, LLS, rust and *Spodoptera* damage scores. The results are presented in Table 4.10 and significant results are presented below.

Table 4.10 Correlation coefficients between biochemical traits and disease and pest score

NO	Trait	ELS	LLS	Rust	*Spodoptera*
1	Total phenol old leaf	-0.05	-0.27*	-0.16	-0.40**
2	Total phenol young leaf	-0.03	-0.17	-0.02	-0.08
3	OD phenol old leaf	-0.04	-0.30**	-0.14	-0.34**
4	OD phenol young leaf	0.03	-0.25**	-0.11	-0.26*
5	Total sugar old leaf	0.24*	0.06	0.22	-0.01
6	Total sugar young leaf	0.12	0.07	-0.02	0.07
7	Reducing sugar old leaf	0.29**	0.43**	0.26*	0.14
8	Reducing sugar young leaf	-0.10	-0.26*	-0.06	-0.11
9	Amino acid old leaf	0.02	0.01	0.05	0.01
10	Amino acid young leaf	0.14	-0.09	0.10	0.27*
11	Wax content old leaf	0.09	-0.27*	-0.06	-0.09
12	Wax content young leaf	0.06	-0.16	-0.09	-0.21

*,** Significant at P= 0.05 and 0.01 respectively

The ELS disease score exhibited positive correlations with 8 characters. Out of which, two characters viz. reducing sugars (r= 0.29) and total sugars (r= 0.24) in the older leaves were found to be significantly and positively correlated with ELS disease score. While five characters were found to be negatively correlated with ELS disease score but none of them were found to be significant.

The LLS disease score exhibited positive correlations with four characters. Among them reducing sugars (r= 0.43) in old leaves was found to be significantly and positively correlated with LLS disease score. While eight characters were found to be negatively correlated with LLS disease score. Out of which, OD phenols (r= -0.30), total phenols (r= -0.27) and wax content (r= -0.27) in old leaves, reducing sugars (r= -0.26) and OD phenols in younger leaves (r= -0.25) were found to be significantly associated with LLS disease score in the negative direction.

The rust disease score exhibited positive associations with four characters but only one character reducing sugars older leaves (r= 0.26) was found to be significant.

While eight characters were found to be negatively correlated with rust disease score but none of them were found to be significant.

The *Spodoptera* leaf damage score exhibited positive correlations with four characters. Among them only, amino acid content in young leaves (r= 0.27) was found to be significant.

While eight characters had negative correlations with *Spodoptera* damage score. Out of which total phenols (r= -0.40) and OD phenols (r= -0.34) in older leaves and OD phenols in young leaves (r= -0.26) were found to be significant.

4.6. Screening against aflatoxin contamination

Seventy five groundnut genotypes which were found to be resistant to either of the three diseases (ELS, LLS and rust) and *Spodoptera* or their combinations were tested to determine their ability to support invasion and aflatoxin production by an aflatoxigenic *A.flavus* strain. The seed infection and colonization recorded after 8 days of incubation at 28$\pm$ 1^{o}C and aflatoxin content in different germplasm accessions was determined by ELISA procedure (Fan and Chu, 1984; Morgan *et al. al*., 1986). The data are provided in Table 4.11 and the results are presented below.

Table 4.11 Mean infection and seed colonization of *A.flavus* in kernel of germplasm after 8 days of incubation

SNO	ICG	NRCG	Variety	Infection %	Colonization %	Aflatoxin Content µg/kg
1	355	13027	WHITE	50	43	19531
2	392	4296	NCAC 1302	27	18	19635
3	398	13052	VALENCIA	33	18	10729
4	1664	9130	NCAc 2679	30	21	12368
5	1697	1177	NCAc 17090	73	26	23318
6	1703	6663	NCAc 17127	47	29	11792
7	1704	6664	NCAc 17129	50	29	18812
8	1707	5177	NCAc 17132	60	32	21794
9	1709	1179	NCAc 17134	67	25	24089
10	1710	5178	NCAc 17135	57	23	15335
11	1712	13079	V 109	67	33	22661
12	4783	13128	KU NO.60	27	17	7720
13	4790	6682	Krap strain 16	87	28	11665
14	4791	9949	ICG 4791	47	14	2219
15	7353	13152	PERU NO.9	67	30	21131
16	7404	4603	V 20	73	23	18287
17	7620	9747	ICG 7620	63	25	11524
18	7881	4849	PI 215696	77	24	14554
19	7889	6703	PI 393517	70	28	20151
20	7893	4859	PI 393531	60	31	24994
21	7896	4861	PI 393646	93	40	23726
22	7897	6707	PI 405132	87	31	24551
23	7924	4873	PI 268491	50	23	16120
24	10975	11581	SPZ 503 DARK PU	63	31	11534
25	11108	11615	SPZ 503 PURPLE	67	32	33427
26	11186	11582	SPZ 488 GASP	73	32	12554
27	316	13015	GA 163	60	26	14370
28	327	13019	CATETO	60	30	19958

Table 4.11 Mean infection and seed colonization of *A.flavus* in kernel of germplasm after 8 days of incubation cont…

SNO	ICG	NRCG	Variety	Infection %	Colonization %	Aflatoxin Content µg/kg
29	329	4238	NCAc 726	50	35	12176
30	334	9185	NCAc 751	70	35	14120
31	341	13020	ACETEIRO CHICO	47	14	6826
32	352	13024	NCAC 845	33	15	21184
33	432	13056	GA 270-8	67	21	16666
34	1606	13065	LUNG TAN YOU DO	23	10	9979
35	1662	9236	NCAc 2673	67	25	15882
36	1669	9237	NCAc 2737	73	29	16717
37	4749	6536	PI 337394F	20	20	50988
38	5156	13132	F 1-79	53	23	32889
39	1654	841	NCAC 2563	43	22	74416
40	2248	4282	NCAc 12	97	37	78776
41	2327	894	NCAC 2479	67	29	11090
42	2331	13099	VIRGINIA RED	90	30	13585
43	2385	13112	DHT 193	77	26	44613
44	5129	952	NCAc 17892	67	28	65835
45	5164	13133	NCAC 17587	63	20	57431
46	5967	13135	KANYOMA	67	29	91119
47	6121	9519	NCAc 1455	47	24	36868
48	6183	13139	S 183	63	29	130109
49	6862	13147	NCAC 2491	50	20	22192
50	7360	4559	101/66/1	60	25	90679
51	7637	13157	M 107-74 K	63	19	40558
52	7664	4751	NCAc 17672	50	18	9906
53	7676	9790	ICG 7676	57	23	54630
54	7696	13158	EGRET	50	21	11269
55	7749	4802	M 380-72	43	22	63612
56	7892	6705	PI 393527 B	63	28	10355
57	7900	6708	PI 414332	90	36	67307
58	10884	8967	KSSc 399	67	19	46298
59	11269	13171	RM 70-1	57	27	47570
60	1656	1703	NCAC 2575	50	16	74849
61	2271	685	NCAc 343	57	30	90598
62	2273	869	NCAC 505	43	20	90176

63	2281	13086	BADAMI ZAMINI	40	21	54523

Table 4.11 Mean infection and seed colonization of *A.flavus* in kernel of germplasm after 8 days of incubation cont…

SNO	ICG	NRCG	Variety	Infection %	Colonization %	Aflatoxin Content μg/kg
64	2285	13088	NCAC 759	53	22	12204
65	2296	4281	NCAc 1107	43	12	7531
66	2326	13097	NCAC 2475	60	23	7230
67	2352	905	NCAc 2785	47	22	11640
68	2360	13104	G 68	37	14	5180
69	2361	13105	GA 139	53	17	7464
70	2363	9000	G 44	20	11	5378
71	2370	13107	GA 124-B	90	30	9812
72	2377	702	NCAC 2945	73	32	12749
73	4750	5187	PI 337409	60	28	6905
74	4765	13119	KU NO.225	53	31	7404
75	5042	6532	NCAc 2232	50	19	3784
			GG 2 (Susceptible check)	**93**	**40**	**23726**
			Minimum	**20**	**10**	**2219**
			Maxixum	**97**	**43**	**130109**
			Mean	**58**	**25**	**28822**
			SD	**17**	**7**	**26894**
			CV (%)	**29**	**27**	**93**

The seed infection ranged as low as 20% (PI 337394 F and GG 44) to as high as 96.6% (NCAc 12). The mean seed infection among all the materials studied was 57.9%, while co-efficient of variation for seed infection was 29.4%.

Among all the genotype studied, seed colonization ranged from 10.4 (LUNG TAN YOU DO) to 43.3% (WHITE). The mean seed colonization was 24.9% and the co-efficient of variation was 27.1%.

The aflatoxin content ranged form 2219.3 (ICG 4791) to 130108.9 µg/kg (S 183). The mean aflatoxin content was 28821.5 µg/kg, while co-efficient of variation for this traits was 93.3%

Among all the 75 germplasm studied, none of the genotypes was found immune to aflatoxin contamination. However, six genotypes (ICG 4791, ACETEIRO CHICO, LUNG TAN YOU DO, NCAc 1107, G 68, G 44) were found to be resistant to seed colonization.

Chapter 5 Discussion

Although, the groundnut production in India suffers from proverbial instability and low yields, cultivated groundnut, a relatively recent introduction to our country, may be considered as a crop of remarkable adaptability. The acreage under groundnut in the country, which was around 0.3 million acres before the beginning of the 20th century rapidly grew to almost 12 million acres by 1950. Presently, it is grown in about 17 to 18 million acres or 7.6 million hectares (Singh and Basu, 2005). Such a rapid spread to almost all parts of the country in a period of about 80 years accounts for its wider adaptability. The cultivation of the crop was under low levels of management and was generally relegated to marginal and sub-marginal holdings from the inception. One result flowing out of this situation is that genes for high yields have been generally eroded in the populations and have given away to the genes conferring adaptability. In the absence of essential inputs like plant-protection measures (in fact the major input in areas where the crop is extensively under rainfed conditions is seed only), the pest and disease build up has assumed alarming proportions threatening the very existence of the crop itself. So there is an urgent need to develop new strategies to put back genes for higher productivity and to introduce genes for pest and disease resistance in cultivars of groundnut apart from developing low-cost and efficient means of crop husbandry (Reddi, 1980).

For any crop improvement programme, it is a pre-requisite to maintain genetic variability to identify promising genes from among the genetic resources available and to incorporate the desired genes in the development of improved cultivars. In this direction, extensive collection of various genetic resources in groundnut has been under taken since 1970 among the several groundnut growing countries. After the formation of International Board of Plant Genetic Resources Institute (IPGRI) in 1974 and the inclusion of groundnut as a mandate crop at International Crops Research Institute for Semi-arid Tropics (ICRISAT) at Hyderabad, India during 1976 (which has been accredited as the world repository for groundnut germplasm), systematic collection, evaluation, maintenance and conservation of groundnut genetic resources got a new fillip. Presently, ICRISAT holds about 15,500 accessions of both cultivated and wild *Arachis* species, and these have been extensively characterized and large number of accessions have been identified for various desirable traits (Amin *et al.* 1983, Subrahmanyam *et al.* 1983).

The National Research Centre for Groundnut (NRCG) is identified as the National Active Germplasm Sites (NAGS) for groundnut under the Indian Plant Genetic Resources System (IPGRS). About 6000 accessions are being maintained in the working collection for evaluation and further utilization.

In addition to the existing germplasm available at NRCG, the accessions received under the repatriation programme would enhance the working collection for further characterization, screening and utilization. Hence, 367 germplasm accessions received under the repatriation programme during Kharif 2001 from ICRISAT were characterized for 19 qualitative and 26 quantitative characters. The salient findings in respect of qualitative and quantitative traits are discussed below.

5.1. Morphological characterization of 367 germplasm

5.1.1. Characterization for 19 qualitative characters

19 qualitative characters studied among different germplasm revealed that among the four botanical varieties, Spanish (VUL) forms had the maximum (96 out of 257 germplasm) number of germplasm exhibiting decumbent-3 type of growth habit followed by Virginia bunch (HYB) (76/257 germplasm) and Valencia (FST) (69/257 germplasm) forms. While among the Virginia runner (HYR) forms, decumbent-2 (19/44 germplasm) and decumbent-3 (16/257 germplasm) were predominant. Bhagat and Lalwani (1981) also observed similar results in 1310 groundnut germplasm characterized, by them.

Pigmented stems were more common in all the accessions of the four botanical varieties studied. Similarly, the stem surface was with sub-glabrous hairs in one or two rows along the main stem. Rajgopal *et al.* (1997), Chandran *et al.* (2003) and Rajgopal *et al.* (2004) also observed the similar results in various germplasm.

Standard petal colour was mostly orange (5 A 7) in most of the germplasm accessions studied with a few accessions exhibiting garnet colour. Singh and Simpson (1994) have screened 12160 accessions of groundnut and reported that range of flower colour in these germplasm was very narrow.

Excepting for FST forms, the pegs were pigmented among the germplasm which belonged to the other three botanical forms. Similar observations were also recorded by Chandran *et al.* (2003).

The leaf colour ranged from light green to green with a few accessions exhibiting dark green colour. Green to dark green leaf colour was observed by Singh and Simpson (1994) in their studies. The leaflet surface was almost glabrous above and with hairs below mostly in case of HYB germplasm, while leaflets with bristles below were more common in FST types (90/193 germplasm) followed by FST germplasm.

Slight to moderate pod beak was more predominant in all the germplasm studied with slight to moderate constriction. Pods were usually reticulated among the germplasm studied and in a few cases they were prominent. Pod and seed size were almost medium in all the material studied. Testa colour was widely variable in FST types while the most common testa colour among the genotypes studied were salmon, followed by rose, grayish red (8 B 3) and red (10 B 7). Singh and Simpson (1994) reported cultigens having greater variability for pod characteristics due to different selection processes. They have indicated that genotypes differ from deep to almost no pod constriction, and from prominent to essentially smooth pod surfaces. They added that some accessions had distinct beaks while others have no beak at all with a pod length ranging from 1 to 9 cm. Considerable variation in seed size was also common among the germplasm characterized by them.

From these observations, it could be observed that the majority of the germplasm had medium pod and seed size with a wide array of seed colour. The pod, seed size and the colour of the testa play a major role in determining market value of the groundnut. Hence, the available spectrum of variability for these characters among the germplasm studied indicated the usefulness of the germplasm studied especially in the breeding programme. The variability in pod beek, pod constriction, pod reticulation and in testa colour was also earlier reported by Gill and Joshi, 1980; Bhagat *et al.,* 1985 and Rajgopal *et al.,* 1997.

Akin to pod and seed size, pod constriction also plays a vital role in deciding the market value of groundnut. The germplasm accessions studied had slight to moderate levels of constriction and reticulation, there by, would result in high shelling out turns and in turn high kernel yields. The pigmentation on stem and peg may play a decisive role as markers especially to identify the true F_1 hybrids from among the selfs.

5.1.2. Characterization for 26 quantitative traits

Among 26 quantitative characters studied the salient findings in respect of yield and its components alone are discussed below.

The days to germination ranged between 7 to 9 days among the germplasm studied. The co-efficient of variability for this trait was low (8.1%) indicating the uniformity in germination and initial vigor of the seeds. Rajgopal *et al.* (2003) observed moderate variability in case of days to germination among the 596 germplasm. They found co-efficient of variation among the germplasm studied for this trait was 15.6%.

The days to initial flowering was as quick as 14 days (NCAc 266) and as late as 32 days (NCAc 218) and the co-efficient of variation was low (11.1%). The wide range observed for the days to flowering will help the breeders to exercise their selection for early as well as late flowering types to suit their breeding objectives. Shelter (1974) also reported the greater variability for days to initial flowering.

The plant height measured in terms of height of main axis, ranged from 25.0 to 76.5 cm. The pod mass per plant was as low as 3.92 to 45.2 g with a high variability of 31.0%. Pod yield (g)/m^2 ranged from 51.6 to 256.1 g. These two characters indicated that sufficient variability for pod mass and pod yield existed among the germplasm studied and can be used in breeding programmes aiming at higher yield in groundnut. For both the characters, many workers have found greater variability (Kuriakose and Joseph, 1986; Reddy *et al.,* 1986; Azad and Hamid, 2000 and Rajgopal *et al.,*2003).

Similarly, hundred pod mass and hundred seed mass were also found to be highly variable (49.8 to 274.5 and 24.3 to 72.0 g respectively) among the germplasm studied. The pod and seed size are the important traits deciding the market value of groundnut. The wide spectrum of variability observed for these two market traits offer enormous scope to suit the crop improvement programmes targeted towards improved marketing quality in groundnut. Several studies have also revealed the presence of wide variation in respect of pod and seed mass in many groundnut germplasm. (Shelter, 1974; Kumar and Yadav, 1979, Qudri and Khunti 1982; Kuriakose and Joseph, 1986 and Rajgopal *et al.*, 2003).

The percent sound mature seed which indicates the uniformity in the seed size ranged from 65.3 to 98.9% with a very low (4.6%) variability. Rajgopal *et al.* (2004) also reported a low variability in case of sound mature seed but among the cultivated groundnut varieties.

From the results on characterization of 367 germplasm studied it was observed that sufficient variability existed for yield and its related traits and marketing qualities, which could be used in breeding programme for increasing groundnut yields.

5.2. Screening of the germplasm accessions against diseases and pest.

Groundnut crop is attacked by many diseases especially during Kharif season, to a much larger extent than many other crops. The relative economic importance of groundnut diseases, in different countries varies depending upon the variety grown, local cultivation practices, the environment and the cropping patterns. Some diseases are widely distributed and cause economic crop losses, while others are restricted in distribution and are not considered economically important. Among the foliar fungal diseases, leaf spots [early (*Cercospora arachidicola* Hori.) and late (*Phaeoisariopsis personata* Berk. & Curt) leaf spot] and rust (*Puccinia arachidis* Speg.) are economically important in India, which are widely distributed and can cause yield losses in susceptible genotypes to the extent of 70 per cent when they occur together. But losses vary considerably from place to place and between seasons.

Both early and late leaf spots are commonly present wherever groundnut is grown. However, the incidence and severity of each disease varies with localities and seasons and there can be both short and long term fluctuation in their relative proportion (Kolte, 1984, McDonald *et al.,* 1985). In India, early leaf spot is more prevalent in northern groundnut growing states

(Fig. 5.1). Recently, it started assuming serious proportion in southern and central states of India also.

Late leaf spot is more severe in southern and central India. In India, this diseases is, however, more severe than early leaf spot. Both early and late leaf spots together cause damage to the plant by reducing the photosynthetic area, by intense lesion formation, and by stimulating leaflet abscission. Yield losses range from 10 to 50 per cent worldwide, but vary considerably from place to place and with seasons (Mc Donald *et al.* 1985).

While in India, losses in yield due to the leaf spots have been estimated to be 15 to 59 per cent (Sundarum, 1965, Sulaiman, 1966, Ghewande *et al.,* 1983). Where chemical control is rare, average losses exceeding 50 per cent are quite usual (Garren and Jackson, 1973). The losses caused in combination with rust are generally substantial (Ghuge *et al.,* 1981, Ghewande *et al.,* 1983, McDonald *et al.*, 1985, Vidyasekaran, 1981). Besides the loss in yield of kernel, the value of the fodder is also adversely affected (Cummins and Smith, 1973).

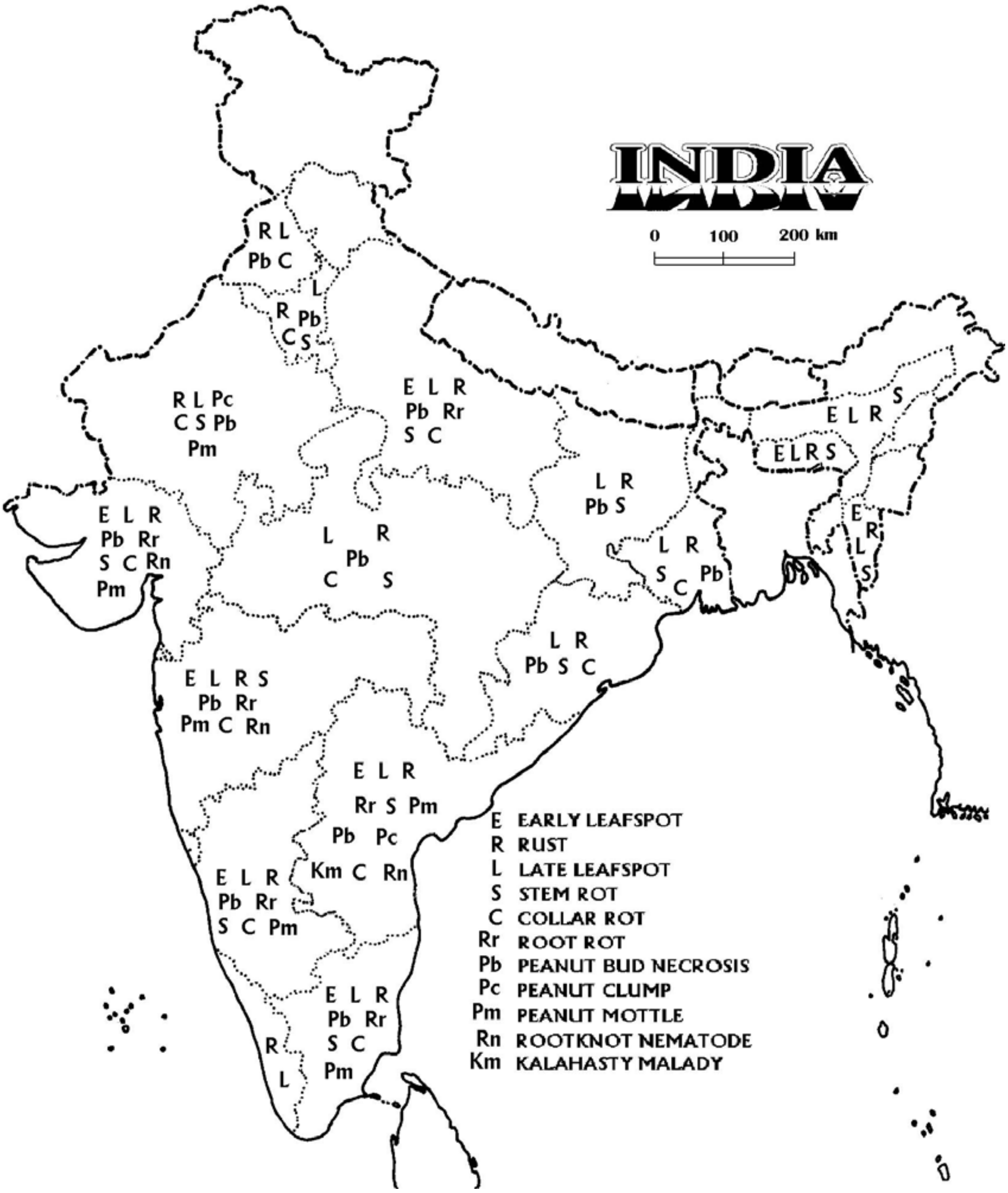


Figure. 5.1 Distribution pattern of diseases of groundnut in India

After the initial report of groundnut rust from Punjab in India (Chahal and Chauhan, 1971) there have been records of its incidence from different parts of the country (Bhama 1972, Mishra and Mistra 1975, Ramakrishanan and Subbayya, 1973, Shinde and More, 1975, Singh 1978). Rust was severe particularly in the southern states of India (Subrahmanyam *et al.*, 1978). Surveys conducted by the National Research Centre for Groundnut (NRCG), Junagadh during the rainy season of 1980-81, 1981-82, 1982-83 revealed that rust with moderate to heavy severity was distributed in all groundnut growing districts of Saurashtra region of Gujarat (Ghewande and Misra, 1983). Rust was present in almost all rabi/ summer groundnut cultivation areas in India (Subrahmanyam and McDonald 1986). In India, losses in yield due to rust alone have been reported to be in the range of 10-52 per cent depending upon the variety (Ghuge *et al.* 1981, Ghewande *et al.* 1983, Siddharamaiah *et al.* 1979, Subrahmanyam and McDonald 1986). Considering the magnitude of losses, and extent of prevalence, rust is now of economic important in almost all groundnut growing area of the country. In addition to the direct yield losses, rust disease can also lower seed quality by reducing seed size, oil content and quality (Reddy *et al.* 1988).

Although several chemicals are available to control these diseases, they not only add to the total cost of production but also bring in grave concern over the environment and food safety. Hence, it is considered that the development of disease resistant cultivars would be the most effective and practical solution especially for the resource limited peasant farmers in the whole of semi-arid tropics.

Before developing varieties with inbuilt resistance/tolerance to any disease, identification of suitable sources of resistance (which can be used as a ‘donor’ in the breeding programmes) is very essential. And with this objective in mind the new and novel sources of variability, i.e. 367 germplasm accessions received through repatriation programme from ICRISAT were subjected initially to field screening (Preliminary screening) during kharif season 2001 for all the three diseases.

From the preliminary screening, 54 genotypes were found to be resistant to ELS, of which the genotype NCAC 759 was found to be highly resistant (2.0) followed by KU NO.225 (2.1). Similarly for LLS, 44 genotypes were found to be resistant, of which the genotype F 1-79 had high (2.0) level of resistance to LLS.

In case of rust, 27 genotypes were resistant, while the genotype PI 393517 exhibited very high degree (2.1) of resistance when compared to others.

While for the only serious pest screened i.e. *Spodoptera litura,* 24 genotypes were found to be resistant. The genotype, NCAc 2679 exhibited high (1.2) degree of resistance *Spodoptera*.

Of the 367 germplasm screened for ELS, LLS, rust and *Spodoptera,* 75 germplasm were found to be resistant to either ELS, LLS, rust and spodoptera or in combination. These accessions were screened for two more years during Kharif season (2002 and 2003) to confirm their resistance under field conditions to ELS, LLS, rust and *Spodoptera* (Confirmative screening). The genotypes were screened in a replicated trial along with an infector row comprising susceptible genotype, GG 2 between every two rows. To ensure the optimum disease pressure, the inoculum was sprayed in the infector rows.

Under confirmative screening, during first year, 25 genotypes were found to be resistant to ELS; two genotypes (PI 405132 and PI 215696) were found to be resistant to LLS; 19 genotypes were found to be resistant to rust and two genotypes (NCAc 1302 and NCAc 17090) were found to be resistant to *Spodoptera.*

During the second year, 14 genotypes showed resistance to ELS; 34 genotypes showed resistance to LLS; 6 genotypes (ICG 4791, NCAC 1302, NCAc 17090, NCAc 12, VALENCIA, NCAc 17129) showed resistance to rust disease and 33 genotypes were resistant to *Spodoptera* respectively.

During both years, one genotype, NCAc 17129 showed resistance to ELS (1.2 and 3.0); two genotypes namely PI 215696 (1.8 and 1.8) and PI 405132 (2.6 and 1.6) were found to be resistant to LLS, two genotypes viz. NCAc 1302 (2.5 and 1.8) and NCAc 17090 (1.6 and 2.4) were found to be resistant to rust and one genotype NCAc 1302 was found to be resistant (2.5 and 1.2) to *Spodoptera*.

Although screening of germplasm and other advanced breeding lines were done at several places for these diseases, systematic screening especially of the germplasm was rather less. The ICRISAT, had systematically evaluated the world collection of germplasm numbering about 13,000 accessions collected from 86 countries for their reaction to ELS, LLS and rust (Subrahmanyam *et al.* 1995). It was observed that of the 13,000 germplasm screened 124 lines were found to be resistant to rust, 54 lines resistant to late leaf spot and 29 were found to be resistant to both the diseases.

Reliable sources of resistance to foliar fungal diseases were identified by Muthusamy *et al.* (1991) after extensive field trial under rainfed and irrigated conditions over six years. The genotypes, PI 259747, PI 405132, PI 215696, NCAc 17132, NCAc 17135 and NCAc 17133 RF were resistant to LLS, rust and *Alternaria alternata.* Among progenies of crosses between FESR and POL 2, screened by them for nine generation, VG 80 and VG 81 showed resistant to rust and tolerace to LLS.

Four germplasm lines, ICGVs 86687, 86675, 86680 and 86694 were reported to possess resistant to ELS coupled with higher yield (Satish *et al.* 1992). Based on the consistency of the genotypes for their reaction to ELS, Ghewande *et al.* (1992) reported five germplasm lines (NCAc 927, NCAc 17149, NCAc 17133, PI 393646 and PI 341879) as reliable sources of resistance for ELS.

Dinakaran *et al.* (1992) reported five sources of resistance from the germplasm screened by them namely, PI 215696, NCAc 927, EC 76446 (292), PI 350680 and PI 259747 for both LLS and rust.

Six genotypes and four susceptible controls (Girnar 1, JL 24, TMV 2 and KRG 1) were evaluated for LLS and rust resistance. R 8972 was the most resistant to LLS and rust, with scores of 3.0 an 2.5 respectively in 1-9 scale. R 8972 served as donor parent in hybridization embarked upon with JL 24, TMV 2 and KRG 1 to evolve disease resistant, high yielding cultivars (Gopal *et al.* 1984).

Of the 979 groundnut germplasm accessions screened by Mehan *et al.* (1996) for resistant to rust and LLS, 38 were found to be resistant to rust and 7 for LLS. The genotypes, ICG Nos 6843, 10890, 11567 and 12112 showed resistant to both the fungal disease. Adiver *et al.* (1997) reported three genotypes, ICG 2760, ICG 6330 and ICG 6284, which exhibited combined resistance of LLS, and rust, which is desirable in the disease endemic transitional zones of Karnataka.

Table 5.1 Habit group wise mean disease scores obtained by resistant germplasm

	Botanical type			
Sub species	***hypogaea***		***fastigiata***	
Disease	**Bunch (HYB)**	**Runner (HYR)**	**Spanish (VUL)**	**Valencia (FST)**
ELS	-	-	-	8 (53 %)
LLS	-	-	-	3 (20 %)
Rust	1 (7 %)	-	-	7 (47 %)
Spodoptera	-	-	1 (7 %)	7 (47 %)

After two years of confirmative screening, it was observed that only 15 germplasm (Table 5.2) were found to be resistant to ELS, LLS, rust and *Spodoptera* indicating the paucity of resistance to these economically important biotic stresses. Few sources of resistance from among 15000 germplasm screened for various biotic stresses including the three diseases and a pest studied have also been identified and documented (Singh *et al*., 1997).

Among these germplasm resistant to ELS (8 genotypes), LLS (3 genotypes), rust (7 genotypes) and *Spodoptera* (7 genotypes) was found only in the sub-species *fastigiata* and the botanical variety *fastigiata.* Whereas among the sub-species *hypogaea* the resistance was almost nil to ELS, LLS and *Spodoptera* except for one genotype (M 107-74 K) which was found to be resistant (3.0) to rust (Table 5.1).

An intensive screening programme was undertaken at ICRISAT Asia Centre, Hyderabad, India which involved more than 10,000 germplasm accessions including a wide array of wild species representing five sections of the genus *Arachis* between 1977 and 1984 under natural disease pressure. Several genotypes were found to be resistant to rust and grouping them based on botanical variety indicated that about 90 per cent of them belonged to the variety Valencia of *ssp fastigiata,* while less than 10 percent belonged to the variety hypogaea of *ssp hypogaea* and none in the vulgaris group. (Rao, 1980; Rao and Sadasivam, 1983; Subrahmanyam *et al.,* 1987; Subrahmanyam and McDonald,1987), as observed in the present study.

Study of all the available rust resistant genotypes revealed that about 84 per cent of them originated in South America or had South American distribution, mostly (74 per cent) originating from Peru. Hence it is probable that variety vulgaris does not include rust resistant types since Spanish forms are not known from Peru (Krapovickas, 1969; Subrahmanyam *et al.* 1989).

Perusal of the geographical origin of the resistant germplasm thus identified indicated that germplasm resistant to ELS and LLS originated from Peru and Venezuela; rust resistant germplasm originated from Peru, Venezuela and Nigeria, while *Spodoptera* resistant germplasm originated from Peru, Nigeria and Japan. Among the 15 resistant germplasm, origin of two germplasm was unknown and thus confirming the earlier reports.

Table 5.2 Geographical origin of the resistant germplasm identified.

Sr. No	Genotype	Country of origin	LLS	ELS	Rust	*Spodoptera* Damage
1	NCAc 17127	PER	+	+	+	+
2	NCAc 17129	PER	-	+	+	-
3	NCAc 17134	PER	-	+	-	+
4	NCAc 17090	PER	-	+	+	+
5	NCAc 1302	UNK	-	-	+	+
6	NCAc 17132	PER	-	-	-	+
7	NCAc 17135	PER	-	-	-	+
8	PI 405132	VEN	+	+	+	-
9	PI 215696	PER	+	-	-	-
10	PI 393531	PER	-	-	+	-
11	ICG 4791	NGA	-	+	+	+
12	ICG 7620	UNK	-	+	-	-
13	V 20	ZWE	-	+	-	-
14	M107-74 K	NGA	-	-	+	-
15	LUNG TAN YOU DO	JPN	-	-	-	+

PER = Peru, UNK= Unknown, VEN= Venezuela, NGA= Nigeria, ZWE= Zimbabwe, JPN= Japan

5.3. Anatomical basis of resistance to diseases and pest

ELS, LLS and rust are the three major foliar fungal diseases causing severe yield losses in groundnut in India. It is now being observed that several physical obstacles present either at the leaf surface or in the tissues of the plant make it difficult or impossible for the entry or spread of the pathogen within the host plant. Certain structural characteristics are being formed as soon as plant is attacked by the pathogen. These structural characteristics present or form following infection appear to defend the plant against invasion or attack by pathogen. It is expected that the leaf level resistance in different genotypes may differ in their response to such foliar diseases following infection. To test this possibility, genotypes which showed resistance to ELS, LLS, rust and *Spodoptera* leaf damage during the preliminary screening were examined and compared with different leaf anatomical characters. It is possible that resistant/ tolerant genotype may possess certain inherent leaf characteristics, which inhibit the diseases progression.

The salient results observed in respect of each of the anatomical traits studied are presented and discussed below.

Trichomes were uniseriate with 2-3 basal cells and an elongated apical cell in all the accessions studied. Their length on leaf margin ranged from 0.3 (PI 393517 and NCAc 17672) to 1.8 mm (ICG 7620). The mean tricome length was 1.2 mm among all the genotypes studied. The co-efficient of variation for this trait was 37.1%. The trichome density ranged from 9.3 in (NCAc 17129) to 27.1/ mm (NCAc 1302). Mean tricome density was 18.7 /mm with a co-efficient of variation 11.3%.

The stomatal type was mainly paracytic with one subsidiary cell (Plate 12) in all the accessions studied. Their average length ranged from 15.4 (NCAc 17127) to 25.2 μm (NCAc 2232). The mean stomatal length at abaxial surface among all the 75 germplasm studied was 18.9 μm and the co-efficient of variation for this trait was 13.4%. The average stomatal width at abaxial surface ranged from 11.2 (NCAc 343) to 19.8 μm (EGRET). The mean stomatal width among the germplasm studied was 15.2 μm with a co-efficient of variation of 15.3%.

The average stomatal length at adaxial surface ranged from 12.9 (NCAc 17127) to 22.7 μm (NCAc 2232). The mean value for this character among all the 75 germplasm studied was 16.4 μm and the co- efficient of variation was 15.4%. The average stomatal width at adaxial surface ranged from 10.8 (NCAc 17127) to 19.7 µm (NCAc 2232). The mean stomatal width at adaxial surface among the germplasm studied was 16.4 µm with a co-efficient of variation of 17.1%.

In general, the accessions having larger leaflet size showed lower stomatal frequency. The number of stomata ranged from 66.4 to 143.2/mm^2. The number of stomata was the least (66.4/mm^2) in the genotype, NCAc 751 while it was greater (143.2/mm^2) in NCAC 845. The mean stomatal frequency was 112.6/mm^2 with a co-efficient of variation of 16.9%. The number of stomata on adaxial surface ranged from 62.2 (CATETO) to 150.1/mm^2 (NCAc 17587). The mean stomatal frequency at adaxial surface was 117.9/mm^2 with a co-efficient of variation of 16.1%.

The number of tannin cells/mm of leaves ranged from 2.8 to 9.8/mm. The tannin cells were minimum (2.8/mm) in genotype, NCAc 1455 while the tannin cells were maximum (9.8/mm) in genotype, ICG 7620. The mean number of tannin cells among all the genotypes studied were 6.8/mm and co-efficient of variation for this trait was 25.4%.

Critical analysis (Table 5.3) of anatomical features of the resistant genotypes in comparison to the susceptible genotype, GG 2 revealed the following observations:

Tricome length

Among the 15 resistant genotypes, trichome was longer when compared to the susceptible check, GG 2 except for NCAc 17132 (0.4 mm) and NCAc 17129 (0.6 mm). This indicates that in these two genotypes, resistance may be governed by traits other than trichome length. Similar results were also observed by Dwivedi *et al.* (1986) and Jasbir *et al.* (1988).

Among the germplasm studied, the trichome length was the highest in ICG 7620 followed by LUNG TAN YOU DO (1.7 mm).

Trichome density

Dense trichomes were observed in resistant genotypes as compared to the susceptible check, GG 2. The germplasm, NCAc 1302 exhibited dense trichomes (27.1 /mm) followed by NCAc 17134 (24.2 /mm) among the resistant germplasm. While only one resistant genotype, NCAc 17129 showed very few (9.3 /mm) trichomes as compared to GG 2.

Length of Stomata at abaxial surface

The length of stomata at abaxial surface of resistant germplasm was shorter when compared to susceptible check, GG 2. Stomatal length at abaxial surface was the shortest in PI 405132 (18.2 μm) while susceptible check, GG 2 had longer (24.4 μm) stomata at abaxial surface.

Table 5.3 Anatomical characters associated with the resistant genotypes

Sr. No	Genotype	TL	T D	STL ab	STW ab	STL ad	STW ad	St/mm ab	St/mm ad	TC
1	NCAc 17127	1.6	18.4	15.4	11.4	12.9	10.8	78.3	85.3	7.8
2	NCAc 17129	0.6	9.3	21.4	17.9	18.9	17.1	125.2	134.2	8.9
3	NCAc 17134	1.3	24.2	16.3	13.4	13.8	11.7	109.8	116.8	8.8
4	NCAc 17090	1.2	21.4	19.4	16.8	16.9	14.1	106.4	117.4	8.8
5	NCAc 1302	1.7	27.1	19.1	16.2	16.6	14.7	117.8	128.8	5.9
6	NCAc 17132	0.4	16.7	17.1	14.8	14.6	12.7	128.0	139.0	6.9
7	NCAc 17135	1.4	17.0	16.5	13.2	14.0	12.1	131.5	142.5	5.7
8	PI 405132	1.5	22.3	16.2	12.2	13.7	11.6	76.8	83.8	9.8
9	PI 215696	1.4	21.0	21.2	17.2	18.7	15.4	90.9	97.9	9.2
10	PI 393531	1.6	18.5	21.3	17.8	18.8	17.0	121.1	130.1	6.4
11	ICG 4791	1.4	17.0	16.5	13.0	14.0	11.9	106.0	115.0	7.6
12	ICG 7620	1.8	18.8	17.1	13.6	14.6	12.7	112.2	121.2	9.8
13	V 20	1.4	18.0	22.2	18.7	19.7	17.8	100.9	108.9	6.7
14	M107-74 K	1.0	20.0	16.4	12.3	13.9	12.0	120.0	131.0	8.5
15	LUNG TAN YOU DO	1.7	19.3	16.3	13.5	13.8	11.9	123.8	134.8	5.7
	GG 2 Susceptible check	**0.4**	**9.5**	**24.4**	**18.4**	**20.3**	**15.4**	**125.4**	**111.3**	**4.2**

Where, TL= Tricome length mm, TD = Tricome density no/mm, STL ab = Stomatal length abaxial surface µm, STW ab = Stoamtal width abaxial surface µm, STL ad = Stomatal length adaxial surface µm, STW ad = Stoamtal width adaxial surface µm, St/mm ab = No of stomata/mm abaxial surface, St/mm ad = No of stomata/mm adaxial surface, TC = No. of tannin cells/mm

Stomata width at abaxial surface

Among the resistant genotypes, the width of stomata at abaxial surface was lower as compared to susceptible check, GG 2 (18.4 µm). The stomatal width at abaxial surface was lesser in NCAc 17127 (11.4 µm) followed by PI 405132 (12.2 µm)

Stomata length at adaxial surface

Among the resistant genotypes studied, length of stomata at adaxial surface was lesser when compared to GG 2 (20.3 µm). The germplasm NCAc

17127, exhibited the shortest stomatal length at adaxial surface (12.9 μm) followed by PI 405132, NCAc 17134 and LUNG TAN YOU DO and (13.8 μm).

Stomata width at adaxial surface

Among the resistant genotypes, width of stomata at adaxial surface was lesser than susceptible check, GG 2 except for four genotypes (NCAc 17129, PI 215696, PI 393531, V 20). Stomata at adaxial surface was the shortest in NCAc 17127 (10.8 μm).

Number of stomata at abaxial surface

Number of stomata on abaxial surface in all the resistant genotypes were fewer than susceptible check, GG 2 except in one genotype, NCAc 17132 (128/mm^2). The number of stomata on abaxial surface was very few (76.8/mm^2) in case of PI 405132 followed by NCAc 17127 (78.3/mm^2).

Number of stomata at adaxial surface

Frequency of stomata at adaxial surface was higher in 11 genotypes as compared to susceptible check, GG 2. While three genotypes had very low stomatal frequency at the adaxial surface than susceptible check.

Tannin cells

Number of tannin cells were found to be more in all resistant genotypes studied when compared to GG 2. The number of tannin cells were more (9.8 mm^2) in genotype, PI 405132 and ICG 7620. While the susceptible check, GG 2 recorded less (4.2 mm^2) number of tannin cells.

From the studies on the anatomical features of the resistant germplasm it is evident that resistant genotypes had longer and dense trichomes and smaller stomata (in term of length and width) on both abaxial and adaxial surface when compared to the susceptible genotypes.

Interestingly, the number of stomata on the abaxial surface were fewer in resistant genotypes while on the adaxial surfaces the number of stomata were more. The tannin cells were, in general, were high among the resistant genotypes than the susceptible genotype.

The leaf spots of groundnut caused by ELS and LLS are the major cause of premature defoliation and losses in pod yield. These pathogens have been reported to penetrate the leaf not only through the stomata but also through lateral faces of the epidermal cell on both the surfaces of the leaf (Bera *et al.,* 1977). Studies on the anatomical characteristics of groundnut leaf in relation to resistance leaf spot are very meager and inconclusive.

Some studies carried out to relate the structural variations for leaf characters with disease incidence indicated that genotypes with resistance to LLS had lowest stomatal frequency and size when compared with moderately susceptible and susceptible genotypes (Sukhwinder *et al.* 1989).

In another study, structural variations were observed for leaf characters in uninfected and diseased leaves of four groundnut genotypes varying in their level of resistance/tolerance to leaf spot disease, LLS in particular. Total leaf area per plant and leaf hair density was higher in the resistant genotypes. Susceptible genotypes, especially in the lower leaf surface, possessed larger stomata with wider apertures than resistant genotypes (Bera *et al.* 1997). It is suggested that the presence of thick palisade and spongy layer in the leaves of these genotype restrict leaf spot Pathogen growth.

Five germplasm accessions resistant to LLS (NCAc 17133, PI 259747, PI 381622, PI 390595 and PI 4051321) were screened together with two susceptible cultivars (JL 24 and UF 70-103) for morphological and anatomical features by Mayee and Suryawnshi (1995). Resistant genotypes were characterized by smaller and fewer stomata, a compact palisade layer, a thicker epidermis-cum-cuticle and trichomes on the abaxial surface of leaves.

The results of the study conducted by Kaur and Dhilllon (1988) revealed that the varieties of groundnut susceptible to *C. personatum* infection had significantly higher frequency, index and size of stomata, and lower palisade index values. The most resistant groundnut variety (PI 259747) also had significantly higher frequency of trichomes, calcium oxalate crystals, and significantly thickest epidermis-cum-cuticle and palisase layers. These results indicated that some of these anatomical characteristics like the number and size of stomata, and the palisade index played some role in providing defense against the penetration and invasion by *C. personatum* thereby conferring resistance against this infection.

However, in the present study results converse to the findings of Kaur and Dhillon (1988) were obtained. This may be due to the fact that as reported in case of rust, the number and frequency of stomata in case of leaf spot resistance also may have less or no role to play and other factors (Physiological, biochemical and molecular) may play a role in the leaf spot resistance (Mayee and Suryawanshi*.,* 1995). In addition, genotypic and environmental variations may also play a role in the observed differences.

The rust of groundnut caused by *Puccinia arachidis* Speg. has become a serious constraint to groundnut production in recent years. Resistance in groundnut against rust is now well known (Subrahmanyan *et al.* 1982). The uredinia appears first on the abaxial leaflet surface of both resistant and susceptible genotypes and the pustule on the adaxial surface always appear opposite to those on lower surface. In the resistant types, uridinia are small in size and few in number on the lower leaflet surface and are rarely observed on the upper surface. In contrast, many large uridinia are formed on the leaflet of susceptible types and sometimes these pustules are surrounded by secondary pustules. It is known that irrespective of whether genotypes are immune, resistant of susceptible, the uridiniospores germinated on the leaflet surfaces and the germ tubes enter the leaflets via the stomata (ICRISAT, 1980). It was reported that differences in the expression of symptoms in resistant and susceptible types could be due to differences in the tissues where the rust mycelium develops.

In the present study, a statistically greater number of stomata of larger size was found in susceptible than in resistant genotypes. This could explain the reduced infection in resistant genotypes. In resistant genotypes, the size of stomata was small. It has been reported (ICRISAT, 1980) that neither size nor frequency of stomata was correlated with resistant to rust disease. Size of stomata may not be important as the fungus can easily penatrate through apertures of stomata both in resistant and susceptible types but higher stomatal frequency can lead to the entry of larger number of germ tubes as observed in the present study.

Suryakumari *et al.* (1984) reported that the number of tannin sacs was highest in the wild species, varying from 42-105 /mm^2 with a mean of 88.88 mm^2, followed by the rust, LLS and *A. flavus* resistant varieties (36-56 mm^2, mean = 45.49 mm^2). The susceptible varieties had the least tannin cells (24-40 mm^2, mean 30.83 mm^2). However, no such variation would be seen in the size (mean diameter) of the tannin sacs.

The inter association estimates between pest and diseases score and anatomical features indicated that stomatal length at abaxial surface, stomatal width at abaxial surface, stomatal length at adaxial surface and stomatal width at adaxial surface were positively and significantly associated with ELS, LLS and *Spodoptera* damage, thus revealing that greater the length and width of stomata at both abaxial and adaxial surfaces higher (susceptibility) will be the disease score and vice versa. While in case of rust, no significant association was found between the disease score and anatomical traits. While the number of tannin cells exhibited negative association with ELS and rust disease score indicating inverse relationship between these two. Although literature pertaining to tannin cells and disease resistance in groundnut are rare but not extinct (Suryakumari *et al.* 1984)

5.4. Biochemical characterization

Plants react to pathogen infection with a broad range of defense response in an attempt to restrict or prevent pathogen growth. Upon sensing the invading pathogen, plants mount a set of general defense reactions like lignification of cell wall, production of phyoalexin, synthesis and accumulation of antimicrobial proteins and biochemical compounds in addition to several other associated events (Kombrink and Somssich, 1995). Of these various biochemical compounds, phenols and their metabolic products synthesized through specific pathways assumed significance in disease resistance mechanism of several crop plants. Each reaction in the specialized pathways is catalyzed by specific enzymes whose activities are corroborated with the resistance response. However, present study was taken up to have a preliminary inquiry regarding the difference in respect of total and ortho-dihydroxy phenols, total and reducing sugar, amino acids and wax content in seventy five resistant germplasm identified after preliminary screening.

To have a better comparison of the role played by each of the biochemical traits studied in the resistance of ELS, LLS, rust and *Spodoptera,* the discussion were restricted to 15 germplasm found resistant in both preliminary and confirmative screening to either of the disease or pest or their combinations.

Total phenols

Among the resistant genotypes, total phenols were higher than in susceptible check, GG 2 in both older and younger leaves. The total phenols were the highest (0.668 mg/100g) in PI 405132 followed by PI 393531 (0.632 mg/100g) in case of older leaves.

In case of young leaves, the highest (0.639 mg/100 g) values for total phenols were recorded by LUNG TAN YOU DO followed by NCAC 17127 (0.588 mg/100 g), while the susceptible check, GG 2 exhibited less (0.279 mg/100 g) total phenol. Rathnakumar *et al*., 2004, also reported similar results.

Table 5.4 Biochemical characters associated with the resistant genotypes

Sr. No	Genotype	TPO	TPY	ODO	ODY	TSO	TSY	RSO	RSY	FAO	FAY	WO	WY
1	NCAc 17127	0.504	0.588	0.454	0.374	1.879	1.907	0.889	0.957	0.191	0.169	1.917	1.207
2	NCAc 17129	0.500	0.494	0.450	0.370	2.011	2.220	1.111	1.230	0.143	0.145	0.934	0.866
3	NCAc 17134	0.444	0.580	0.394	0.314	2.110	1.403	0.613	0.453	0.175	0.121	1.335	1.406
4	NCAc 17090	0.447	0.486	0.397	0.317	1.722	2.069	0.522	1.169	0.189	0.156	1.037	1.179
5	NCAc 1302	0.538	0.504	0.488	0.408	2.052	1.740	0.852	1.240	0.148	0.142	1.235	1.491
6	NCAc 17132	0.495	0.373	0.445	0.365	1.728	2.006	0.528	1.506	0.152	0.123	1.123	1.363
7	NCAc 17135	0.529	0.514	0.479	0.399	2.821	1.815	1.621	1.315	0.169	0.191	1.235	1.108
8	PI 405132	0.668	0.571	0.638	0.598	1.555	1.927	1.351	0.977	0.153	0.254	2.112	1.912
9	PI 215696	0.566	0.541	0.536	0.496	1.890	2.010	0.900	1.060	0.125	0.159	1.956	1.164
10	PI 393531	0.632	0.543	0.602	0.562	2.283	1.873	1.383	0.673	0.145	0.145	2.101	1.963
11	ICG 4791	0.467	0.401	0.417	0.377	2.722	2.312	1.822	1.112	0.118	0.156	1.079	1.562
12	ICG 7620	0.472	0.381	0.442	0.402	2.040	1.661	1.180	0.761	0.205	0.133	1.235	1.889
13	V 20	0.530	0.296	0.500	0.460	2.306	1.913	1.446	1.013	0.172	0.214	1.193	1.235
14	M107-74 K	0.400	0.530	0.360	0.340	2.011	1.975	0.811	1.475	0.171	0.140	1.136	1.221
15	LUNG TAN YOU DO	0.600	0.639	0.540	0.530	2.765	2.453	1.565	1.953	0.171	0.138	1.193	1.704
	GG 2 Susceptible check	**0.221**	**0.279**	**0.200**	**0.160**	**2.524**	**2.335**	**2.201**	**0.995**	**0.136**	**0.205**	**0.350**	**0.790**

TPO= Total phenol old leaf (mg/100mg), TPY= Total phenol young leaf (mg/100mg), ODO= OD phenol old leaf (mg/100mg), ODY= OD phenol young leaf (mg/100mg), TSO= Total sugar old leaf (mg/100mg), TSY= Total sugar young leaf (mg/100mg), RSO= Reducing sugar old leaf (mg/100mg), RSY= Reducing sugar young leaf (mg/100mg), FAO= Free amino acid old leaf (mg/100mg), FAY= Free amino acid young leaf (mg/100mg), WO= Wax content old leaf (mg/dm2), WY= Wax content young leaf (mg/dm2)

Ortho-dihydoxy phenols

All the resistant genotypes exhibited higher OD phenols both in older and younger leaves as compared to susceptible check, GG 2. OD phenols were more in older leaves as recorded by PI 405132 (0.638 mg/100 g) while in younger leaves it was PI 393531 (0.562 mg/100 g) which had higher phenol content. The susceptible check, GG 2 exhibited 0.200 and 0.160 mg/100 g of OD phenol in older and younger leaves respectively.

Several studies have indicated that resistant genotypes had more OD phenols than the susceptible ones (Reddy, 1983; Velazhahan and Vidhyasekharan, 1994; Gurdeep, 1998; and Rathnakumar *et al.*, 2004).

Total sugars

Total sugar content was less in all the 15 germplasm studied as compared to susceptible check, GG 2 (2.524 mg/100 g) except in three genotypes, NCAc 17135 (2.821 mg/100 g), ICG 4791(2.722 mg/100 g) and LUNG TAN YOU DO (2.765 mg/100 g) which had higher total sugar contents in case of older leaves.

While in younger leaves, total sugars were less in all the genotypes when compared with GG 2 (2.335 mg/100 g) except in LUNG TAN YOU DO (2.453 mg/100 g). Among all the genotypes total sugars were the least (1.403 mg/100 g) in younger leaves of NCAc 17134.

Inverse relationship between the sugar contents and disease susceptibility has already been reported by several workers (Suddharamaih *et al.,* 1979; Mhapatra, 1982; Patel and Vaishnav, 1986 and Rathankumar *et al.,* 2004) as observed in the present study.

Reducing sugars

All the resistant genotypes showed lesser reducing sugars content compared to susceptible check, GG 2 (2.201 mg/100 g) in case of older leaves. The genotype, NCAc 17090 exhibited the lowest (0.522 mg/100 g) levels of reducing sugars followed by NCAc 17132 (0.528 mg/100 g) in older leaves.

In case of younger leaves, all the resistant genotypes exhibited higher amount of reducing sugars when compared to GG 2, except in five genotypes viz. NCAc 17127, NCAc 17134, PI 405132, PI 393531 and ICG 7620.

Free amino acids

Free amino acids contents in older leaves of resistant genotypes were higher when compared to GG 2 (0.136 mg/100 g) except in two genotypes PI 215696 (0.125 mg/100 g) and ICG 4791 (0.118 mg/100 g). The maximum (0.205 mg/100 g) amount of free amino acids was found in ICG 7620 in older leaves.

In case of younger leaves, free amino acids were lesser when compared to susceptible check, GG 2 (0.205 mg/100 g) except for two genotypes, PI 405132 (0.254 mg/100 g) and V 20 (0.214 mg/100 g). The free amino acids were the least in NCAc 17134. Similar results were also reported by Rathanakumar *et al.*, 2004.

Epiculticular wax

Among all the resistant genotypes, epiculticular wax content was higher as compared to susceptible check, GG 2 in case of both older and younger leaves. The susceptible check, GG 2 had the least wax contents (0.350 and 0.790 mg/100 g) in case of older as well as younger leaves respectively.

The epicuticular wax content is associated with both biotic and moisture deficit stress resistance in several crop species. In case of groundnut rust, the uridiniospores usually develops from the older leaves and gradually progress toward the new leaves at apical nodes. Hence, in the new leaves of both resistant and susceptible genotypes, the wax content was high indicating that accumulation of wax may be a general defense response in arresting the pathogen ingress rather than a specific resistance response against the rust (Rathnakumar *et al.,* 2004).

It is now well established that phenols play an important role in determining resistance or susceptibility of a host to parasite infection. The accumulation of phenolic compounds due to infection by pathogens has been reported by several workers (Vidhyasekaran 1974; Arora and Bajaj, 1978; Borah *et al.,* 1978 and Arora, 1983). Phenol accumulation is usually higher in resistant genotypes than in susceptible ones (Arora and Bajaj, 1978; Patil *et al.* 1985; Bashan, 1986). Many phenols and their oxidation products such as quinines are highly toxic to invading fungi (Lyr, 1965; Hampton, 1970; Sequeira, 1983; Vidhyasekaran 1988).

In the present study the resistant genotypes exhibited higher levels of total and OD phenols, higher free amino acids and epicuticular wax contents but less total and reducing sugars as reported by various workers.

The inter association estimates between pest and disease scores and biochemical features indicated that total and reducing sugars in old leaves were positively and significantly associated with ELS disease score. In case of LLS, reducing sugars in old leaves were positively and significantly associated with disease score, while total phenol in old leaves; OD phenols in old and young leaves; reducing sugars in young leaves and wax content in old leaves showed significant but negative association.

For rust disease score only one character, reducing sugar in old leaves showed positive and significant association.

In case of *Spodoptera* leaf damage score, one trait amino acids in young leaves exhibited positive and significant association. While the associations were significant but negative in case of totals phenol in young leaves and OD phenols in old and young leaves.

From the biochemical studies it was observed that resistance to LLS and *Spodoptera* was influenced by total and OD phenols and wax contents in older leaves. Interestingly, none of the biochemical traits except for reducing sugars were found to influence rust disease score.

While, total and reducing sugars played a major role in the susceptibility of ELS. In case of LLS and rust, reducing sugars played a major role towards susceptibility.

5.5. Screening against aflatoxin contamination

India has been largest producer of groundnut in the world for the last several years, with an annual production of between 6 and 7 million metric tonnes (unshelled). Groundnut is the most important of the wide variety of oilseed crops grown in India and accounts for 50% of the total annual oilseed output of approximately 12 million tonnes.

Almost all the groundnuts produced in India are used for oil extraction. Its use as a table nut is not as widespread here as it is in some West European countries. However, India has traditionally been an exporter of handpicked selected (HPS) groundnuts, also known as edible groundnuts. Indian groundnuts are known for their nutty flavour, natural taste, and crunchy texture. However, owing to high level of aflatoxin in the Indian export commodities of groundnut and the stringent limits of aflatoxin in various produce by importing agencies the groundnut export in the country is drastically reduced there by loosing valuable foreign exchange.

Groundnut invaded by toxigenic strains of *A. flavus* in the soil before harvest can be the source of serious aflatoxin contamination during crop drying and storage if environmental condition favour continued development of the fungus. Significant fresh invasion by *A.flavus* and aflatoxin contamination can also take place during the post-harvest drying period. At harvest groundnut seeds contain about 40% moisture and are susceptible to fungal invasion until their moisture content drops below 8%. The length of the time seeds remain at critical moisture and temperature levels probably influences the amount of aflatoxin produced by *A. flavus* (McDonald and A' Brook, 1963).

Although pre and post harvest management operations are available to check the aflatoxin content in groundnut, developing of resistant cultivars to *A. flavus* is the most useful approach. Hence, a systematic effort was made to identify source of *A. flavus* resistance in the germplasm especially in those which exhibited resistance to ELS, LLS, rust and *Spodoptera* or their combination so that it can be effectively employed in the breeding programme.

In the present study, groundnut germplasm which exhibited resistant to ELS, LLS, rust or *Spodoptera* during the preliminary screening were also screened for *in vitro A.flavus* infection, colonization and aflatoxin content.

The germplasm with <15% seed colonization, with sparse growth and sporulation were regarded as resistant, 16-30% seed colonization and moderate growth and sporulation were regarded as moderately resistant and 31-50% seed colonization and moderate to dense growth were regarded as susceptible and >50% seed colonization with dense growth were regarded as highly susceptible.

The results (Table 5.5) of infection, colonization and aflatoxin production by *A.flavus* in the resistant genotypes identified through confirmative screening are discussed below.

Table 5.5 Seed infection, colonization and aflatoxin production by *A.flavus* in disease and pest resistant genotypes.

Sr. No	Genotype	Infection %	Colonization %	Aflatoxin Content µg/kg	Level of aflatoxin resistance
1	NCAc 17127	47	29	11792	**M**
2	NCAc 17129	50	29	18812	**M**
3	NCAc 17134	67	25	24089	**M**
4	NCAc 17090	73	26	23318	**M**
5	NCAc 1302	27	18	19635	**M**
6	NCAc 17132	60	32	21794	**S**
7	NCAc 17135	57	23	15335	**M**
8	PI 405132	87	31	24551	**S**
9	PI 215696	77	24	14554	**M**
10	PI 393531	60	31	24994	**M**
11	ICG 4791	47	14	2219	**R**
12	ICG 7620	63	25	11524	**M**
13	V 20	73	23	18287	**M**
14	M107-74 K	63	19	40558	**M**
15	LUNG TAN YOU DO	23	10	9979	**R**
	GG 2 Susceptible check	**93**	**40**	**23726**	**S**

R = Resistant, M =Moderately resistant, S = Susceptible

5.5.1. Seed infection

Among the 15 genotypes studied, the least (23%) seed infection was exhibited by LUNG TAN YOU DO followed by NCAc 1302 (27%) while the maximum (87%) seed infection was exhibited by PI 405132 followed by PI 215696 (77%). All the 15 genotypes exhibited comparatively lower seed infection than the susceptible check, GG 2 (93%).

5.5.2. Seed colonization

All 15 genotypes exhibited lesser seed colonization when compared to susceptible check, GG 2 (40%). The genotype, LUNG TAN YOU DO exhibited least (10%) colonization followed by ICG 4791 (14%). While the highest (32%) seed colonization was recorded by NCAc 17132.

5.5.3. Aflatoxin content

Aflatoxin content was found to be the least (2219 µg/kg) in ICG 4791 followed by LUNG TAN YOU DO (9979 µg/kg). While the susceptible check, GG 2 exhibited higher (23726 µg/kg) amount of aflatoxin. Among the 15 genotypes, aflatoxin content was higher (24994 µg/kg) in PI 393531.

From the above results it was observed that LUNG TAN YOU DO supported the least infection and seed colonization by *A.flavus* in addition to aflatoxin production. This was followed by ICG 4791. LUNG TAN YOU DO which exhibited lowest values of seed infection, colonization and aflatoxin content. While, ICG 4791 showed the least aflatoxin production (2219 µg/kg) and seed colonization (14%) with moderate seed infection (47%). Though reports on screening of germplasm for *A. flavus* resistance are very few, several reports are available in case of cultivated varieties of groundnut.

While working with *A.flavus* resistance, McDonald and Mehan (1982) found that seed colonization by toxigenic *A. flavus* was less in J-11. Devidson *et al.* (1983) found that cultivar “Sunbelt runner” and “Florunner” to be resistant and moderately susceptible respectively to *in vitro* seed colonization by *A.flavus*. Groundnut varieties, Ah-7223, Faizapur, Monir-240-30 and AR-1-2-3 were categorized as a resistant to strain of *A. flavus* (Mixion, 1983).

The resistance of groundnut seed to *A.flavus* is associated with certain morphological and biochemical characters. The seeds of damaged pod are more frequently contaminated with *A.flavus*, because groundnut shell has been considered a barrier to penetration by *A.flavus* (McDonald and Harkness, 1967). Carter (1973) and Mixon and Roger (1973) established protective role of seed testa in case of seed colonization by aflatoxin fungi. Presence of wax layer on testa has been found as an important character for resistance to *A.flavus* (Laprade, 1973). Sometimes phenolic compounds have been found in testa which may play a role in resistance (Amaya *et al.,* 1977). More compact cell structure of testa was one of the important reason of resistance in the genotypes, PI 337394 and PI 337409 (Dieckert and Dieckert, 1977). Moisture levels in resistant variety is one of the important factors for its resistance (Ketring *et al.,* 1976). Amaya *et al.* (1980) reported that resistant genotypes had less water soluble amino acid.

In case of aflatoxin production by *A.flavus*, the present results are in conformity with several workers. Different groundnut varieties differ in their ability to produce aflatoxin as shown by Kulkarni *et al*. (1967). Rao and Tulpule (1961) first reported varietal difference in groundnut aflatoxin production. They reported that interaction between genotypes and *A.falvus* isolates might cause variation in aflatoxin production. Nagaraj and Bhat (1973) reported higher aflatoxin production in TMV-2 as compared to US-26. Ghewande *et al.* (1989) reported higher aflatoxin in BG-1 followed by JL-24 and GG-2, while RSB-87, TMV-12, TMV-7, S-230 and KRG-1 produced aflatoxin below 2000 µg/kg. Desai *et al.* (1991) reported highest aflatoxin content in Kaushal (38250 µg/kg), while lowest aflatoxin content was recorded in Chitra (3200 µg/kg). Thus the present results are in accordance with the reports of earlier workers.

The present study has brought out the important two genotypes (ICG 4791 and LUNG TAN YOU DO), which exhibited resistance to seed colonization. These genotypes can be utilized in the breeding programme to exploit their resistance.

5.6. Implications of the present study

The pod yield and its related characters of the germplasm which exhibited resistance to ELS, LLS, rust and *Spodoptera* indicated that, in ELS resistant genotypes, the pod yield ranged from 8.8 g (PI 405132) to 24.4 g (NCAC 17134). This genotype exhibited high (43.4 g) kernel weight also. For shelling, ICG 4791 was found to be good (68.5%) followed by V 20 (62.9%). The genotype ICG 4791 also recorded high (95.9%) sound mature kernel (SMK) among the ELS resistant genotypes. The genotype, PI 405132 was found to mature earlier (93 days) when compared to the others (Fig. 5.2 & 5.6).

In case of LLS resistant genotypes, pod yield/plant ranged from 8.8 (PI 405132) to 17.0 g (NCAc 17127). The genotype, NCAc 17127 also exhibited high (40.7 g) hundred seed weight, shelling (63.8%) and sound mature kernel (93.3%). The genotype, PI 405132 was found to be early (93 days) in maturity (Fig. 5.3 & 5.6).

In rust resistant genotypes, pod yield/ plant ranged from 8.8 (PI 405132) to 26.6 g (M-107-41-K). The genotype, M-107-41-K also exhibited high (48.0 g) hundred seed weight and shelling (70.3%). While high (95.9%) sound mature kernel was observed in ICG 4791. Among the rust resistant genotypes, NCAc 1302 was early (93 days) in maturity (Fig. 5.4 & 5.6).

Among the *Spodoptera* resistant genotypes, pod yield/ plant ranged from 15.7 (LUNG TAN YOU DO) to 24.4 g (NCAc 17134). The genotype, NCAc 17135 had high (53.1 g) hundred kernel weight, while the genotype, ICG 4791 had high (68.5%) shelling percentage, Sound mature kernel was high (96.3%) in the genotype NCAc 1302. While, two genotypes, LUNG TAN YOU DO and NCAc 17127 matured early (Fig. 5.5 & 5.6).

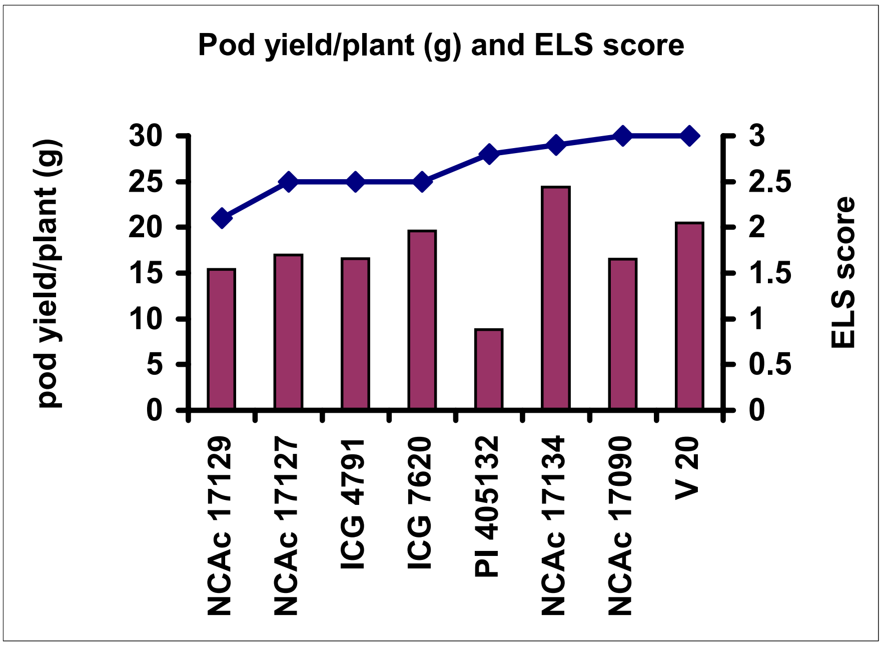
For resistant to *A. flavus* colonization, genotype ICG 4791 exhibited high (16.9 g) pod yield/plant and shelling (68.5%), while the genotype, LUNG TAN YOU DO exhibited high (39.0 g) hundred kernel weight and sound mature kernel (95.9%) (Fig. 5.7).

In addition few genotypes were also found to have multiple resistance against more than a disease and or pest.

Two genotypes, NCAC 17127 and PI 405132 exhibited resistance to both the leaf spot and rust. Interestingly, the genotype NCAc 17127 recorded less *Spodoptera* damage score, thus exhibiting multiple diseases and pest resistant. While for ELS and rust five genotypes (NCAc 17127, NCAc 17129, NCAc17090, PI 405132, ICG 4791) were found to be resistant.

For ELS and *Spodoptera*, four genotypes (NCAc 17127, NCAc 17134, NCAc 17090 and ICG 4791) found to exhibit resistance, where as four genotypes (NCAc 17127, NCAc 17090, NCAc 1302 and ICG 4791) were found resistant to rust and *Spodoptera* damage.

Hence, these genotypes can be used as donors in diseases and *Spodoptera* resistant breeding programmes as they not only had desired level of resistance but also exhibited high pod yield along with desirable marketing qualities.



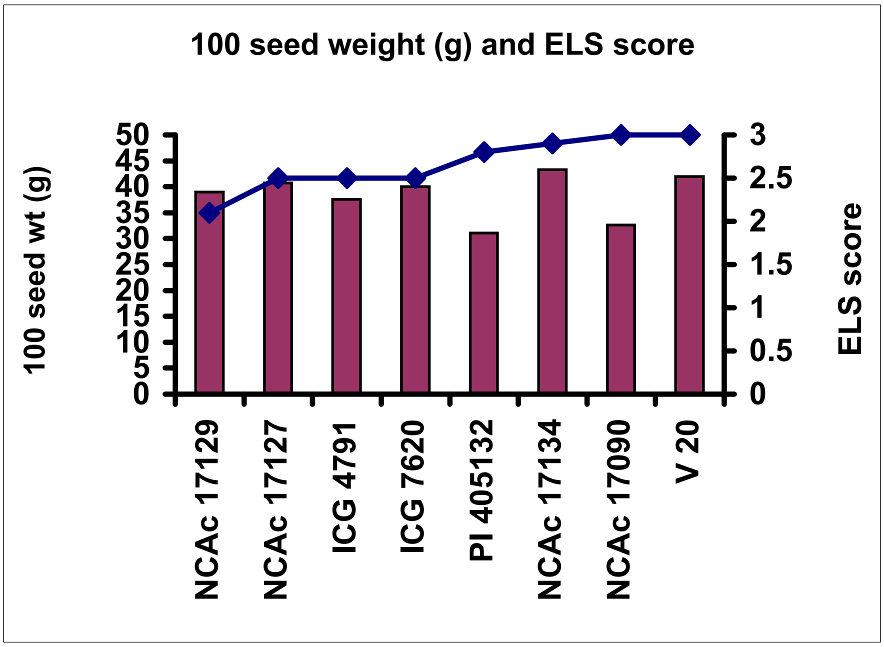
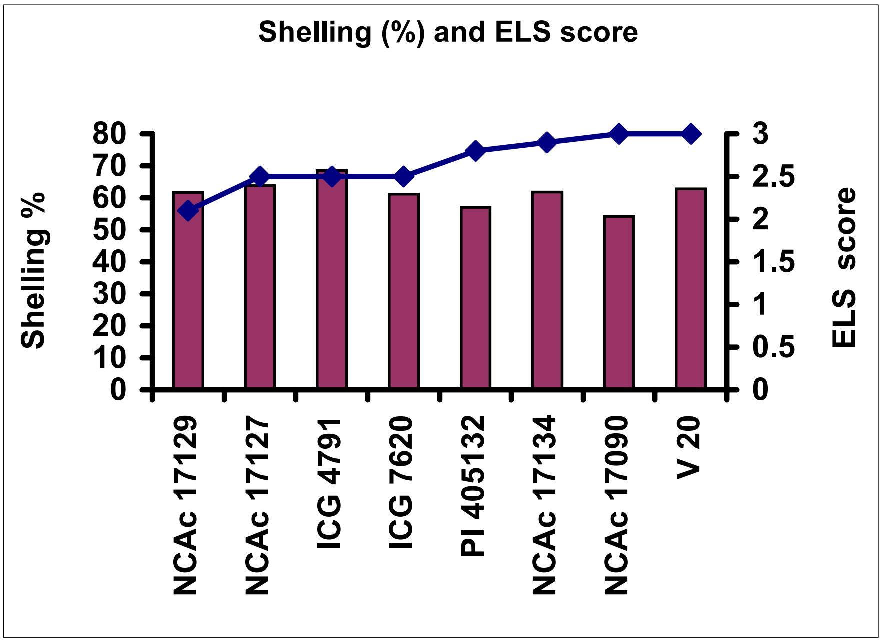


Fig. 5.2 Yield attributes of germplasm identified as resistant to ELS (*Cercospora arachidicola* Hori.).



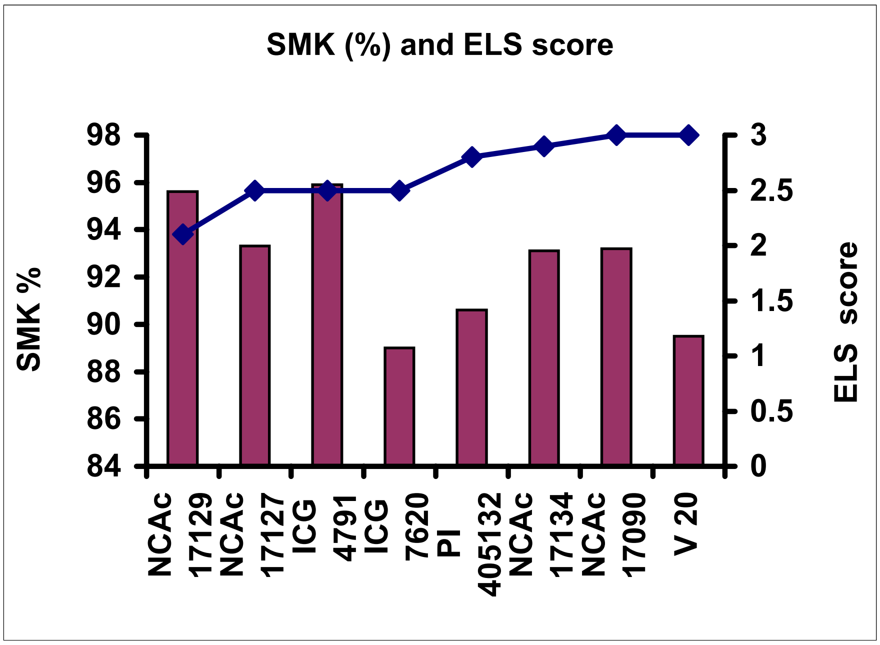
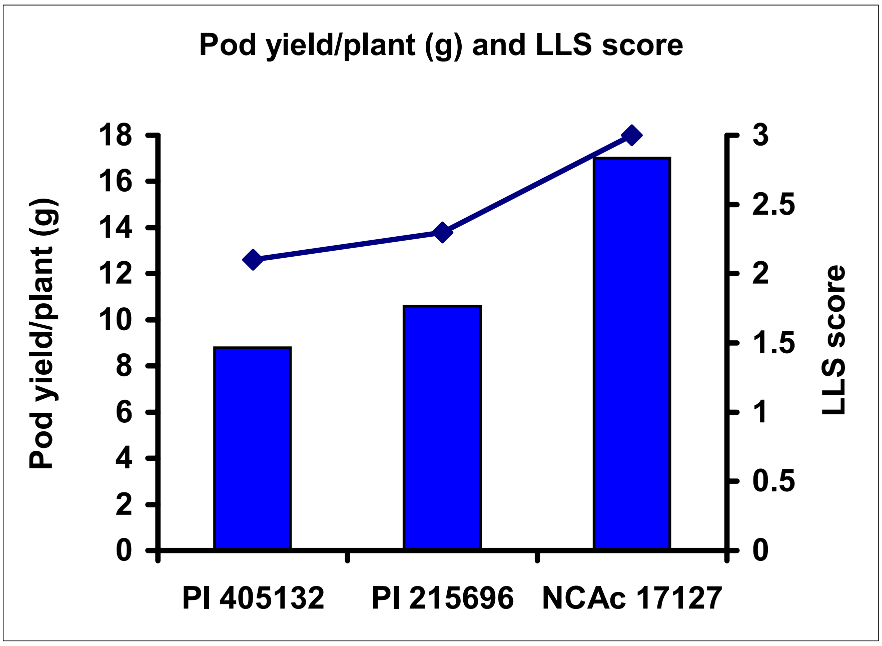


Fig. 5.2 Yield attributes of germplasm identified as resistant to ELS (*Cercospora arachidicola* Hori.). Cont…



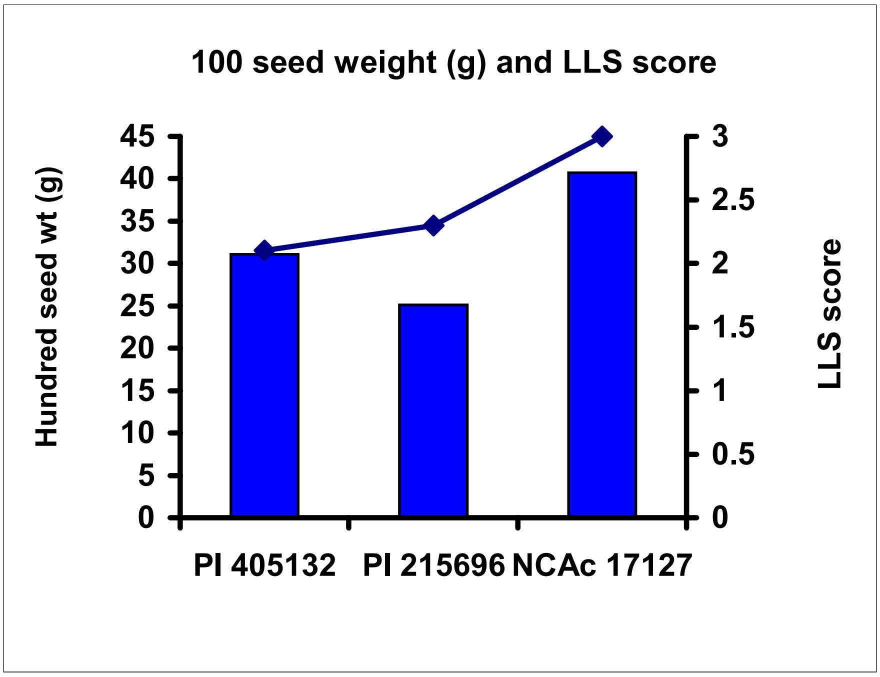
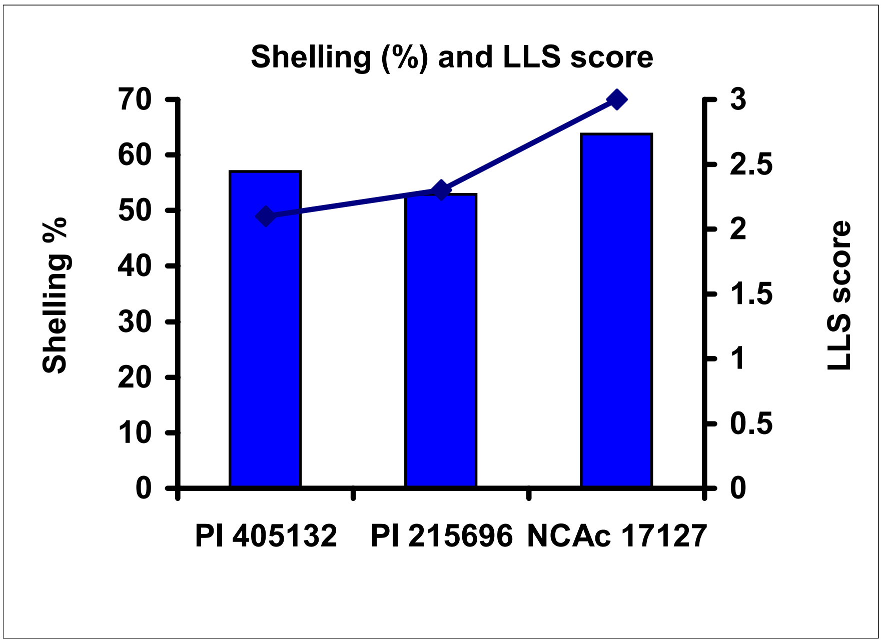


Fig. 5.3 Yield attributes of germplasms identified as resistant to LLS (*Phaeoisariopsis personata* Berk. & Curt).



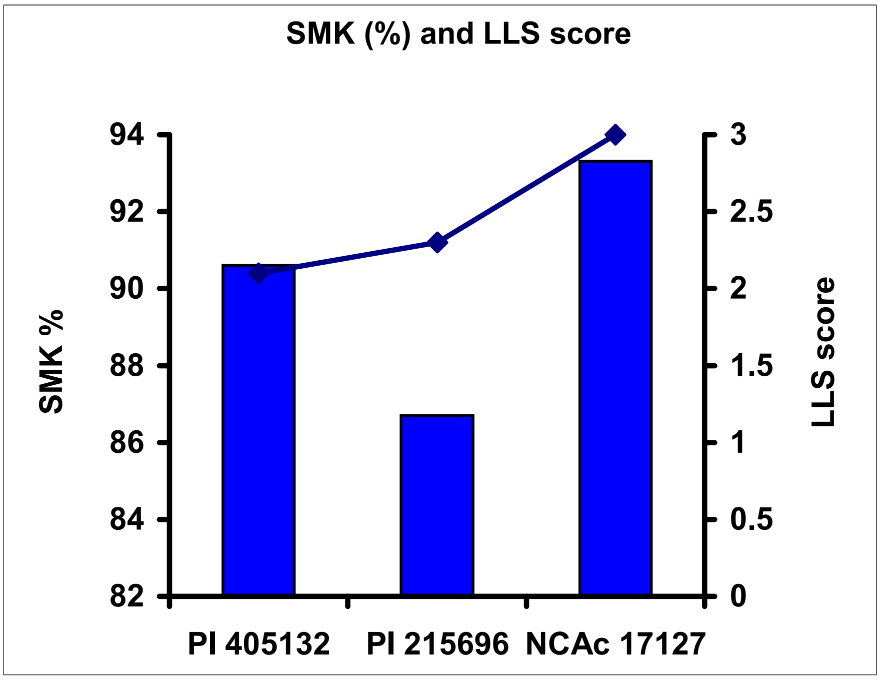
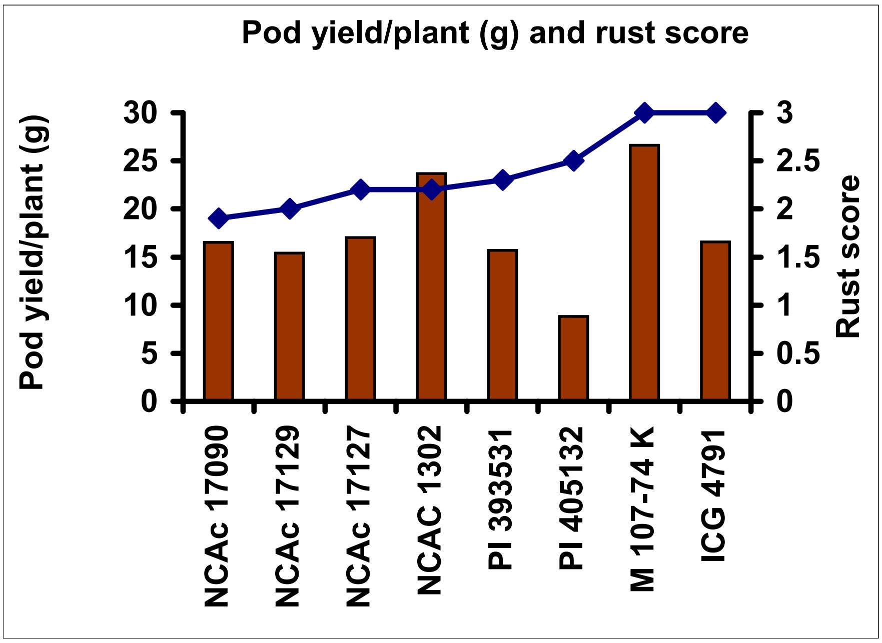


Fig. 5.3 Yield attributes of germplasms identified as resistant to LLS (*Phaeoisariopsis personata* Berk. & Curt). Cont….



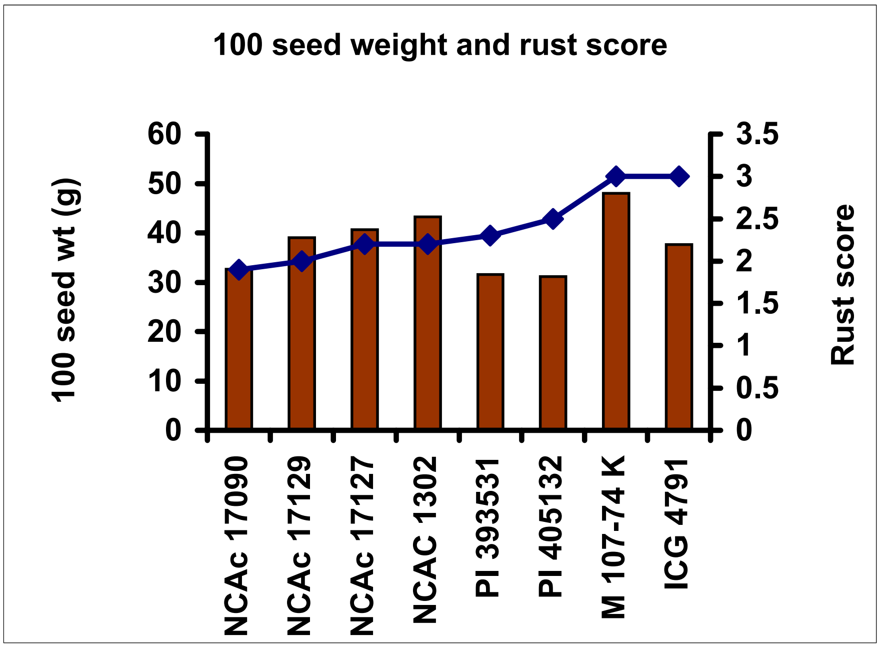
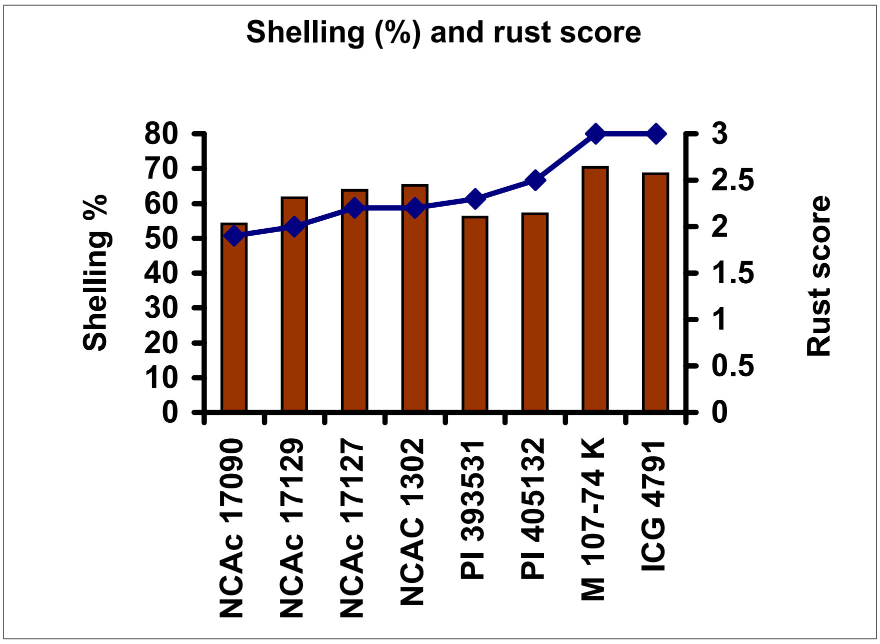


Fig. 5.4 Yield attributes of germplasm identified as resistant to Rust (*Puccinia arachidis* Speg.) .



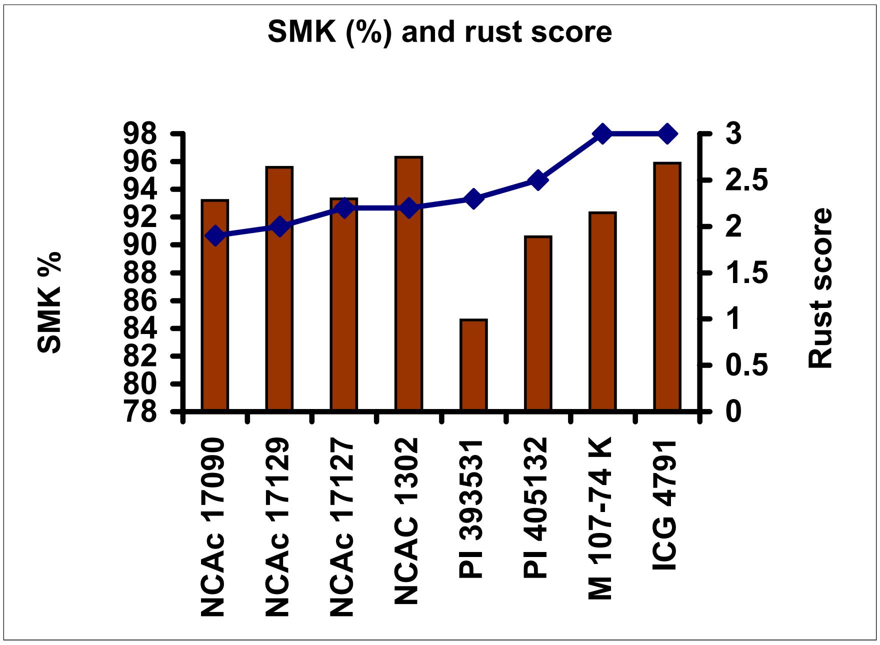
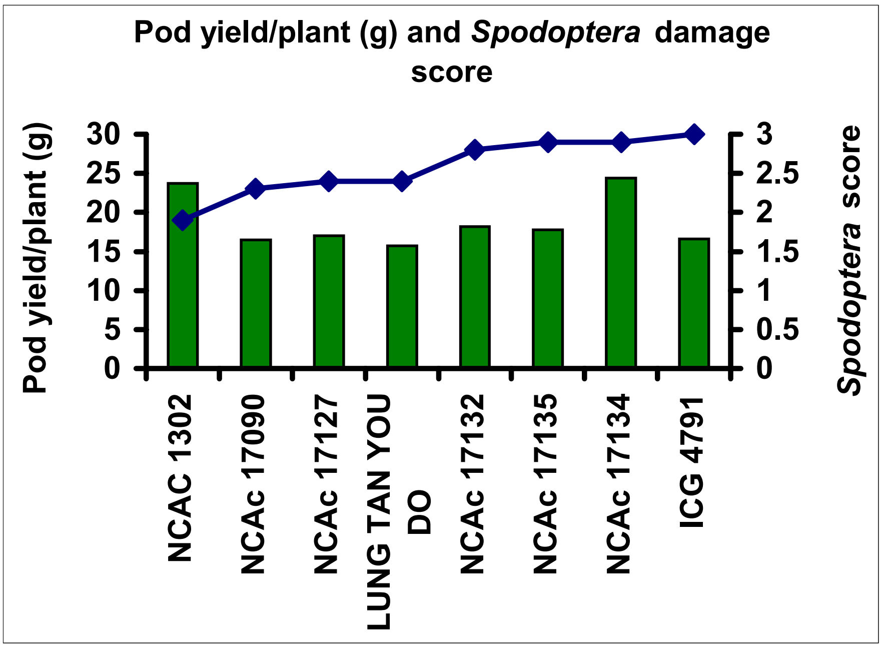


Fig. 5.4 Yield attributes of germplasm identified as resistant to Rust (*Puccinia arachidis* Speg.) . Cont…



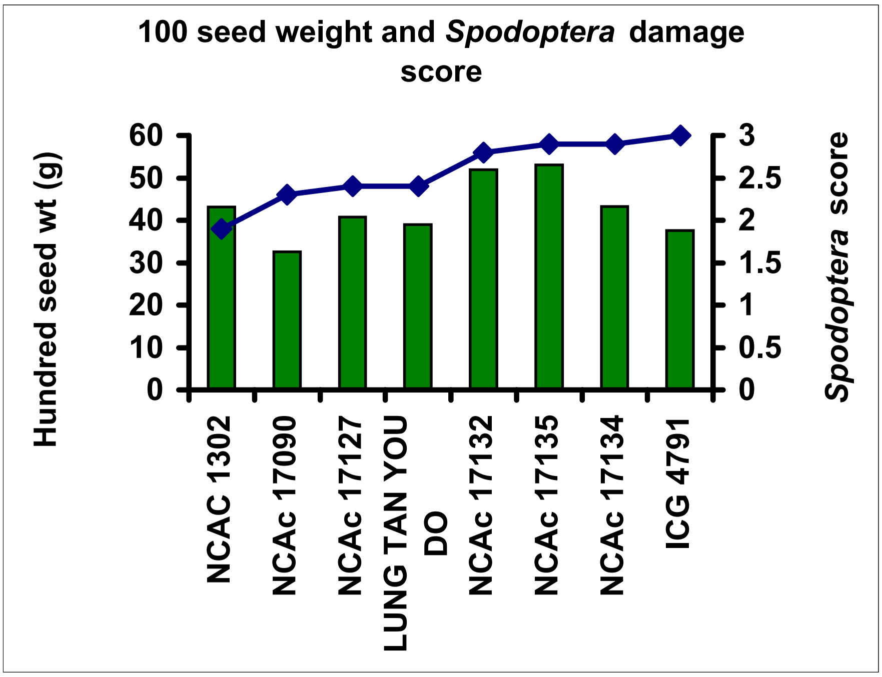
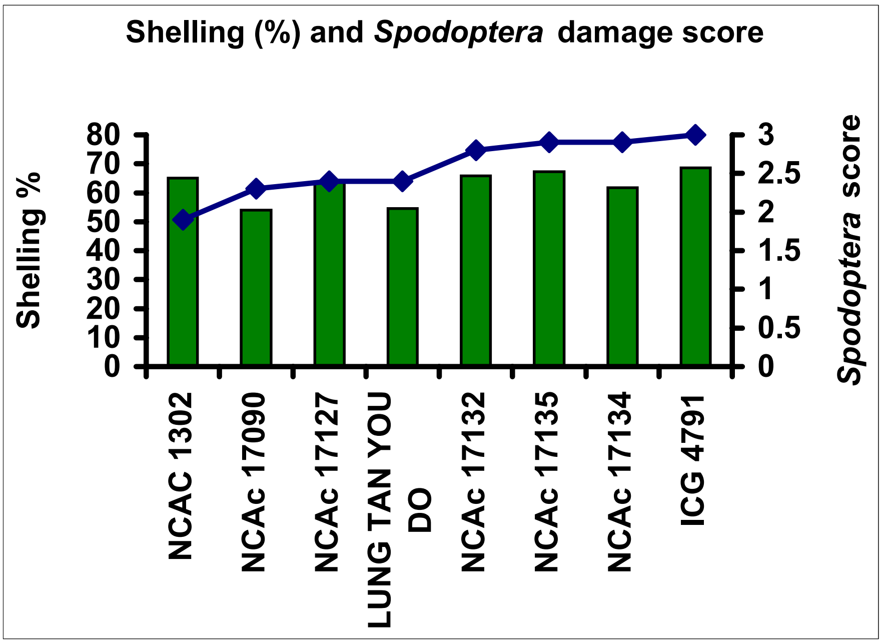


Fig. 5.5 Yield attributes of germplasm identified as resistant to *Spodoptera litura*.



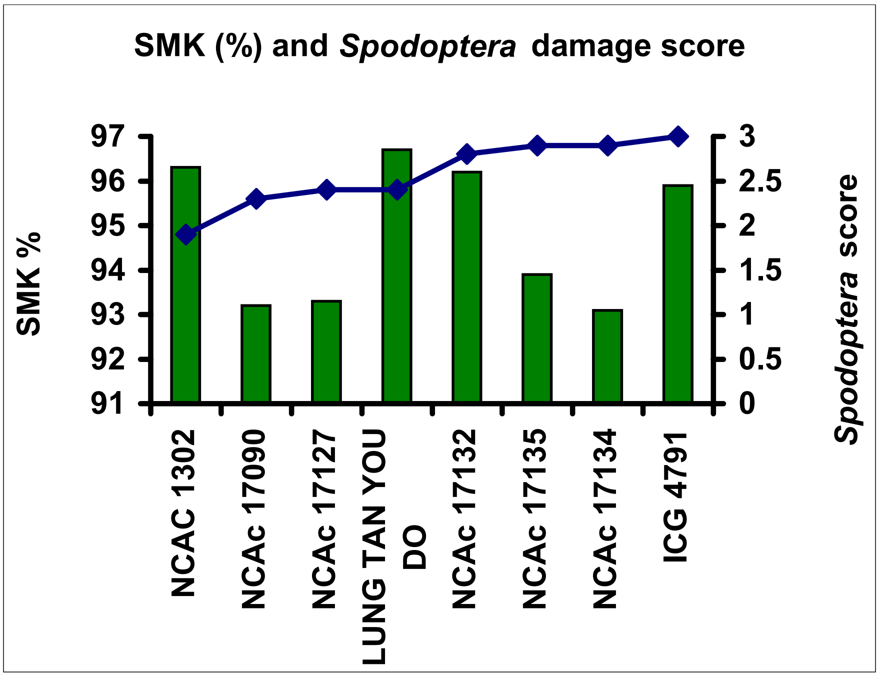
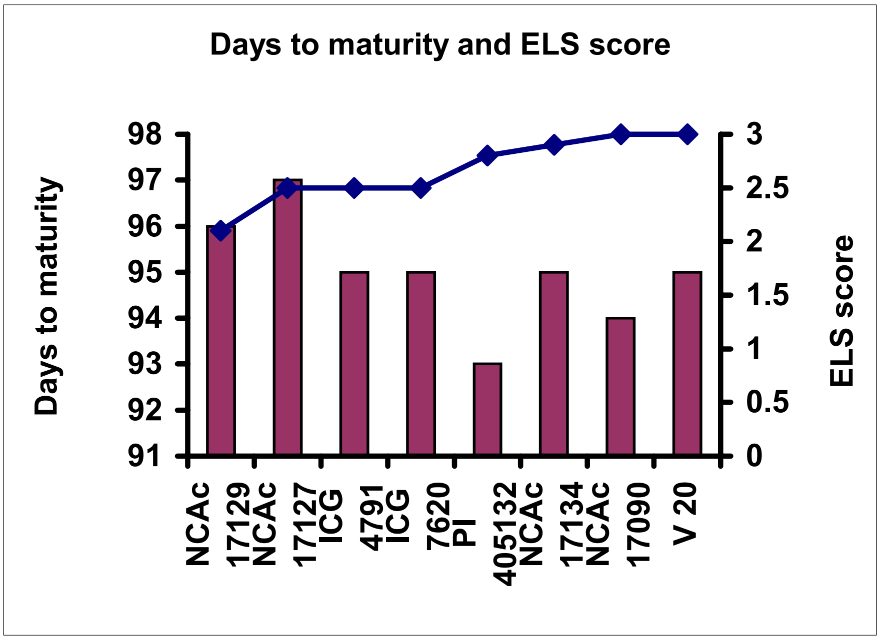


Fig. 5.5 Yield attributes of germplasm identified as resistant to *Spodoptera litura*. Cont….



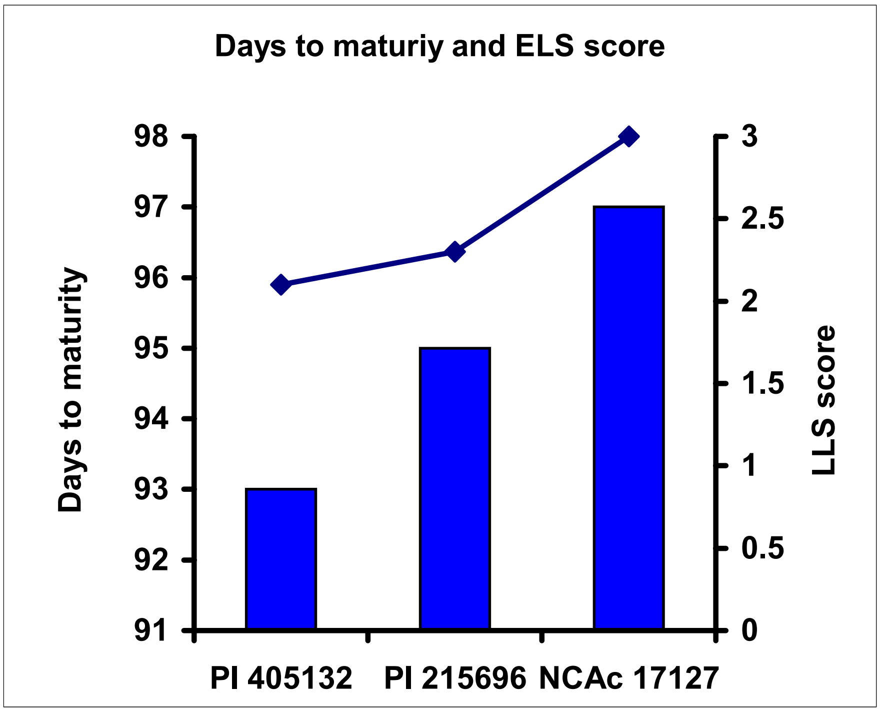
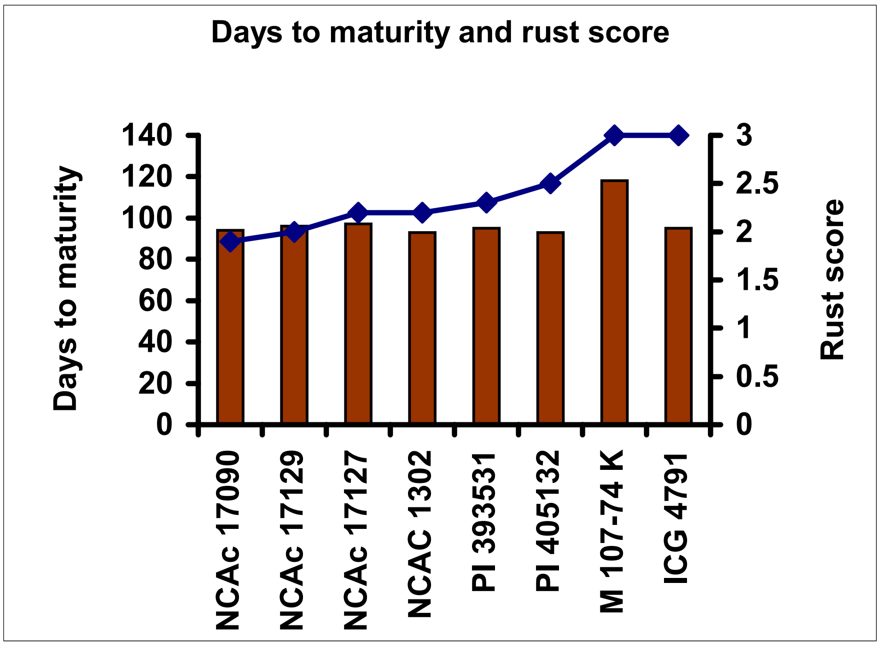


Fig. 5.6 Day to maturity of germplasm identified as resistant to ELS, LLS, rust and *Spodoptera litura*.



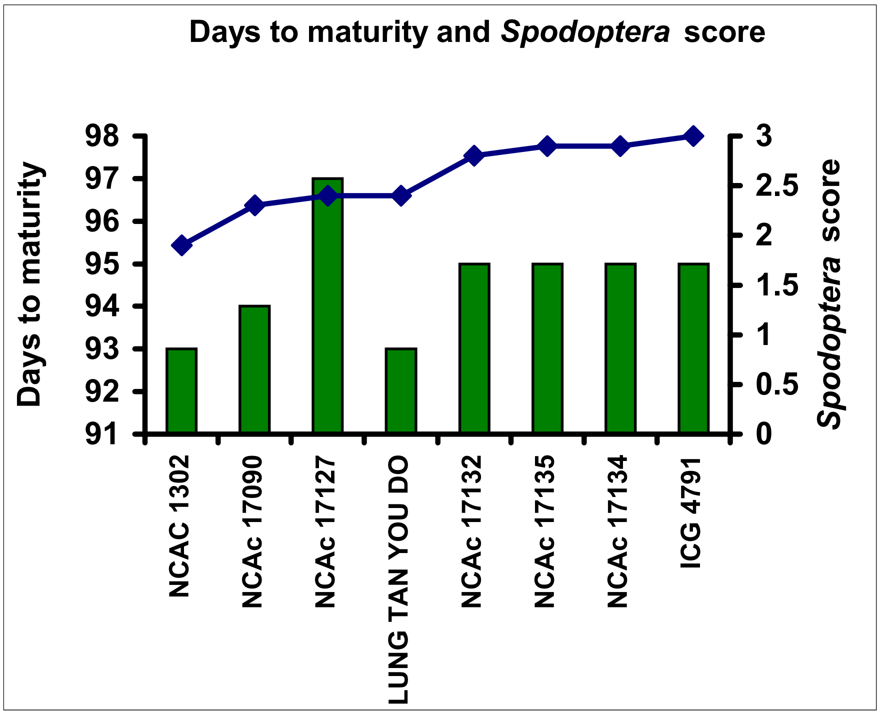


Fig. 5.6 Day to maturity of germplasm identified as resistant to ELS, LLS, rust and *Spodoptera litura*. Cont….

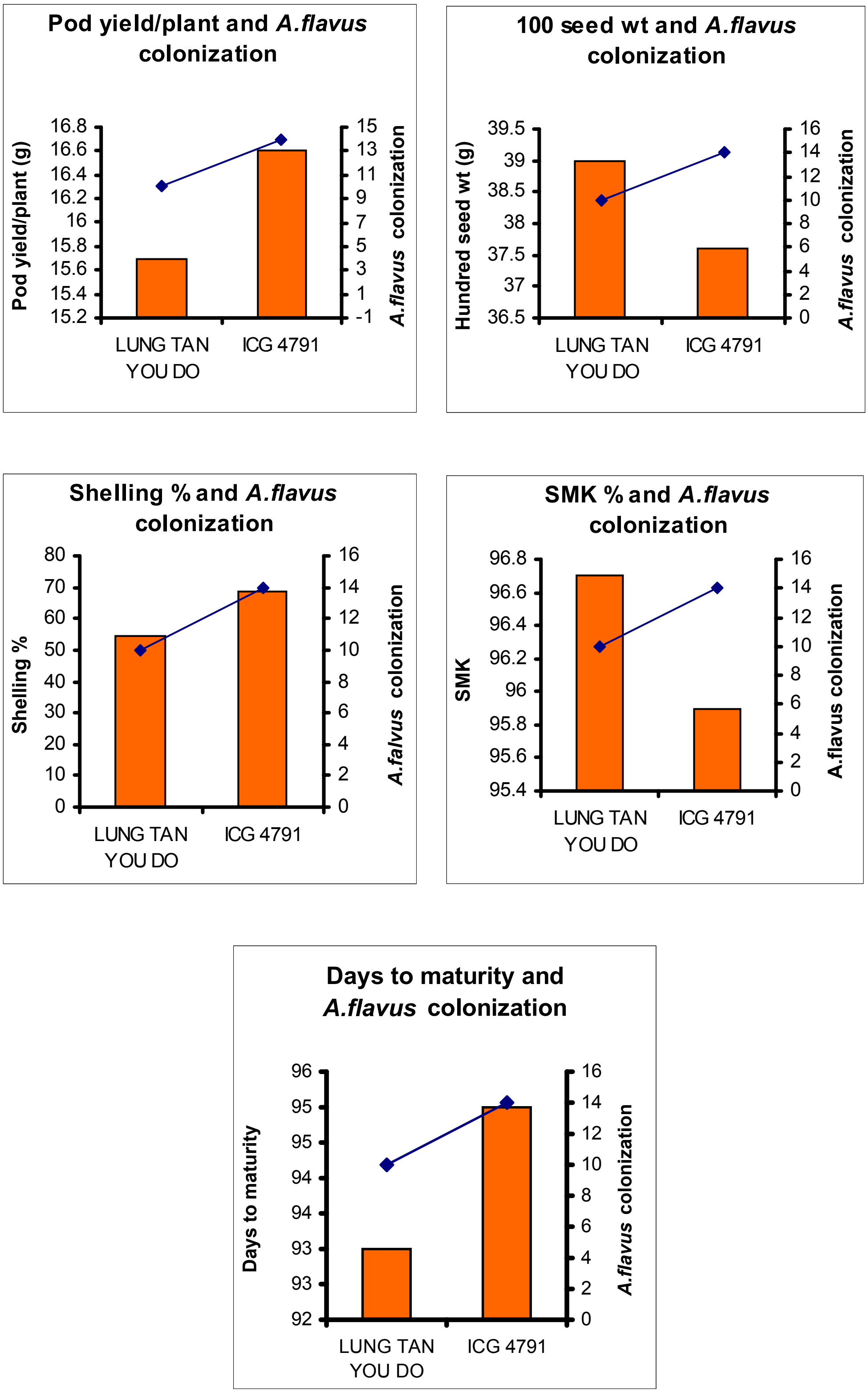


Fig. 5.7 Yield attributes of germplasm found as resistant to *A. flavus* colonization

Chapter 6 *Summary*

The foliar fungal diseases of groundnut, Early leaf spot (*Cercospora arachidicola* Hori.), late leaf spot (*Phaeoisariopsis personata* Berk. & Curt) and rust (*Puccinia arachidis* Speg.) and *Spodoptera litura* (F) are serious diseases and pest in many groundnut growing areas of the world affecting yield and quality. Yield losses over 50 per cent have been recorded due to rust disease alone, while the combination of leaf spots and rust can result in more than 70 per cent of the yield losses. In view of the economic importance of these diseases, several strategies including chemical methods of control have been developed but were found to be cost intensive. Since, groundnut is grown mostly by resource poor peasant farmers in the semi-arid and arid regions, such methods become expensive. Under these circumstances, developing disease resistant cultivars becomes a viable alternative.

Before formulation of any breeding strategy, it is essential to identify suitable source of resistance. Hence, the present study was undertaken to fulfill the above requirements.

Three hundred and sixty seven groundnut germplasm accessions received from International Crops Research Institute for Semi-Arid And Tropic (ICRISAT) under the repatriation programme were evaluated and characterized. Out of these 367 groundnut germplasm, 103 germplasm accessions belonged to habit Spanish (VUL) group; 135 were Valencia (FST); 92 were Virginia Bunch (HYB); and 37 were of Virginia runner (HYR).

These groundnut germplasm were characterized morphologically for 19 qualitative and 26 quantitative traits using the Descriptors for groundnut (IBPGR/ICRISAT, 1992). Morphological characterization was done for two consecutive years under the field conditions. Sowing was done in the month of June in 2001 and 2002 after the onset of monsoon in a single replication; in an augmented block design (ABD) with a grid plot check. The sowing was done in a row of 4 m length, with a row-to-row spacing of 75 cm and a plant-to-plant spacing of 10 cm during both the years. Recommended agronomic practices were followed to raise a successful crop.

These 367 groundnut germplasm were also used as base materials for screening of three major foliar fungal diseases namely early leaf spot (ELS), late leaf spot (LLS) rust and a major pest, across India *Spodoptera litura* (F.).

To confirm the resistance in groundnut germplasm which were found resistant in the preliminary screening, a confirmative screening was also undertaken for two consecutive years (*Kharif* season 2002 and 2003).

Nine anatomical characteristics were recorded in the seventy-five groundnut germplasm which were found as resistant to either ELS, LLS, rust or the *Spodoptera* or combination of the three diseases and *Spodoptera* during preliminary screening. All the leaf anatomical characters were recorded on the 3rd leaf from the apex on the main stem of 110 days old plants.

The germplasm accessions which exhibited resistance (1-3 scale) to either of the three diseases or their combination and *Spodoptera* during the preliminary screening were selected for biochemical characterization.

In addition 75 groundnut germplasm, found as resistant against the three diseases and *Spodoptera* in preliminary screening were also screened against *Aspergillus flavus* infection, colonization and aflatoxin production to check whether they are also resistant to *A.flavus* colonization and aflatoxin content.

Salient findings of the studies are:

1. Among the 19 qualitative traits, growth habit, stem pigmentation, standard petal colour, pod beak, pod constriction, pod reticulation, pod and seed size and testa colour exhibited high levels of variability.

2. Adequate variability for important yield and its related traits was observed among the 367 groundnut germplasm studied.

3. The genotype, NCAc 266 was found to be early (14 days) in flowering while CHICO was found to be early (86 days) maturing. These two genotypes can be extensively used in breeding programme aiming at early maturity.

4. The genotype, WHITE'S RUNNER exhibited maximum pod mass (45.2 g/plant) among the germplasm studied, while pod yield was maximum in

case of PORTO AlEGRE (250.1 g/m$^{2)}$. The genotype, PI 393527 exhibited maximum 100 pod mass (274.5 g). While shelling outturn was maximum (87.6 %) in NCAc 751.

5. Maximum sound mature seeds (98.9 %) was observed in NCAc 2654, while KU NO. 61 showed highest value of 100 seed mass (72.0 g).

6. None of the accessions were found to be immune to either of the three diseases or pest, among the germplasm studied.

7. The preliminary screening for ELS, LLS, rust and *Spodoptera* revealed that the maximum disease and pest resistance was found in Valencia habit group and the resistance was found to be confined to Peru, the centre of origin of groundnut.

8. Fifteen groundnut germplasm were found to be resistant to either of the three diseases and *Spodoptera* damage from the material studied.

9. Only one genotype, NCAc 17127 exhibited multiple disease (ELS, LLS and rust) and pest (*Spodoptera*) resistance.

10. Two genotypes, NCAc 17129 and NCAc 17090 showed resistance to ELS, rust and *Spodoptera* damage.

11. Eight genotypes were found to be resistant to ELS and eight genotypes showed resistance to rust disease among the material studied.

12. The results of confirmative screening revealed that three genotypes viz. NCAc 17217, PI 405132 and PI 215696, exhibited resistance to LLS.

13. In case of *Spodoptera*, eight genotypes showed minimum damage score.

14. The genotype, NCAc17127 and PI 405132 exhibited resistance to both LLS and rust diseases. These two genotypes are important for disease resistant breeding programme, as combination of LLS and rust disease can cause higher yield losses.

15. From the studies on the anatomical features of the resistant germplasm it was evident that resistant genotypes had longer and dense trichomes and smaller stomata (in term of length and width) on both abaxial and adaxial surface when compared to the susceptible genotypes. Interestingly, the number of stomata on the abaxial surface were fewer in resistant genotypes while on the adaxial surfaces the number of stomata were more. The tannin cells were, in general, more among the resistant genotypes than the susceptible genotype.

16. The inter association estimates between pest and diseases scores and anatomical features indicated that stomatal length and width at abaxial and adaxial surfaces were positively and significantly associated with ELS, LLS and *Spodoptera* damage score, thus revealing that greater the length and width of stomata at both abaxial and adaxial surfaces higher (susceptibility) will be the disease score and vice versa. While in case of rust, no significant association was found between the disease score and anatomical traits. While the number of tannin cells exhibited negative association with ELS and rust disease score indicating inverse relationship between these two.

17. The inter association estimates between pest and disease score and biochemical features indicated that total and reducing sugars in old leaves were positively and significantly associated with ELS disease score. In case of LLS, reducing sugars in old leaves were positively and significantly associated with disease score, while total phenol in old leaves; OD phenols in old and young leaves; reducing sugars in young leaves and wax content in old leaves showed significant but negative association.
18. From the biochemical studies it was observed that resistance to LLS and *Spodoptera* was influenced by total and OD phenols and wax contents in older leaves. Interestingly, none of the biochemical traits except for reducing sugars were found to influence rust disease score. While, total and reducing sugars played a major role in the susceptibility of ELS. In case of LLS and rust, reducing sugars played a major role towards susceptibility.
19. Studies on biochemical attributes among the germplasm studied indicated that the total phenols and *ortho* dihydroxy phenols were higher in resistant genotypes suggesting their role in disease resistance mechanism.
20. Screening against aflatoxin contamination showed that none on of the genotypes were found to be completely free (immune) to seed infection, colonization and aflatoxin production.

21. Germplasm which were found to be resistant to the three diseases and a pest in preliminary screening exhibited resistant, moderately resistant and susceptibility- respectively to *A.flavus* colonization.

22. Among the 75 germplasm screened, six genotypes, ICG 4791, ACETEIRO CHICO, LUNG TAN YOU DO, NCAc 1107, G 68 and G44 exhibited resistance to *A. flavus* colonization. The least aflatoxin content was recorded by ICG 4791 (2219.0 μg/kg).

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Annexure I. Passport information of 367 groundnut germplasm studied

No.	NRCG	ICG	VARIETY	ORG	HBT
1	9189	436	4133	USA	HYB
2	840	1647	NCAC 2188	USA	HYB
3	1613	6834	PI 268899	SEN	HYB
4	13108	2372	1357-10	USA	HYB
5	9036	1634	NC Bunch	USA	HYB
6	9038	1641	B 33	USA	HYB
7	9039	1646	NCAc 2187	USA	HYB
8	9040	1648	NCAc 2189	USA	HYB
9	9042	1653	NCAc 2562	USA	HYB
10	841	1654	NCAC 2563	USA	HYB
11	13072	1655	NCAC 2564	USA	HYB
12	13073	1671	D 32	USA	HYB
13	13077	1691	GA 61-35	USA	HYB
14	4282	2248	NCAc 12	UNK	HYB
15	9044	2249	NCAc 23	USA	HYB
16	13080	2251	8-19	USA	HYB
17	13081	2255	NCAC 63	USA	HYB
18	9045	2261	45185	USA	HYB
19	9047	2267	X 5 Sel.	USA	HYB
20	13082	2269	X 11	USA	HYB
21	13083	2275	G 340	ZAF	HYB
22	9048	2276	GA 61-42	USA	HYB
23	13084	2277	NC 1296	USA	HYB
24	13087	2282	CASTLE CARY SEL	TZA	HYB
25	13089	2286	NCAC 819	USA	HYB
26	13090	2289	SAMARU 38 SEL 4	NGA	HYB
27	13092	2297	C 39	USA	HYB
28	9052	2304	NCAc 1826	USA	HYB
29	882	2308	NCAC 2145	UNK	HYB
30	885	2312	NCAC 2172	UNK	HYB
31	13094	2315	NCAC 2277	USA	HYB
32	13095	2316	NCAC 2279	USA	HYB
33	13096	2317	NCAC 2316	USA	HYB
34	888	2319	NCAC 2377	UNK	HYB
35	889	2320	NCAc 2462	USA	HYB
36	894	2327	NCAC 2479	UNK	HYB
37	13098	2328	NCAC 2480	USA	HYB
38	13099	2331	VIRGINIA RED	ISR	HYB
39	897	2333	NCAC 2556	UNK	HYB
40	13100	2335	NCAC 2561	USA	HYB
41	9059	2337	NCAc 2569	USA	HYB
42	900	2339	NCAc 2690	USA	HYB

No.	NRCG	ICG	VARIETY	ORG	HBT
43	13102	2345	V 45	BRA	HYB
44	9065	2353	White's Runner	USA	HYB
45	9066	2354	Carolina bunch	USA	HYB
46	13109	2374	GA 119072	USA	HYB
47	13110	2376	3303	USA	HYB
48	9069	2380	A. monticola	ARG	HYB
49	9070	2383	DHT 190	BOL	HYB
50	13112	2385	DHT 193	BOL	HYB
51	13114	2404	RCM 596-1	BOL	HYB
52	6673	2741	G.Narrow leaf	IND	HYB
53	6678	4746	PI 298115	ISR	HYB
54	13116	4753	G 153	NGA	HYB
55	9945	4757	ICG 4757	UNK	HYB
56	13126	4777	KU NO.61	USA	HYB
57	9947	4778	ICG 4778	JPN	HYB
58	13127	4780	KU NO.11	ARG	HYB
59	927	5013	NCAc 784	BRA	HYB
60	6683	5030	NCAc 1741	USA	HYB
61	6684	5037	NCAc 2154	USA	HYB
62	952	5129	NCAc 17892	USA	HYB
63	13133	5164	NCAC 17587	USA	HYB
64	988	5725	NCAC 17751	USA	HYB
65	13135	5967	KANYOMA	ZIM	HYB
66	9519	6121	NCAc 1455	USA	HYB
67	13139	6183	S 183	ZIM	HYB
68	13140	6229	RCM 596-1	BOL	HYB
69	1022	6764	NCAC 1705	USA	HYB
70	13146	6826	C 35	USA	HYB
71	13147	6862	NCAC 2491	USA	HYB
72	9507	7237	ICG 7237	UNK	HYB
73	13153	7446	M 6-76 M	NGA	HYB
74	13154	7454	M 399-72 K	NGA	HYB
75	13155	7490	M 57-72 K	NGA	HYB
76	4734	7621	NCAc 17718	USA	HYB
77	13157	7637	M 107-74 K	NGA	HYB
78	4751	7664	NCAc 17672	USA	HYB
79	9790	7676	ICG 7676	UNK	HYB
80	13158	7696	EGRET	ZIM	HYB
81	4802	7749	M 380-72	NGA	HYB
82	6699	7883	PI 315608	ISR	HYB
83	6705	7892	PI 393527 B	PER	HYB
84	6708	7900	PI 414332	IDN	HYB
85	4921	8030	NCAc 17866	USA	HYB
86	4978	8099	PI 270934	ZWE	HYB

No.	NRCG	ICG	VARIETY	ORG	HBT
87	13167	9116	75-72	NGA	HYB
88	9524	10756	TGR 997	ZWE	HYB
89	8967	10884	KSSc 399	BOL	HYB
90	13171	11269	RM 70-1	TZA	HYB
91	13115	2438	88/6/7	ARG	HYR
92	811	384	NCAc 1085	USA	HYR
93	676	1637	NCAc 944	ARG	HYR
94	1703	1656	NCAC 2575	USA	HYR
95	685	2271	NCAc 343	USA	HYR
96	869	2273	NCAC 505	USA	HYR
97	13085	2278	NCAC 595	EGY	HYR
98	13086	2281	BADAMI ZAMINI	IRN	HYR
99	13088	2285	NCAC 759	CHN	HYR
100	13091	2293	NCAC 886	USA	HYR
101	4281	2296	NCAc 1107	USA	HYR
102	13097	2326	NCAC 2475	USA	HYR
103	898	2336	NCAC 2566	USA	HYR
104	905	2352	NCAc 2785	USA	HYR
105	13104	2360	G 68	ZAF	HYR
106	13105	2361	GA 139	USA	HYR
107	9000	2363	G 44	ZAF	HYR
108	13107	2370	GA 124-B	USA	HYR
109	702	2377	NCAC 2945	USA	HYR
110	13113	2401	NCAC 2763	USA	HYR
111	5187	4750	PI 337409	ARG	HYR
112	13119	4765	KU NO.225	TWN	HYR
113	13125	4773	KU NO.9	ARG	HYR
114	9517	5040	NCAc 2214	USA	HYR
115	6686	5041	NCAc 2230	USA	HYR
116	6532	5042	NCAc 2232	USA	HYR
117	6687	5043	NCAc 2240	USA	HYR
118	1699	5055	NCAC 2477	USA	HYR
119	6691	6147	NCAc 2326	USA	HYR
120	763	6317	NCAc 17888	USA	HYR
121	9523	7625	M 1069-7K	NGA	HYR
122	4810	7803	NCAc 2460	USA	HYR
123	4857	7891	PI 393527-A	PER	HYR
124	4863	7899	PI 414331	IDN	HYR
125	9791	11080	ICG 11080	UNK	HYR
126	13169	11094	ZFA 3186-1	ZMB	HYR
127	4153	2405	NCAC 2821	USA	HYR
128	13134	5932	NCAC 1715	USA	HYB
129	13137	6135	CUP 8	USA	HYB
130	714	5045	NCAC 2243	UNK	FST

No.	NRCG	ICG	VARIETY	ORG	HBT
131	6677	4743	88/23/7	ARG	VUL
132	13103	2358	NCAC 2836	USA	VUL
133	4559	7360	101/66/1	ZWE	VUL
134	13005	263	CPI 10507	ARG	FST
135	1070	265	NCAc 405	USA	FST
136	1071	266	NCAc 406	USA	FST
137	1073	274	NCAc 490	BRA	FST
138	1074	276	NCAc 503	ARG	FST
139	13009	283	NCAC 524	ARG	FST
140	13012	291	SENEGAL 1120	TZA	FST
141	13013	296	MTUTU-A	TZA	FST
142	782	301	NCAc 583	USA	FST
143	13016	320	NCAC 706	BRA	FST
144	794	322	NCAC 710	BRA	FST
145	5571	325	PI 152129	BRA	FST
146	13018	326	NCAC 721	BRA	FST
147	13025	353	GA 177	USA	FST
148	13026	354	V 54	BRA	FST
149	13027	355	WHITE	BRA	FST
150	13028	357	NCAC 881	PRY	FST
151	13029	358	NCAC 884	URY	FST
152	13031	362	ZANDI	SDN	FST
153	13032	364	CORDOFAN	SDN	FST
154	13034	366	LE 29	ARG	FST
155	13035	367	MANI GUAYCURU 1	ARG	FST
156	13038	370	DETOST ADERO	ARG	FST
157	13042	379	NCAC 1001	BRA	FST
158	13043	380	NCAC 1002	TUR	FST
159	13046	385	CPI 10496	ARG	FST
160	4214	389	NCAc 1286	ARG	FST
161	13049	391	TORO	NGA	FST
162	4296	392	NCAC 1302	UNK	FST
163	13052	398	VALENCIA	USA	FST
164	4299	403	NCAC 2653	UNK	FST
165	1108	404	NCAc 2654	USA	FST
166	1109	405	NCAc 2663	PRY	FST
167	1113	411	NCAc 2700	BRA	FST
168	13055	427	44-183	ARG	FST
169	13059	447	2293	USA	FST
170	13060	452	NCAC 2927	USA	FST
171	13061	460	RCM 462	PRY	FST
172	13062	462	RCM 467	PRY	FST
173	4220	463	NCAc 17089	PER	FST
174	13063	469	WCG 131	BRA	FST

No.	NRCG	ICG	VARIETY	ORG	HBT
175	9110	470	WCG 169	PER	FST
176	9125	1603	Krapovickas 4	ARG	FST
177	13066	1608	KINORALES	PHL	FST
178	13068	1613	SP 2B	USA	FST
179	1151	1615	NCAC 414	UNK	FST
180	4290	1627	NCAC 568	UNK	FST
181	1164	1660	NCAC 2666	BRA	FST
182	9130	1664	NCAc 2679	USA	FST
183	9131	1665	Gemana	ZAR	FST
184	13075	1683	G 90 A	ZAF	FST
185	851	1696	NCAc 16026	PRY	FST
186	1177	1697	NCAc 17090	PER	FST
187	6663	1703	NCAc 17127	PER	FST
188	6664	1704	NCAc 17129	PER	FST
189	5177	1707	NCAc 17132	PER	FST
190	1179	1709	NCAc 17134	PER	FST
191	5178	1710	NCAc 17135	PER	FST
192	9135	1713	Peru No. 3	PER	FST
193	13101	2338	KRAPOVICKAS 5	PER	FST
194	13118	4764	KU NO.220	BRA	FST
195	13124	4772	KU NO.8	ARG	FST
196	13130	4788	KU NO.189	BEN	FST
197	6682	4790	Krap strain 16	ARG	FST
198	9949	4791	ICG 4791	NGA	FST
199	13136	6090	NCAC 664	BRA	FST
200	13138	6140	NCAC 2209	USA	FST
201	10774	6201	BC 119	CUB	FST
202	13141	6271	WCG 149	BRA	FST
203	13142	6277	WCG 166B	BRA	FST
204	6692	6280	NCAc 17124	PER	FST
205	13143	6355	RCM 533	BRA	FST
206	13144	6691	ROGUE DE PLODIV	CIV	FST
207	13145	6709	PERU NO.2	PER	FST
208	11247	6726	WCG 135	BRA	FST
209	4471	6775	PI 262058	BRA	FST
210	1527	6960	PI 262007	PRY	FST
211	13148	7205	WCG 115	BRA	FST
212	13149	7296	203/66	PER	FST
213	13150	7320	NCAC 17656	UNK	FST
214	13151	7340	WCG 182	PER	FST
215	13152	7353	PERU NO.9	PER	FST
216	4603	7404	V 20	ZWE	FST
217	4486	7433	NCAc 17518	UNK	FST
218	9747	7620	ICG 7620	UNK	FST

No.	NRCG	ICG	VARIETY	ORG	HBT
219	13156	7628	WCG 170	PER	FST
220	13159	7712	PERU NO.9	PER	FST
221	13160	7777	SAM COL. 186	UNK	FST
222	4849	7881	PI 215696	PER	FST
223	4850	7882	PI 314817	PER	FST
224	6700	7885	PI 381622	IDN	FST
225	6529	7886	PI 390593	PER	FST
226	6703	7889	PI 393517	PER	FST
227	4859	7893	PI 393531	PER	FST
228	4861	7896	PI 393646	PER	FST
229	6707	7897	PI 405132	VEN	FST
230	4873	7924	PI 268491	ZWE	FST
231	13161	7927	MUBENDI	ZIM	FST
232	4498	8000	PI 268492	ZWE	FST
233	1587	8003	Tesa bunch	UGA	FST
234	4934	8047	PI 268525	ZWE	FST
235	13162	8105	RCM 449-3	ARG	FST
236	6540	8257	NCAc 17099	BRA	FST
237	13166	8599	TYPE NO.7	ARG	FST
238	13168	9185	75-16	ISR	FST
239	10995	10005	SP 425 FLESH	PER	FST
240	11589	10039	SPZ 482 DARK PU	PER	FST
241	11007	10048	SPZ 487 FLESH	PER	FST
242	11594	10057	SPZ 492 PURPLE	PER	FST
243	11009	10058	SPZ 493 FLESH	PER	FST
244	11595	10059	SPZ 493 PURPLE	PER	FST
245	11598	10063	SPZ 496 PURPLE	PER	FST
246	11600	10067	SPZ 499 PURPLE	PER	FST
247	11012	10070	SPZ 501 PURPLE	PER	FST
248	11032	10450	TINGO MARIA	PER	FST
249	11604	10890	SPA 406 RED	PER	FST
250	11605	10918	SPZ 459 FLESH	PER	FST
251	11611	10935	SPZ 476 DARK PU	PER	FST
252	11918	10949	SPZ 486 LIGHT P	PER	FST
253	11612	10966	SPZ 496 FLESH	PER	FST
254	9740	10974	ICG 10974	UNK	FST
255	11581	10975	SPZ 503 DARK PU	PER	FST
256	11614	11073	SPZ 459 PURPLE	PER	FST
257	9746	11075	ICG 11075	UNK	FST
258	11615	11108	SPZ 503 PURPLE	PER	FST
259	13170	11182	SP 403 TAN	PER	FST
260	11582	11186	SPZ 488 GASP	PER	FST
261	11622	11282	SPA 411	PER	FST
262	13172	11285	SPZ 473 GASP	PER	FST

No.	NRCG	ICG	VARIETY	ORG	HBT
263	13173	11485	P 2435	PER	FST
264	13174	12112	SPZ 485 LPL	PER	FST
265	5176	1705	NCAc 17130	PER	FST
266	1520	6903	PI 268988	ZWE	FST
267	4212	361	NCAc 963	ARG	FST
268	4206	279	NCAc 515	ARG	VUL
269	13036	368	MANI NEGRO	PRY	VUL
270	1172	1679	NCAc 2838	USA	VUL
271	13079	1712	V 109	BRA	VUL
272	13128	4783	KU NO.60	USA	VUL
273	13006	268	GA 167	USA	VUL
274	13007	275	GA 181	USA	VUL
275	13008	282	NCAC 520	USA	VUL
276	1079	286	NCAC 529	USA	VUL
277	13010	289	SPANISH 2B	BRA	VUL
278	13011	290	NCAC 542	BRA	VUL
279	9182	294	MPUTU-C	ZAR	VUL
280	13014	310	GA 199	USA	VUL
281	4236	311	NCAc 608	USA	VUL
282	13015	316	GA 163	USA	VUL
283	13017	323	BAKU FOIRE	BRA	VUL
284	13019	327	CATETO	BRA	VUL
285	4238	329	NCAc 726	BRA	VUL
286	4239	333	NCAc 746	USA	VUL
287	9185	334	NCAc 751	CHN	VUL
288	13020	341	ACETEIRO CHICO	URY	VUL
289	13021	344	LE 36	URY	VUL
290	13022	348	NCAC 821	BRA	VUL
291	13023	350	NCAC 831	USA	VUL
292	13024	352	NCAC 845	BRA	VUL
293	1107	359	NCAC 888	USA	VUL
294	13030	360	NCAC 892	USA	VUL
295	13033	365	MANI BLANCA 61	ARG	VUL
296	13037	369	MANI BLANCO 26A	ARG	VUL
297	13039	374	NCAC 967	ARG	VUL
298	13040	377	NCAC 990	ARG	VUL
299	13041	378	SH 130	BRA	VUL
300	13044	381	A 30	USA	VUL
301	13045	382	A 18	USA	VUL
302	13047	386	CPI 11996	ARG	VUL
303	13048	388	CPI 12154	ZAF	VUL
304	13050	394	RED SPANISH	AUS	VUL
305	13051	396	NCAC 1333	USA	VUL
306	819	400	NCAC 2600	IDN	VUL

No.	NRCG	ICG	VARIETY	ORG	HBT
307	13053	402	SP 2B	USA	VUL
308	13054	410	NCAC 2698	USA	VUL
309	9187	426	Mfoka-A	ZAR	VUL
310	5573	428	NCAc 2816	USA	VUL
311	5574	431	PI 152108	BRA	VUL
312	13056	432	GA 270-8	USA	VUL
313	13057	438	PORTO ALEGRE	BRA	VUL
314	13058	444	MTUTU-B	TZA	VUL
315	9190	456	NCAc 2953	USA	VUL
316	13064	473	V 26	BRA	VUL
317	5007	476	Chico	USA	VUL
318	9225	1605	Pei-Kang-Pe-You-Don	JPN	VUL
319	13065	1606	LUNG TAN YOU DO	JPN	VUL
320	13067	1609	SCHWARZ 21	IDN	VUL
321	1680	1612	NCAC 399	UNK	VUL
322	13069	1616	GA 159	USA	VUL
323	9228	1617	NCAc 429	PRY	VUL
324	13070	1623	DOI	USA	VUL
325	13071	1628	BILB	USA	VUL
326	1158	1636	NCAC 889	USA	VUL
327	9235	1644	Maseni	SLE	VUL
328	9236	1662	NCAc 2673	ZAR	VUL
329	9237	1669	NCAc 2737	USA	VUL
330	1169	1674	NCAC 2753	USA	VUL
331	1688	1677	NCAC 2820	USA	VUL
332	13074	1681	GA 195	USA	VUL
333	13076	1685	MTUTU-C	ZAR	VUL
334	13078	1699	WCG 156	BRA	VUL
335	9238	1711	DHT 191	BOL	VUL
336	9344	2272	GA 165	USA	VUL
337	13093	2310	NCAC 2158	USA	VUL
338	9347	2359	Clark 8	USA	VUL
339	13106	2364	GA 198	USA	VUL
340	13111	2378	RCM 439	BOL	VUL
341	9444	3516	US 16-B	USA	VUL
342	6536	4749	PI 337394F	ARG	VUL
343	7320	4751	T-900 (krinkle leaf	UNK	VUL
344	6681	4756	Ku# 191	TZA	VUL
345	9946	4758	ICG 4758	TWN	VUL
346	13117	4759	KU NO.159	TWN	VUL
347	13120	4766	KU NO.235	AUS	VUL
348	13121	4767	KU NO.236	AUS	VUL
349	13122	4768	KU NO.237	AUS	VUL
350	13123	4770	KU NO.203	CHN	VUL

No.	NRCG	ICG	VARIETY	ORG	HBT
351	13129	4785	KU NO.134	JPN	VUL
352	9540	4787	KU No. 144	IDN	VUL
353	1200	5100	NCAc 16820	ZWE	VUL
354	13131	5144	NCAC 2308	USA	VUL
355	13132	5156	F 1-79	ZIM	VUL
356	6696	7633	UF 71513	USA	VUL
357	6706	7895	PI 393643	PER	VUL
358	1657	7906	PI 268802	ZWE	VUL
359	4491	7930	PI 268741	ZWE	VUL
360	13163	8230	MANYEMA TANGANY	TZA	VUL
361	13164	8450	RG 23	ZIM	VUL
362	13165	8472	RG 89	ISR	VUL
363	9575	8662	Acc # 727	IDN	VUL
364	9577	8664	Acc # 731	IDN	VUL
365	6407	8977	PI 268573	USA	VUL
366	11676	5048	NCAC 2313	USA	VUL
367	9062	2343	FLA 76-10	USA	VUL

Country code

Code	Country	Code	Country
ARG	Argentina	SLE	Sierra Leone
AUS	Australia	TUR	Turkey
BOL	Bolivia	TWN	Taiwan
BRA	Brazil	TZA	Tanzania
CHN	China	UGA	Uganda
CIV	Ivory coast	UNK	Unknown
CUB	Cuba	URY	Uruguay
EGY	Egypt	USA	United state of America
IDN	Indonesia	VEN	Venezuela
IND	India	ZAF	South Africa
IRN	Iran	ZAR	Zaire
ISR	Israel	ZIM	Zimbabwe
JPN	Japan	ZMB	Zambia
NGA	Nigeria	ZWE	Zimbabwe
PER	Peru		
PHL	Philippines		
PRY	Paraguay		
SDN	Sudan		
SEN	Senegal		

Annexure II 19 Qualitative traits of 367 groundnut germplasm (two year pooled)

Abbreviations

GHB	Growth habit	LLT	Leaflet tip
BPT	Branching pattern	PDB	Pod beak
STP	Stem pigmentation	PDC	Pod constriction
STH	Stem surfaces	PDR	Pod reticulation
INF	Type of inflorescence	SDC	Seed colour
FLC	Flower colour	PDZ	Pod size
PGP	Peg pigmentation	SHT	Shell thickness
LFC	Leaflet colour	SDS	Seed shape
LLS	Leaflet shape	SDZ	Seed size
LFH	Leaflet surface		

SNO	NRCG	ICG	VARIETY	HBT	GHB	BPT	STP	STH	INF	FLC	PGP	LFC	LLS	LFH	LLT	PDB	PDC	PDR	SDC	PDZ	SHT	SDS	SDZ
1	9189	436	4133	HYB	3	3	0	5	2	2	+	2	1	5	1	0	3	3	11	2	1	1	2
2	840	1647	NCAC 2188	HYB	3	1	0	3	2	2	+	2	1	3	1	3	5	3	11	2	3	2	2
3	1613	6834	PI 268899	HYB	3	1	0	3	1	2	+	3	1	3	1	3	3	3	10	2	2	2	2
4	13108	2372	1357-10	HYB	3	1	0	3	2	2	+	3	1	3	1	5	5	5	10	3	3	3	3
5	9036	1634	NC Bunch	HYB	3	1	0	3	2	2	+	3	1	3	1	5	5	7	11	3	3	3	3
6	9038	1641	B 33	HYB	3	1	+	3	2	2	+	3	1	3	1	5	5	5	10	3	3	3	3
7	9039	1646	NCAc 2187	HYB	3	1	0	3	1	2	+	3	1	3	1	3	5	5	11	3	3	3	3
8	9040	1648	NCAc 2189	HYB	3	1	0	3	1	2	+	3	1	3	1	3	5	5	11	2	3	2	3
9	9042	1653	NCAc 2562	HYB	3	4	+	3	2	2	+	3	1	3	1	3	3	3	10	2	3	1	2
10	841	1654	NCAC 2563	HYB	3	4	+	3	2	2	+	2	1	3	1	3	5	5	10	2	3	2	3
11	13072	1655	NCAC 2564	HYB	2	4	+	3	1	2	+	3	1	3	1	0	0	3	10	2	3	1	2
12	13073	1671	D 32	HYB	3	1	+	3	2	2	+	2	1	3	1	3	3	3	10	2	2	2	2
13	13077	1691	GA 61-35	HYB	3	4	0	3	2	2	0	3	1	3	1	3	3	3	2	1	1	2	2
14	4282	2248	NCAc 12	HYB	3	4	0	3	2	2	+	2	1	3	1	3	5	5	10	2	3	2	2

SNO	NRCG	ICG	VAR	HBT	GHB	BPT	STP	STH	INF	FLC	PGP	LFC	LLS	LFH	LLT	PDB	PDC	PDR	SDC	PDZ	SHT	SDS	SDZ
15	9044	2249	NCAc 23	HYB	3	1	+	3	2	2	+	4	1	3	1	5	5	5	10	2	3	3	2
16	13080	2251	8-19	HYB	3	4	+	3	2	2	+	3	1	3	1	3	5	5	10	2	3	3	2
17	13081	2255	NCAC 63	HYB	3	4	0	3	2	2	+	3	1	3	1	3	5	3	10	2	2	1	2
18	9045	2261	45185	HYB	3	1	+	3	2	2	+	3	1	3	1	3	3	5	11	3	3	2	3
19	9047	2267	X 5 Sel.	HYB	3	1	0	3	2	2	+	3	1	3	1	3	5	5	10	2	3	2	2
20	13082	2269	X 11	HYB	3	4	0	5	2	2	+	3	1	5	1	5	5	3	10	2	2	3	2
21	13083	2275	G 340	HYB	3	4	+	3	1	2	+	3	1	3	1	7	5	7	10	3	3	3	3
22	9048	2276	GA 61-42	HYB	3	4	0	3	2	2	0	3	1	3	1	5	5	5	2	2	3	2	2
23	13084	2277	NC 1296	HYB	2	4	+	3	2	2	+	3	1	3	1	3	3	3	10	2	2	2	2
24	13087	2282	CASTLE CARY SEL	HYB	2	4	+	5	2	2	+	3	1	5	1	7	5	3	11	2	1	3	2
25	13089	2286	NCAC 819	HYB	3	4	+	5	1	2	+	2	1	5	1	5	7	7	11	2	3	3	2
26	13090	2289	SAMARU 38 SEL 4	HYB	3	1	+	3	2	2	+	3	1	3	1	3	3	3	10	2	2	2	2
27	13092	2297	C 39	HYB	3	1	+	3	2	2	+	3	1	3	1	5	3	7	11	2	3	2	2
28	9052	2304	NCAc 1826	HYB	3	1	+	5	2	2	+	2	1	5	1	5	5	3	10	2	2	2	2
29	882	2308	NCAC 2145	HYB	3	1	+	3	2	2	+	3	1	1	1	5	5	5	10	2	2	2	2
30	885	2312	NCAC 2172	HYB	4	4	+	3	1	2	+	4	1	3	1	5	7	5	10	3	3	3	3
31	13094	2315	NCAC 2277	HYB	4	1	+	5	1	2	+	3	1	5	1	5	7	7	11	2	2	2	2
32	13095	2316	NCAC 2279	HYB	2	1	+	5	2	2	+	2	1	5	1	5	5	7	11	2	3	3	2
33	13096	2317	NCAC 2316	HYB	3	1	+	3	1	2	+	3	1	3	1	0	3	3	10	2	2	1	2
34	888	2319	NCAC 2377	HYB	3	4	+	3	2	2	+	2	1	3	1	5	5	3	10	2	3	3	2
35	889	2320	NCAc 2462	HYB	3	1	+	3	1	2	+	3	1	3	1	5	5	3	10	2	2	2	2
36	894	2327	NCAC 2479	HYB	3	1	+	3	2	2	+	3	1	3	1	3	3	5	10	2	2	2	2
37	13098	2328	NCAC 2480	HYB	3	1	+	3	1	2	+	3	1	3	1	3	3	3	10	2	2	2	2
38	13099	2331	VIRGINIA RED	HYB	3	1	+	3	1	2	+	2	1	5	1	5	5	5	16	2	3	3	2
39	897	2333	NCAC 2556	HYB	3	4	0	3	1	2	+	4	1	3	1	3	5	3	10	2	1	2	2
40	13100	2335	NCAC 2561	HYB	3	4	+	3	1	2	+	2	1	3	1	5	5	3	14	2	2	2	2
41	9059	2337	NCAc 2569	HYB	3	4	+	3	1	2	+	2	1	3	1	3	5	3	10	2	2	2	2
42	900	2339	NCAc 2690	HYB	3	1	+	3	1	2	+	3	1	3	1	7	5	5	10	3	3	3	3

SNO	NRCG	ICG	VAR	HBT	GHB	BPT	STP	STH	INF	FLC	PGP	LFC	LLS	LFH	LLT	PDB	PDC	PDR	SDC	PDZ	SHT	SDS	SDZ
43	13102	2345	V 45	HYB	4	4	+	3	1	2	+	2	1	3	1	5	5	7	1+12	2	3	2	2
44	9065	2353	White's Runner	HYB	3	1	+	3	2	2	+	4	1	3	1	5	5	7	10	3	3	3	3
45	9066	2354	Carolina bunch	HYB	3	1	0	3	2	2	+	2	1	3	1	5	7	5	11	2	1	2	2
46	13109	2374	GA 119072	HYB	3	1	+	3	1	2	+	3	1	3	1	3	3	3	10	2	2	2	2
47	13110	2376	3303	HYB	3	1	+	3	1	2	+	3	1	3	1	5	5	3	10	2	2	2	2
48	9069	2380	A. monticola	HYB	4	4	+	3	2	2	+	2	1	5	1	5	5	5	14	2	2	2	2
49	9070	2383	DHT 190	HYB	3	1	+	1	1	2	+	3	1	3	1	5	5	5	13	2	3	2	2
50	13112	2385	DHT 193	HYB	3	1	+	3	1	2	+	3	1	3	1	5	5	5	14	2	2	2	2
51	13114	2404	RCM 596-1	HYB	3	1	+	3	1	2	+	3	1	3	1	5	3	3	13+1	2	2	2	2
52	6673	2741	G.Narrow leaf	HYB	3	1	+	5	2	2	+	3	1	5	1	5	5	3	10	2	2	2	2
53	6678	4746	PI 298115	HYB	3	1	+	3	2	2	+	2	1	1	1	5	5	7	2	3	3	2	3
54	13116	4753	G 153	HYB	3	1	+	3	2	2	+	2	1	1	1	3	3	3	10	2	2	2	2
55	9945	4757	ICG 4757	HYB	3	4	+	3	2	2	+	3	1	5	1	5	5	7	11	3	3	3	3
56	13126	4777	KU NO.61	HYB	3	4	+	3	1	2	+	3	1	3	1	3	5	5	10	2	2	2	3
57	9947	4778	ICG 4778	HYB	3	4	+	3	2	2	+	3	1	3	1	5	5	5	10	3	3	3	3
58	13127	4780	KU NO.11	HYB	3	1	+	3	2	2	+	3	1	5	1	5	5	7	11	3	3	3	3
59	927	5013	NCAc 784	HYB	3	4	+	3	2	2	+	2	1	3	1	3	5	5	10	2	3	3	2
60	6683	5030	NCAc 1741	HYB	3	4	+	3	2	2	+	2	1	1	1	3	5	5	10	2	3	2	2
61	6684	5037	NCAc 2154	HYB	4	1	+	1	1	2	+	4	1	5	1	5	5	7	10	3	3	3	3
62	952	5129	NCAc 17892	HYB	3	4	+	3	2	2	+	3	1	3	1	5	5	7	10	3	3	3	3
63	13133	5164	NCAC 17587	HYB	3	4	+	3	2	2	+	3	1	3	1	0	3	3	10	2	2	1	2
64	988	5725	NCAC 17751	HYB	4	1	+	3	1	2	+	3	1	5	1	0	3	5	11	3	3	1	3
65	13135	5967	KANYOMA	HYB	3	4	+	5	1	2	+	4	1	3	1	5	5	5	10	2	2	2	2
66	9519	6121	NCAc 1455	HYB	3	1	+	3	2	2	+	3	1	3	1	5	5	7	10	2	3	3	2
67	13139	6183	S 183	HYB	3	1	+	3	1	2	+	3	1	3	1	3	3	3	10	2	2	2	2
68	13140	6229	RCM 596-1	HYB	3	4	+	3	1	2	+	2	1	3	1	5	5	3	13+1	2	3	2	3
69	1022	6764	NCAC 1705	HYB	4	1	+	5	1	2	+	4	1	5	1	7	5	7	10	3	3	3	3
70	13146	6826	C 35	HYB	4	4	+	3	2	2	+	4	1	5	1	5	7	5	11	2	2	3	2

SNO	NRCG	ICG	VAR	HBT	GHB	BPT	STP	STH	INF	FLC	PGP	LFC	LLS	LFH	LLT	PDB	PDC	PDR	SDC	PDZ	SHT	SDS	SDZ
71	13147	6862	NCAC 2491	HYB	4	4	+	5	1	2	+	3	1	5	1	3	3	3	10	2	2	2	2
72	9507	7237	ICG 7237	HYB	3	1	+	3	1	2	+	2	1	3	1	5	5	5	10+1	2	3	2	2
73	13153	7446	M 6-76 M	HYB	3	3	+	3	2	2	+	2	1	5	1	3	3	3	10	2	1	2	1
74	13154	7454	M 399-72 K	HYB	3	1	+	3	1	2	+	3	1	3	1	0	0	3	10	2	1	1	2
75	13155	7490	M 57-72 K	HYB	3	4	0	3	1	2	+	3	1	5	1	3	5	3	10	2	2	2	2
76	4734	7621	NCAc 17718	HYB	3	4	+	3	1	2	+	3	1	3	1	3	5	3	10	2	1	1	2
77	13157	7637	M 107-74 K	HYB	3	4	+	3	2	2	+	3	1	3	1	3	5	5	11	2	2	2	2
78	4751	7664	NCAc 17672	HYB	2	1	+	3	1	2	+	3	1	3	1	0	0	3	10	2	1	1	2
79	9790	7676	ICG 7676	HYB	3	1	+	3	2	2	+	3	1	3	1	3	5	7	10	3	3	2	2
80	13158	7696	EGRET	HYB	3	1	+	5	1	2	+	3	1	5	1	5	5	3	10	2	3	2	2
81	4802	7749	M 380-72	HYB	3	1	+	3	1	2	+	3	1	3	1	3	3	3	10	2	2	2	2
82	6699	7883	PI 315608	HYB	3	4	+	3	2	2	+	3	1	3	1	5	5	7	2	3	2	2	3
83	6705	7892	PI 393527 B	HYB	3	4	+	3	2	2	+	3	1	3	1	0	0	7	14	3	3	2	2
84	6708	7900	PI 414332	HYB	3	4	0	3	1	2	+	2	1	3	1	5	5	5	10	2	2	3	2
85	4921	8030	NCAc 17866	HYB	3	4	0	3	1	2	+	3	1	5	1	0	5	3	10	2	2	1	2
86	4978	8099	PI 270934	HYB	4	4	+	3	1	2	+	4	2	3	2	5	0	5	10+1	2	2	1	2
87	13167	9116	75-72	HYB	3	2	+	3	1	2	+	2	1	5	1	3	5	5	10	2	2	3	2
88	9524	10756	TGR 997	HYB	3	1	+	3	2	2	+	2	1	3	1	5	3	3	14	2	2	2	2
89	8967	10884	KSSc 399	HYB	3	1	+	3	1	2	+	3	1	3	1	5	3	3	13+1	2	2	2	2
90	13171	11269	RM 70-1	HYB	3	1	+	3	1	2	+	3	1	3	1	3	3	3	10	2	2	2	2
91	13115	2438	88/6/7	HYR	2	4	+	3	1	2	+	3	1	3	1	3	5	5	10	2	2	2	2
92	811	384	NCAc 1085	HYR	3	1	+	3	1	2	+	3	1	3	1	3	3	3	10	2	2	2	2
93	676	1637	NCAc 944	HYR	3	3	+	5	2	2	+	2	1	5	1	3	5	5	11	2	2	3	2
94	1703	1656	NCAC 2575	HYR	4	4	+	3	2	2	+	3	1	3	1	0	3	3	10	2	1	2	2
95	685	2271	NCAc 343	HYR	3	1	+	3	2	2	+	3	1	5	1	3	3	5	11	3	2	3	3
96	869	2273	NCAC 505	HYR	2	1	+	3	2	2	+	3	1	3	1	3	3	3	10	2	2	2	2
97	13085	2278	NCAC 595	HYR	2	1	+	3	1	2	+	2	1	3	1	5	5	5	10	2	2	3	3
98	13086	2281	BADAMI ZAMINI	HYR	2	1	+	3	2	2	+	2	1	3	1	5	5	5	10	2	2	3	2

SNO	NRCG	ICG	VAR	HBT	GHB	BPT	STP	STH	INF	FLC	PGP	LFC	LLS	LFH	LLT	PDB	PDC	PDR	SDC	PDZ	SHT	SDS	SDZ
99	13088	2285	NCAC 759	HYR	2	1	+	3	2	2	+	3	1	3	1	5	3	3	10	2	2	3	2
100	13091	2293	NCAC 886	HYR	3	1	+	5	2	2	+	2	1	5	1	5	5	3	10	2	2	2	2
101	4281	2296	NCAc 1107	HYR	2	1	+	3	2	2	+	2	1	3	1	5	5	3	10	2	2	3	2
102	13097	2326	NCAC 2475	HYR	3	1	+	3	2	2	+	2	1	3	1	3	3	3	10	2	2	2	2
103	898	2336	NCAC 2566	HYR	3	4	+	5	2	2	+	2	1	5	1	3	3	3	10	2	2	1	2
104	905	2352	NCAc 2785	HYR	2	1	+	3	2	2	+	2	1	3	1	5	5	3	10	2	1	2	2
105	13104	2360	G 68	HYR	3	4	+	1	1	2	+	3	1	3	1	5	5	5	10	2	2	2	2
106	13105	2361	GA 139	HYR	2	1	+	1	2	2	+	3	1	3	1	3	3	3	10	2	2	1	2
107	9000	2363	G 44	HYR	2	1	+	1	1	2	+	3	1	3	1	5	5	3	10	2	1	2	2
108	13107	2370	GA 124-B	HYR	2	1	0	1	1	2	0	3	1	3	1	5	5	5	2	2	2	2	2
109	702	2377	NCAC 2945	HYR	2	1	+	3	2	2	+	2	1	3	1	5	5	7	10	3	3	3	3
110	13113	2401	NCAC 2763	HYR	2	1	+	3	2	2	+	3	1	3	1	5	5	7	10	3	3	3	3
111	5187	4750	PI 337409	HYR	2	4	+	3	2	2	+	3	1	3	1	5	5	7	10	3	3	3	3
112	13119	4765	KU NO.225	HYR	2	1	+	3	2	2	+	2	1	3	1	5	5	3	10	2	2	2	2
113	13125	4773	KU NO.9	HYR	2	1	+	3	2	2	+	2	1	3	1	5	5	5	10	2	2	3	2
114	9517	5040	NCAc 2214	HYR	2	4	+	9	1	4	+	4	1	1	1	3	3	5	17	2	3	3	2
115	6686	5041	NCAc 2230	HYR	2	4	+	9	2	2	+	3	1	9	1	7	5	7	10	2	2	3	2
116	6532	5042	NCAc 2232	HYR	3	3	0	5	2	2	+	2	1	5	1	5	5	7	10	2	2	2	2
117	6687	5043	NCAc 2240	HYR	2	4	+	9	1	4	+	4	1	3	1	7	7	7	17	2	2	2	2
118	1699	5055	NCAC 2477	HYR	3	1	+	3	2	2	+	2	1	3	1	3	3	3	10	2	2	2	2
119	6691	6147	NCAc 2326	HYR	3	1	+	3	2	2	+	3	1	3	1	3	5	5	11	3	3	2	2
120	763	6317	NCAc 17888	HYR	3	1	+	5	1	2	+	2	1	5	1	5	5	3	14	2	2	2	2
121	9523	7625	M 1069-7K	HYR	3	4	+	3	1	2	+	2	1	3	1	3	3	3	11	2	2	1	2
122	4810	7803	NCAc 2460	HYR	3	1	+	3	1	2	+	3	1	3	1	3	3	5	10+2	2	2	2	2
123	4857	7891	PI 393527-A	HYR	3	4	0	3	2	2	+	3	1	3	1	0	0	7	14	3	3	1	2
124	4863	7899	PI 414331	HYR	3	4	0	3	1	2	0	2	1	3	1	0	0	7	11	2	2	1	2
125	9791	11080	ICG 11080	HYR	4	2	0	5	2	2	0	3	1	7	1	7	5	9	11	2	3	2	2
126	13169	11094	ZFA 3186-1	HYR	3	4	+	3	1	2	+	3	1	5	1	5	5	5	10	2	3	3	2

SNO	NRCG	ICG	VAR	HBT	GHB	BPT	STP	STH	INF	FLC	PGP	LFC	LLS	LFH	LLT	PDB	PDC	PDR	SDC	PDZ	SHT	SDS	SDZ
127	4153	2405	NCAC 2821	HYR	2	1	+	1	2	2	+	3	1	3	1	3	3	3	10	2	2	1	2
128	13134	5932	NCAC 1715	HYB	4	4	+	5	1	2	+	3	1	5	1	3	5	5	10	2	2	3	2
129	13137	6135	CUP 8	HYB	3	4	+	5	2	2	+	3	1	5	1	5	5	5	10	2	2	3	2
130	714	5045	NCAC 2243	FST	3	3	+	3	2	2	0	3	1	5	1	3	3	5	10	2	2	2	2
131	6677	4743	88/23/7	VUL	2	4	+	3	2	2	+	3	1	3	1	3	5	3	10	2	2	2	2
132	13103	2358	NCAC 2836	VUL	3	3	+	5	2	2	+	2	1	5	1	5	3	5	11	2	2	2	2
133	4559	7360	101/66/1	VUL	3	2	+	7	2	2	+	2	1	7	1	3	0	3	11	3	3	1	2
134	13005	263	CPI 10507	FST	3	2	+	3	2	2	+	3	1	5	1	5	5	3	10	2	2	2	2
135	1070	265	NCAc 405	FST	3	2	+	3	1	2	+	2	1	5	1	0	3	3	17	2	2	1	2
136	1071	266	NCAc 406	FST	3	2	+	3	2	2	+	2	1	5	1	0	3	3	17	2	3	1	2
137	1073	274	NCAc 490	FST	3	2	+	3	2	2	+	2	1	5	1	5	5	3	13	2	3	2	2
138	1074	276	NCAc 503	FST	3	2	+	3	2	2	+	3	1	5	1	3	5	3	11	2	3	1	2
139	13009	283	NCAC 524	FST	2	2	+	3	2	2	+	2	1	5	1	3	5	3	13	2	3	2	2
140	13012	291	SENEGAL 1120	FST	3	2	+	3	2	2	+	2	1	3	1	3	5	3	13	2	3	2	2
141	13013	296	MTUTU-A	FST	3	3	+	3	2	2	+	2	1	5	1	3	5	3	13	2	3	2	2
142	782	301	NCAc 583	FST	2	2	+	3	1	2	+	2	1	5	1	0	3	3	13	2	3	2	2
143	13016	320	NCAC 706	FST	3	3	+	3	2	2	+	2	2	5	2	3	5	3	13	2	3	2	2
144	794	322	NCAC 710	FST	3	3	+	5	1	2	+	2	1	5	1	5	5	5	13	2	2	3	2
145	5571	325	PI 152129	FST	3	2	+	3	1	2	+	2	1	5	1	3	5	3	13	2	3	2	2
146	13018	326	NCAC 721	FST	3	2	+	3	2	2	+	2	1	5	1	3	3	3	11	2	3	2	2
147	13025	353	GA 177	FST	3	3	+	5	1	2	+	2	1	5	1	3	5	3	11	2	3	2	2
148	13026	354	V 54	FST	3	3	+	5	2	2	+	2	1	5	1	5	5	7	13	2	3	2	2
149	13027	355	WHITE	FST	3	3	+	3	1	2	+	2	1	3	1	3	5	5	11	3	3	3	2
150	13028	357	NCAC 881	FST	3	2	+	5	2	2	+	2	1	5	1	3	5	5	17	2	2	2	2
151	13029	358	NCAC 884	FST	3	3	+	3	2	2	+	2	1	5	1	3	5	3	13	2	3	2	2
152	13031	362	ZANDI	FST	2	3	+	5	2	2	+	2	1	3	1	3	5	5	13	2	3	2	2
153	13032	364	CORDOFAN	FST	2	3	+	3	2	2	+	2	1	5	1	3	5	5	13	2	3	3	2
154	13034	366	LE 29	FST	3	2	+	3	2	2	+	2	2	3	2	3	5	5	13	2	3	2	2

SNO	NRCG	ICG	VAR	HBT	GHB	BPT	STP	STH	INF	FLC	PGP	LFC	LLS	LFH	LLT	PDB	PDC	PDR	SDC	PDZ	SHT	SDS	SDZ
155	13035	367	MANI GUAYCURU 1	FST	2	3	+	3	2	2	+	2	2	3	2	5	5	3	11	2	2	2	2
156	13038	370	DETOST ADERO	FST	3	2	+	3	2	2	+	2	1	5	1	5	5	5	13	2	3	3	2
157	13042	379	NCAC 1001	FST	3	2	+	3	2	2	+	2	1	5	1	3	5	3	13	2	3	2	2
158	13043	380	NCAC 1002	FST	2	3	+	5	2	2	+	2	1	5	1	3	3	3	13	2	3	2	2
159	13046	385	CPI 10496	FST	2	2	+	3	2	2	+	2	2	5	2	5	5	5	11	2	3	3	2
160	4214	389	NCAc 1286	FST	2	3	+	3	1	2	+	2	1	5	1	3	5	5	13	2	3	2	2
161	13049	391	TORO	FST	3	2	+	3	1	1	+	2	1	5	1	3	5	3	13	2	3	2	2
162	4296	392	NCAC 1302	FST	2	3	+	3	1	2	+	2	1	5	1	3	5	5	13	2	3	3	2
163	13052	398	VALENCIA	FST	3	2	+	3	2	2	+	2	1	3	1	3	5	5	13	2	3	3	2
164	4299	403	NCAC 2653	FST	2	2	+	3	1	2	+	2	1	3	1	3	5	3	13	2	3	2	2
165	1108	404	NCAc 2654	FST	3	2	+	3	2	2	+	2	1	5	1	3	5	3	13	2	3	2	2
166	1109	405	NCAc 2663	FST	2	2	+	5	1	2	+	4	1	5	1	3	5	3	13	2	3	3	2
167	1113	411	NCAc 2700	FST	2	3	+	3	2	2	+	2	1	5	1	3	5	3	13	2	3	2	2
168	13055	427	44-183	FST	3	2	+	5	1	2	+	2	1	5	1	3	5	3	17	2	3	2	2
169	13059	447	2293	FST	3	3	+	5	1	2	+	2	1	5	1	0	5	3	17	2	3	1	2
170	13060	452	NCAC 2927	FST	3	2	+	3	1	2	+	2	1	5	1	3	5	5	16	2	3	2	2
171	13061	460	RCM 462	FST	3	2	+	3	2	2	+	2	1	5	1	3	5	3	13	2	3	2	2
172	13062	462	RCM 467	FST	3	2	+	3	2	2	+	2	1	5	1	3	5	3	17	2	3	2	2
173	4220	463	NCAc 17089	FST	3	2	+	5	2	2	+	2	1	5	1	3	5	5	13	2	3	2	2
174	13063	469	WCG 131	FST	3	3	+	3	1	2	+	2	1	5	1	7	5	7	17	2	3	3	2
175	9110	470	WCG 169	FST	2	2	+	5	2	2	+	2	1	5	1	3	5	5	13	2	3	2	2
176	9125	1603	Krapovickas 4	FST	3	2	+	5	2	2	+	2	1	5	1	5	5	7	13	2	3	3	2
177	13066	1608	KINORALES	FST	3	3	+	5	1	2	+	2	1	5	1	5	5	5	13	2	3	3	2
178	13068	1613	SP 2B	FST	3	2	+	5	1	2	+	2	1	5	1	5	5	7	11	2	1	3	2
179	1151	1615	NCAC 414	FST	3	3	+	3	2	2	+	3	1	3	1	3	5	3	11	2	1	2	2
180	4290	1627	NCAC 568	FST	3	3	+	3	2	2	+	2	1	5	1	3	5	3	13	2	3	3	2
181	1164	1660	NCAC 2666	FST	3	2	+	3	1	2	+	2	1	5	1	3	5	3	13	2	3	3	2
182	9130	1664	NCAc 2679	FST	2	2	+	3	2	2	+	3	1	3	1	3	5	3	17	2	2	2	2

SNO	NRCG	ICG	VAR	HBT	GHB	BPT	STP	STH	INF	FLC	PGP	LFC	LLS	LFH	LLT	PDB	PDC	PDR	SDC	PDZ	SHT	SDS	SDZ
183	9131	1665	Gemana	FST	3	3	+	3	1	2	+	2	1	3	1	3	5	3	13	2	3	2	2
184	13075	1683	G 90 A	FST	4	2	+	5	2	2	+	3	1	5	1	5	3	7	11	2	2	2	2
185	851	1696	NCAc 16026	FST	2	2	+	3	2	2	+	2	1	5	1	3	5	3	13	2	3	3	2
186	1177	1697	NCAc 17090	FST	3	2	0	7	2	2	0	3	1	7	1	5	5	7	11	2	3	3	2
187	6663	1703	NCAc 17127	FST	4	2	0	5	2	2	0	3	1	5	1	5	5	9	11+17	2	3	3	2
188	6664	1704	NCAc 17129	FST	4	2	0	3	1	2	0	3	1	5	1	5	5	9	11	2	3	3	2
189	5177	1707	NCAc 17132	FST	4	2	+	5	1	4	+	3	1	5	1	9	5	9	17	2	3	3	2
190	1179	1709	NCAc 17134	FST	3	2	+	3	2	3	+	3	1	3	1	5	5	9	17+11	2	3	3	2
191	5178	1710	NCAc 17135	FST	4	2	+	3	1	4	+	2	1	5	1	9	5	9	17	2	3	3	2
192	9135	1713	Peru No. 3	FST	4	2	+	3	1	2	+	3	1	5	1	5	5	3	11	2	2	2	2
193	13101	2338	KRAPOVICKAS 5	FST	4	2	+	9	1	4	+	3	1	9	1	5	5	9	17	2	3	3	2
194	13118	4764	KU NO.220	FST	3	2	+	3	1	2	+	3	1	3	1	3	5	3	11	2	3	2	2
195	13124	4772	KU NO.8	FST	3	2	+	3	2	2	+	3	1	3	1	3	5	3	13	2	3	2	2
196	13130	4788	KU NO.189	FST	3	2	+	3	2	2	+	3	1	3	1	3	5	3	13	2	3	2	2
197	6682	4790	Krap strain 16	FST	4	2	+	5	2	4	+	3	1	5	1	7	5	9	17	2	3	3	2
198	9949	4791	ICG 4791	FST	3	2	+	3	1	2	+	3	1	5	1	3	5	3	13	2	3	1	2
199	13136	6090	NCAC 664	FST	3	3	+	3	1	2	+	3	1	3	1	3	5	3	13	2	3	2	2
200	13138	6140	NCAC 2209	FST	3	2	+	5	1	2	+	3	1	5	1	3	5	3	13	2	3	2	2
201	10774	6201	BC 119	FST	3	2	+	3	1	2	+	3	1	5	1	3	5	3	13	2	3	2	2
202	13141	6271	WCG 149	FST	3	2	+	3	1	2	+	2	1	3	1	0	5	3	17	2	3	2	2
203	13142	6277	WCG 166B	FST	3	2	+	5	2	2	+	2	1	5	1	0	5	3	17	2	3	2	2
204	6692	6280	NCAc 17124	FST	4	2	0	5	2	2	0	3	1	5	1	7	5	9	11+17	2	3	2	2
205	13143	6355	RCM 533	FST	3	2	+	5	1	2	+	2	1	5	1	3	5	3	17	2	3	2	2
206	13144	6691	ROGUE DE PLODIV	FST	2	2	+	5	2	2	+	2	1	5	1	3	5	3	13	2	3	3	2
207	13145	6709	PERU NO.2	FST	3	2	+	3	2	2	+	2	2	3	2	5	3	5	13	2	3	2	2
208	11247	6726	WCG 135	FST	3	3	+	3	1	2	+	2	1	5	1	3	5	3	13	2	3	1	2
209	4471	6775	PI 262058	FST	3	3	+	3	1	2	+	2	1	5	1	3	5	3	13	2	3	2	2
210	1527	6960	PI 262007	FST	3	3	+	3	2	2	+	3	1	5	1	3	5	3	13	2	3	2	2

SNO	NRCG	ICG	VAR	HBT	GHB	BPT	STP	STH	INF	FLC	PGP	LFC	LLS	LFH	LLT	PDB	PDC	PDR	SDC	PDZ	SHT	SDS	SDZ
211	13148	7205	WCG 115	FST	3	3	+	3	2	2	+	2	1	5	1	5	5	7	11	2	2	3	2
212	13149	7296	203/66	FST	4	2	+	3	2	2	+	3	1	5	1	3	5	5	11	2	3	1	2
213	13150	7320	NCAC 17656	FST	3	2	0	3	1	2	0	3	1	5	1	3	5	7	11	2	3	2	2
214	13151	7340	WCG 182	FST	4	2	0	3	2	2	0	3	1	3	1	5	5	9	11+17	2	3	2	2
215	13152	7353	PERU NO.9	FST	4	2	0	3	2	2	0	3	1	3	1	5	5	9	11	2	3	3	2
216	4603	7404	V 20	FST	4	2	0	5	2	2	0	3	1	5	1	3	5	9	11	2	3	3	2
217	4486	7433	NCAc 17518	FST	4	3	+	5	2	3	+	3	1	5	1	3	5	9	11+17	2	3	2	2
218	9747	7620	ICG 7620	FST	4	2	+	5	2	3	+	2	1	5	1	5	5	9	11+17	2	3	2	2
219	13156	7628	WCG 170	FST	4	2	+	3	2	3	+	3	1	3	1	3	5	9	17	2	3	2	2
220	13159	7712	PERU NO.9	FST	3	2	0	5	1	2	0	3	1	5	1	3	5	9	11	2	3	3	2
221	13160	7777	SAM COL. 186	FST	4	3	+	3	1	2	+	2	1	3	1	5	5	5	14	2	3	3	3
222	4849	7881	PI 215696	FST	4	2	+	3	2	3	+	3	2	3	2	5	5	7	17	2	3	2	2
223	4850	7882	PI 314817	FST	4	2	0	3	2	2	0	2	1	3	1	3	3	7	11	2	3	2	2
224	6700	7885	PI 381622	FST	4	2	+	5	2	3	+	2	1	5	1	5	5	7	17	2	3	2	2
225	6529	7886	PI 390593	FST	4	2	0	5	1	2	0	3	1	5	1	5	5	9	11	2	3	2	2
226	6703	7889	PI 393517	FST	4	2	0	7	2	2	0	3	1	7	1	5	5	7	2	2	3	2	2
227	4859	7893	PI 393531	FST	4	3	0	3	2	2	0	3	1	5	1	5	5	9	11+17	2	3	3	2
228	4861	7896	PI 393646	FST	4	2	+	5	2	2	+	3	1	5	1	5	5	9	16	2	3	3	2
229	6707	7897	PI 405132	FST	4	2	+	5	2	3	+	3	1	5	1	5	5	9	17	2	3	2	2
230	4873	7924	PI 268491	FST	3	3	+	5	1	2	+	3	1	5	1	0	5	3	13	2	3	1	2
231	13161	7927	MUBENDI	FST	3	2	+	3	2	2	+	4	1	5	1	3	5	3	13	2	3	2	2
232	4498	8000	PI 268492	FST	3	2	+	3	2	2	+	4	1	5	1	3	5	3	13	2	3	2	2
233	1587	8003	Tesa bunch	FST	3	3	+	3	2	2	+	3	1	5	1	3	5	3	13	2	3	2	2
234	4934	8047	PI 268525	FST	3	3	+	3	2	2	+	3	1	5	1	3	5	3	13	2	3	2	2
235	13162	8105	RCM 449-3	FST	3	2	+	3	2	2	+	3	1	5	1	5	5	5	17	2	3	3	2
236	6540	8257	NCAc 17099	FST	2	2	+	3	1	2	+	2	1	5	1	5	5	3	17	2	2	3	2
237	13166	8599	TYPE NO.7	FST	3	2	+	3	2	2	+	3	1	5	1	3	5	3	13	2	3	2	2
238	13168	9185	75-16	FST	3	2	+	3	2	2	+	2	1	5	1	3	0	9	13+1	3	3	2	2

SNO	NRCG	ICG	VAR	HBT	GHB	BPT	STP	STH	INF	FLC	PGP	LFC	LLS	LFH	LLT	PDB	PDC	PDR	SDC	PDZ	SHT	SDS	SDZ
239	10995	10005	SP 425 FLESH	FST	4	2	0	3	2	2	0	2	1	3	1	5	5	9	11	2	3	3	2
240	11589	10039	SPZ 482 DARK PU	FST	4	2	+	5	2	4	+	2	1	5	1	5	5	9	17	2	3	2	2
241	11007	10048	SPZ 487 FLESH	FST	4	2	0	5	2	2	0	2	1	5	1	3	5	9	11	2	3	2	2
242	11594	10057	SPZ 492 PURPLE	FST	4	2	+	5	2	3	+	2	1	5	1	5	5	9	16	2	3	2	2
243	11009	10058	SPZ 493 FLESH	FST	4	2	0	5	1	2	0	2	1	5	1	5	5	9	11	2	3	2	2
244	11595	10059	SPZ 493 PURPLE	FST	2	2	+	3	2	3	+	2	1	5	1	5	5	9	16	2	3	3	2
245	11598	10063	SPZ 496 PURPLE	FST	4	2	+	7	2	2	+	2	1	7	1	5	5	9	16	2	3	3	2
246	11600	10067	SPZ 499 PURPLE	FST	4	2	+	7	2	2	+	2	1	7	1	5	5	9	16	2	3	2	2
247	11012	10070	SPZ 501 PURPLE	FST	4	2	+	7	2	3	+	2	1	7	1	5	5	9	16	2	3	2	2
248	11032	10450	TINGO MARIA	FST	4	2	+	7	2	4	+	3	1	7	1	7	3	9	17	2	3	1	2
249	11604	10890	SPA 406 RED	FST	4	2	+	7	2	2	+	3	1	7	1	5	5	3	13	2	3	2	2
250	11605	10918	SPZ 459 FLESH	FST	4	2	0	5	2	2	0	3	1	7	1	3	5	9	11	2	3	2	2
251	11611	10935	SPZ 476 DARK PU	FST	4	2	+	5	2	4	+	3	1	7	1	3	5	9	17	2	3	2	2
252	11918	10949	SPZ 486 LIGHT P	FST	4	2	+	5	2	4	+	3	1	5	1	9	7	9	17	2	3	3	2
253	11612	10966	SPZ 496 FLESH	FST	4	2	+	7	2	2	+	3	1	7	1	5	5	9	11	2	3	2	2
254	9740	10974	ICG 10974	FST	4	2	0	7	2	2	+	3	1	7	1	5	5	9	16	2	3	2	2
255	11581	10975	SPZ 503 DARK PU	FST	4	2	+	5	2	3	+	2	1	7	1	5	5	9	17	2	3	2	2
256	11614	11073	SPZ 459 PURPLE	FST	4	2	+	7	2	3	+	3	1	7	1	5	5	9	16	2	3	2	2
257	9746	11075	ICG 11075	FST	4	2	0	7	2	2	0	2	1	7	1	5	5	9	11+17	2	3	3	2
258	11615	11108	SPZ 503 PURPLE	FST	3	2	+	7	2	3	+	2	1	7	1	5	5	9	16	2	3	3	2
259	13170	11182	SP 403 TAN	FST	3	2	0	7	2	2	0	3	1	7	1	5	5	9	11	2	3	3	2
260	11582	11186	SPZ 488 GASP	FST	4	2	0	5	2	2	0	3	1	5	1	5	5	9	11+17	2	3	3	2
261	11622	11282	SPA 411	FST	4	2	+	7	2	2	+	2	1	7	1	5	5	3	13	2	3	3	2
262	13172	11285	SPZ 473 GASP	FST	3	2	0	7	2	2	0	2	1	7	1	5	5	9	11+17	2	3	2	2
263	13173	11485	P 2435	FST	4	2	+	7	2	3	+	2	1	7	1	7	5	9	17	2	3	3	2
264	13174	12112	SPZ 485 LPL	FST	4	2	+	7	2	3	+	3	1	7	1	9	7	9	17	2	3	3	2
265	5176	1705	NCAc 17130	FST	4	2	0	5	2	2	0	3	1	5	1	5	5	9	11	2	3	2	2
266	1520	6903	PI 268988	FST	3	2	+	5	2	2	+	2	1	5	1	3	5	3	13	2	3	2	2

SNO	NRCG	ICG	VAR	HBT	GHB	BPT	STP	STH	INF	FLC	PGP	LFC	LLS	LFH	LLT	PDB	PDC	PDR	SDC	PDZ	SHT	SDS	SDZ
267	4212	361	NCAc 963	FST	3	2	+	5	1	2	+	2	1	5	1	3	5	3	13	2	3	1	2
268	4206	279	NCAc 515	VUL	3	2	+	5	2	2	+	2	1	5	1	3	3	3	11	2	2	2	2
269	13036	368	MANI NEGRO	VUL	3	2	0	5	2	2	0	2	1	5	1	5	5	3	2	2	2	2	2
270	1172	1679	NCAc 2838	VUL	3	2	0	5	2	2	+	3	1	5	1	0	7	5	11	2	1	1	2
271	13079	1712	V 109	VUL	4	2	0	3	1	2	0	2	1	3	1	3	5	9	11	2	3	2	2
272	13128	4783	KU NO.60	VUL	3	2	+	5	2	2	+	2	1	5	1	3	5	3	11	2	2	2	2
273	13006	268	GA 167	VUL	3	3	+	3	1	2	+	2	1	3	1	0	5	3	11	1	1	1	1
274	13007	275	GA 181	VUL	3	2	+	3	2	2	+	3	1	3	1	0	3	3	11	2	2	1	2
275	13008	282	NCAC 520	VUL	3	2	+	5	1	2	+	2	1	5	1	5	5	7	11	2	2	3	2
276	1079	286	NCAC 529	VUL	3	2	+	5	2	2	+	2	1	5	1	3	7	5	11	2	3	3	2
277	13010	289	SPANISH 2B	VUL	3	2	+	5	2	2	+	2	1	5	1	3	5	5	11	2	2	2	2
278	13011	290	NCAC 542	VUL	3	2	+	5	2	2	+	2	1	5	1	5	3	5	11	2	2	1	2
279	9182	294	MPUTU-C	VUL	3	3	0	5	1	2	+	2	1	5	1	3	3	3	11	2	1	1	2
280	13014	310	GA 199	VUL	3	2	0	5	2	2	+	2	1	5	1	3	7	5	13	2	1	2	2
281	4236	311	NCAc 608	VUL	3	3	+	5	2	2	+	2	1	5	1	5	5	5	11	2	2	2	2
282	13015	316	GA 163	VUL	3	2	+	5	2	2	+	3	1	5	1	3	5	5	11	2	2	2	2
283	13017	323	BAKU FOIRE	VUL	3	2	+	7	2	2	+	2	1	7	1	3	5	5	11	2	2	2	2
284	13019	327	CATETO	VUL	3	2	+	5	2	2	+	2	1	5	1	3	5	5	11	2	2	2	2
285	4238	329	NCAc 726	VUL	3	2	+	5	1	2	+	2	1	5	1	3	5	5	17	2	1	2	2
286	4239	333	NCAc 746	VUL	3	2	+	5	2	2	+	2	1	5	1	3	5	5	11	2	2	2	2
287	9185	334	NCAc 751	VUL	3	2	+	5	1	2	+	2	1	5	1	3	5	5	11	2	2	2	2
288	13020	341	ACETEIRO CHICO	VUL	3	2	+	3	1	2	+	3	1	3	1	0	3	3	11	2	1	1	2
289	13021	344	LE 36	VUL	3	2	+	3	2	2	+	2	1	3	1	0	3	3	11	2	1	1	2
290	13022	348	NCAC 821	VUL	3	2	+	5	2	2	+	3	2	5	2	3	5	5	13	2	3	2	2
291	13023	350	NCAC 831	VUL	3	2	+	5	2	2	+	3	1	5	1	3	0	5	11	2	2	1	2
292	13024	352	NCAC 845	VUL	3	3	+	5	2	2	+	2	1	7	1	3	5	3	11	2	1	2	2
293	1107	359	NCAC 888	VUL	3	2	+	3	2	2	+	2	1	5	1	0	5	3	16	2	1	1	2
294	13030	360	NCAC 892	VUL	3	2	+	3	1	2	+	2	1	5	1	0	7	3	11	2	1	1	2

SNO	NRCG	ICG	VAR	HBT	GHB	BPT	STP	STH	INF	FLC	PGP	LFC	LLS	LFH	LLT	PDB	PDC	PDR	SDC	PDZ	SHT	SDS	SDZ
295	13033	365	MANI BLANCA 61	VUL	3	3	0	5	2	2	+	2	1	3	1	3	5	3	11	2	1	2	2
296	13037	369	MANI BLANCO 26A	VUL	3	3	+	3	2	2	+	2	1	5	1	3	3	3	11	2	1	1	2
297	13039	374	NCAC 967	VUL	3	2	+	5	2	2	+	3	1	5	1	3	3	3	11	2	1	2	2
298	13040	377	NCAC 990	VUL	3	3	+	5	2	2	+	2	1	5	1	3	3	3	13	2	1	2	2
299	13041	378	SH 130	VUL	3	2	+	5	2	2	+	2	1	5	1	3	5	5	17	2	2	2	2
300	13044	381	A 30	VUL	3	2	0	3	1	2	+	2	1	5	1	3	3	3	11	2	1	1	2
301	13045	382	A 18	VUL	3	2	+	3	2	2	+	2	1	5	1	3	5	5	11	2	2	2	2
302	13047	386	CPI 11996	VUL	3	2	+	5	2	2	+	2	1	5	1	0	5	5	11	2	1	2	2
303	13048	388	CPI 12154	VUL	3	2	+	5	1	2	+	2	1	5	1	3	3	3	11	2	1	1	2
304	13050	394	RED SPANISH	VUL	3	3	+	5	2	2	+	2	1	5	1	3	3	3	13	2	1	1	2
305	13051	396	NCAC 1333	VUL	3	3	+	3	2	2	+	2	1	5	1	3	5	5	11	2	2	2	2
306	819	400	NCAC 2600	VUL	3	2	+	3	2	2	+	3	1	5	1	5	5	5	11	2	3	2	2
307	13053	402	SP 2B	VUL	3	3	+	3	2	2	+	2	1	3	1	3	5	5	11	2	2	3	2
308	13054	410	NCAC 2698	VUL	3	2	+	5	2	2	+	3	1	5	1	5	5	5	11	2	2	2	2
309	9187	426	Mfoka-A	VUL	3	3	+	3	2	2	+	2	1	5	1	0	3	3	11	2	2	1	2
310	5573	428	NCAc 2816	VUL	3	2	+	3	2	2	+	3	2	5	2	3	3	5	11	2	1	1	2
311	5574	431	PI 152108	VUL	3	3	+	5	2	2	+	3	2	5	1	5	7	5	11	2	2	2	2
312	13056	432	GA 270-8	VUL	3	3	+	5	2	2	+	2	1	5	1	5	9	3	1	2	2	2	2
313	13057	438	PORTO ALEGRE	VUL	3	3	+	5	2	2	+	3	1	5	1	0	3	3	11	2	1	1	2
314	13058	444	MTUTU-B	VUL	3	2	+	5	1	2	+	2	1	5	1	0	3	3	11	2	1	1	2
315	9190	456	NCAc 2953	VUL	3	2	+	5	2	2	+	2	1	5	1	3	5	5	11	2	2	2	2
316	13064	473	V 26	VUL	3	2	+	5	2	2	+	2	2	5	2	5	5	5	13	2	2	2	2
317	5007	476	Chico	VUL	3	2	+	3	2	2	+	3	1	3	1	7	5	3	11	2	1	3	2
318	9225	1605	Pei-Kang-Pe-You-Don	VUL	3	2	+	3	2	2	+	3	1	3	1	3	5	5	11	2	2	2	2
319	13065	1606	LUNG TAN YOU DO	VUL	3	2	+	5	2	2	+	2	1	5	1	3	5	5	11	2	3	2	2
320	13067	1609	SCHWARZ 21	VUL	3	3	+	3	1	2	+	2	1	3	1	3	5	5	11	2	3	2	2
321	1680	1612	NCAC 399	VUL	3	2	+	3	2	2	+	2	1	3	1	3	5	5	11	2	3	2	2
322	13069	1616	GA 159	VUL	3	2	+	3	1	2	+	2	1	3	1	5	5	5	11	2	2	2	2

SNO	NRCG	ICG	VAR	HBT	GHB	BPT	STP	STH	INF	FLC	PGP	LFC	LLS	LFH	LLT	PDB	PDC	PDR	SDC	PDZ	SHT	SDS	SDZ
323	9228	1617	NCAc 429	VUL	3	2	+	3	2	2	+	2	1	5	1	5	5	5	11	2	2	2	2
324	13070	1623	DOI	VUL	3	2	+	5	1	2	+	3	1	5	1	0	3	3	11	2	1	1	2
325	13071	1628	BILB	VUL	3	3	+	3	1	2	+	2	1	5	1	5	5	5	11	2	2	2	2
326	1158	1636	NCAC 889	VUL	3	3	+	3	2	2	+	2	1	5	1	3	5	3	11	1	1	1	1
327	9235	1644	Maseni	VUL	3	2	+	3	2	2	+	2	1	3	1	5	5	5	11	2	2	2	2
328	9236	1662	NCAc 2673	VUL	3	3	+	5	2	2	+	3	1	5	1	3	5	5	11	2	2	2	2
329	9237	1669	NCAc 2737	VUL	3	3	+	3	2	2	+	3	1	3	1	3	5	7	10	2	3	3	3
330	1169	1674	NCAC 2753	VUL	3	2	+	3	2	2	+	2	1	3	1	3	5	5	11	2	2	2	2
331	1688	1677	NCAC 2820	VUL	3	2	+	3	2	2	+	2	1	5	1	3	5	3	11	2	1	1	2
332	13074	1681	GA 195	VUL	3	3	+	5	2	2	+	2	1	5	1	0	3	5	11	2	3	3	2
333	13076	1685	MTUTU-C	VUL	3	3	+	3	2	2	+	3	1	3	1	0	3	5	11	2	1	1	2
334	13078	1699	WCG 156	VUL	3	3	+	5	2	2	+	2	2	5	2	5	5	5	11	2	2	2	2
335	9238	1711	DHT 191	VUL	3	2	+	3	2	2	+	3	1	3	1	3	5	5	11	2	1	1	2
336	9344	2272	GA 165	VUL	3	2	+	3	2	2	+	3	1	3	1	3	5	5	11	2	3	2	2
337	13093	2310	NCAC 2158	VUL	3	3	+	3	2	2	+	4	1	3	1	5	5	5	10	3	3	3	3
338	9347	2359	Clark 8	VUL	3	2	+	5	2	2	+	2	1	5	1	3	5	5	11	2	1	1	2
339	13106	2364	GA 198	VUL	3	2	+	3	1	2	+	2	1	3	1	5	3	5	13	2	3	2	2
340	13111	2378	RCM 439	VUL	3	2	+	3	2	2	+	2	1	3	1	5	7	5	11	2	2	2	2
341	9444	3516	US 16-B	VUL	3	2	+	3	2	2	+	2	1	3	1	5	5	5	11	2	3	2	2
342	6536	4749	PI 337394F	VUL	3	2	+	3	2	2	+	2	1	5	1	5	3	3	11	2	2	2	2
343	7320	4751	T-900 (krinkle leaf	VUL	4	2	+	3	1	2	+	3	1	3	1	3	5	5	11	1	1	1	1
344	6681	4756	Ku# 191	VUL	3	3	+	5	2	2	+	2	1	5	1	0	3	5	11	2	2	2	2
345	9946	4758	ICG 4758	VUL	3	2	+	5	2	2	+	2	1	5	1	0	3	5	11	2	2	2	2
346	13117	4759	KU NO.159	VUL	3	2	0	3	2	2	0	2	1	5	1	0	0	5	11	2	2	2	2
347	13120	4766	KU NO.235	VUL	3	3	+	3	2	2	+	2	1	3	1	5	5	5	11	2	1	2	2
348	13121	4767	KU NO.236	VUL	3	2	+	3	1	2	+	2	1	5	1	5	5	5	11	2	2	2	2
349	13122	4768	KU NO.237	VUL	3	2	+	3	1	2	+	2	1	5	1	3	5	3	11	2	1	1	2
350	13123	4770	KU NO.203	VUL	3	2	+	3	2	2	+	3	1	3	1	5	7	5	10	2	2	2	2

SNO	NRCG	ICG	VAR	HBT	GHB	BPT	STP	STH	INF	FLC	PGP	LFC	LLS	LFH	LLT	PDB	PDC	PDR	SDC	PDZ	SHT	SDS	SDZ
351	13129	4785	KU NO.134	VUL	3	2	+	3	2	2	+	2	1	5	1	3	5	5	11	2	1	2	2
352	9540	4787	KU No. 144	VUL	3	3	+	3	1	2	+	2	1	5	1	5	3	5	11	2	1	2	2
353	1200	5100	NCAc 16820	VUL	3	3	+	5	2	2	+	2	1	5	1	3	3	5	11	2	1	1	2
354	13131	5144	NCAC 2308	VUL	4	4	+	3	1	4	+	4	1	5	1	5	5	5	17	2	2	2	2
355	13132	5156	F 1-79	VUL	3	2	+	3	2	2	+	3	1	5	1	0	0	3	11	2	1	1	2
356	6696	7633	UF 71513	VUL	3	2	+	3	2	2	+	3	1	5	1	5	5	5	11	2	2	2	2
357	6706	7895	PI 393643	VUL	4	2	0	7	2	2	0	2	1	7	1	5	5	7	10	2	3	2	2
358	1657	7906	PI 268802	VUL	3	3	+	3	2	2	+	2	1	3	1	3	5	5	11	2	1	1	2
359	4491	7930	PI 268741	VUL	3	2	+	3	2	2	+	2	1	5	1	3	3	3	11	2	1	1	2
360	13163	8230	MANYEMA TANGANY	VUL	3	2	+	5	2	2	+	2	1	5	1	0	3	3	11	2	1	1	2
361	13164	8450	RG 23	VUL	3	2	+	3	2	2	+	2	1	5	1	3	5	5	11	2	1	1	2
362	13165	8472	RG 89	VUL	3	2	+	5	2	2	+	2	1	5	1	3	5	5	11	2	1	2	2
363	9575	8662	Acc # 727	VUL	3	2	+	3	2	2	+	3	1	5	1	0	3	5	11	2	2	1	2
364	9577	8664	Acc # 731	VUL	2	3	+	5	1	2	+	2	1	5	1	5	5	5	11	2	2	2	2
365	6407	8977	PI 268573	VUL	3	3	+	5	2	2	+	2	1	5	1	0	3	3	11	2	1	1	2
366	11676	5048	NCAC 2313	VUL	4	4	+	5	1	4	+	4	1	5	1	7	7	5	17	2	2	2	2
367	9062	2343	FLA 76-10	VUL	3	3	0	5	1	2	+	2	1	5	1	3	3	5	11	2	2	2	2

Annexure III 26 quantitative characters of 367 groundnut germplasm (two years pooled data)

Abbreviations

DTG	Days to germination	LLW	Leaflet width	FSP	Four seeded pod
DIF	Days to initial flowering	LWR	Leaflet length/width	PDL	Pod length
DFF	Days to 50 % flowering	NIMP	Immature pods/plant	PDW	Pod width
DTM	Days to maturity	PYP	Pod mass (g/plant)	SDL	Seed length
LMA	Height of main axis	PPMT	Pod yield m^{-2} (g)	SDW	Seed width
LPB	Leanght of n+1 branches	HPW	100 pod mass	SHE	Shelling outturn %
NPB	No. of n+1 branches	OSP	One seeded pod	SMK	Sound mature seed
NSB	No. of n+2 branches	TSP	Two seeded pod	HSW	Hundred seed mass
LLL	Leaflet length	THP	Three seeded pod		

SNO	NRCG	ICG	VAR	HBT	DTG	DIF	DFF	DTM	LMA	LPB	NPB	NSB	LLL	LLW	LWR	NIMP	PYP	PPMT	HPW	OSP	TSP	THP	FSP	PDL	PDW	SDL	SDW	SHE	SMK	HSW
1	9189	436	4133	HYB	8	19	21	93	53.5	61.8	5.0	3.0	58.8	27.3	2.2	0.8	18.6	126.7	74.3	6.9	93.1	0.0	0.0	22.4	11.2	10.7	7.5	77.3	93.1	30.0
2	840	1647	NCAC 2188	HYB	8	32	33	120	44.0	58.8	4.0	21.5	55.0	23.2	2.4	3.8	17.7	108.4	106.3	24.0	53.1	22.9	0.0	30.5	14.0	15.0	7.5	63.7	84.6	35.0
3	1613	6834	PI 268899	HYB	8	22	23	118	43.3	52.3	4.0	24.3	46.7	19.7	2.4	4.0	19.1	122.4	90.9	13.1	86.9	0.0	0.0	28.1	12.8	14.0	8.2	55.6	82.0	34.0
4	13108	2372	1357-10	HYB	8	20	21	116	42.0	57.8	4.0	15.3	54.5	21.7	2.5	2.3	28.2	146.5	150.5	24.8	75.2	0.0	0.0	34.2	14.2	7.4	8.2	68.4	93.3	65.0
5	9036	1634	NC Bunch	HYB	8	19	21	118	45.3	58.0	4.0	21.8	56.7	21.8	2.6	4.5	26.9	93.3	161.0	30.0	70.0	0.0	0.0	37.0	18.0	20.0	8.0	64.6	92.3	66.0
6	9038	1641	B 33	HYB	8	21	21	118	45.3	59.5	4.0	12.0	54.8	22.3	2.5	2.8	26.5	159.1	163.6	22.2	77.8	0.0	0.0	38.0	17.0	18.0	9.0	63.6	92.2	66.0
7	9039	1646	NCAc 2187	HYB	8	23	26	118	44.0	56.0	4.0	15.0	49.2	23.0	2.1	3.3	20.7	107.7	112.4	26.7	73.3	0.0	0.0	31.0	10.2	14.5	8.4	60.2	88.7	52.0
8	9040	1648	NCAc 2189	HYB	8	23	26	116	44.0	55.5	4.0	10.3	50.7	23.3	2.2	2.8	18.9	90.8	125.5	17.0	83.0	0.0	0.0	34.0	14.9	16.4	10.4	61.9	82.2	49.0
9	9042	1653	NCAc 2562	HYB	8	21	22	114	34.5	38.5	4.0	3.0	48.7	24.5	2.0	2.3	23.7	145.6	137.2	17.0	83.0	0.0	0.0	26.0	14.0	14.0	10.0	70.5	87.9	51.0
10	841	1654	NCAC 2563	HYB	8	21	22	114	38.5	45.8	4.0	12.8	54.5	23.3	2.3	3.3	31.2	178.7	123.8	17.8	82.2	0.0	0.0	30.2	14.5	16.2	9.1	68.8	93.0	48.0
11	13072	1655	NCAC 2564	HYB	8	22	23	116	25.3	35.5	4.0	2.3	47.0	21.2	2.2	1.5	26.8	139.6	153.2	14.9	85.1	0.0	0.0	26.5	14.8	15.0	10.5	68.1	93.9	62.0
12	13073	1671	D 32	HYB	8	21	23	115	47.3	61.8	4.0	22.3	55.3	21.2	2.6	5.8	24.6	141.1	124.2	9.1	90.9	0.0	0.0	31.4	15.2	15.5	8.4	67.5	91.6	51.0
13	13077	1691	GA 61-35	HYB	8	21	23	114	34.8	52.0	4.0	21.8	46.2	20.7	2.2	5.5	18.8	155.7	60.6	40.4	59.6	0.0	0.0	20.5	11.4	11.4	7.7	70.0	92.9	30.0
14	4282	2248	NCAc 12	HYB	7	22	23	116	40.0	52.5	4.0	14.3	50.5	21.0	2.4	4.3	28.2	222.0	118.0	25.0	75.0	0.0	0.0	30.0	14.8	15.0	8.4	68.6	90.1	51.0
15	9044	2249	NCAc 23	HYB	8	21	22	116	39.3	61.5	4.0	20.8	50.5	21.5	2.3	5.0	29.8	183.1	132.1	6.3	93.8	0.0	0.0	30.0	13.0	16.0	8.5	67.6	92.0	51.0
16	13080	2251	8-19	HYB	8	21	22	116	37.0	44.8	4.0	8.5	50.0	21.2	2.4	3.0	35.3	202.1	142.0	5.9	91.6	2.5	0.0	35.0	14.0	15.0	9.0	69.8	98.3	56.0
17	13081	2255	NCAC 63	HYB	8	23	27	115	37.0	50.5	4.0	15.8	45.8	23.0	2.0	3.5	18.9	174.1	84.2	16.3	83.7	0.0	0.0	23.0	12.0	10.5	7.5	67.9	95.5	35.0

SNO	NRCG	ICG	VAR	HBT	DTG	DIF	DFF	DTM	LMA	LPB	NPB	NSB	LLL	LLW	LWR	NIMP	PYP	PPMT	HPW	OSP	TSP	THP	FSP	PDL	PDW	SDL	SDW	SHE	SMK	HSW
18	9045	2261	45185	HYB	8	23	24	118	37.3	45.3	4.0	10.3	52.8	23.5	2.2	4.5	26.8	110.8	161.7	8.4	91.6	0.0	0.0	32.0	16.0	17.0	9.5	64.2	93.7	62.0
19	9047	2267	X 5 Sel.	HYB	8	22	23	118	50.3	72.5	3.8	19.0	48.7	19.8	2.5	5.0	26.5	173.1	119.2	12.3	87.7	0.0	0.0	27.0	12.5	14.0	8.5	67.2	94.9	51.0
20	13082	2269	X 11	HYB	8	23	26	116	43.0	51.3	4.0	10.0	46.2	20.5	2.3	3.5	38.8	201.6	128.3	25.5	74.5	0.0	0.0	32.0	14.0	16.0	8.0	72.0	91.0	60.0
21	13083	2275	G 340	HYB	8	20	21	118	46.8	55.5	4.0	12.3	56.2	25.3	2.2	5.0	19.7	120.5	156.0	18.7	48.4	33.0	0.0	31.0	13.0	16.0	8.5	64.8	87.0	58.0
22	9048	2276	GA 61-42	HYB	8	23	26	115	44.0	61.3	4.0	24.8	40.5	18.8	2.2	4.3	27.7	133.1	104.7	14.8	85.2	0.0	0.0	32.5	14.0	14.4	8.2	71.2	92.9	41.0
23	13084	2277	NC 1296	HYB	8	21	22	120	48.5	54.0	4.0	6.8	48.5	24.0	2.0	1.8	5.0	100.0	99.5	15.1	84.9	0.0	0.0	24.0	12.5	13.5	8.5	60.9	83.0	47.0
24	13087	2282	CASTLE CARY SEL	HYB	8	21	22	120	35.0	43.3	4.0	11.3	47.8	23.3	2.1	4.8	27.1	130.3	95.1	27.8	63.2	9.0	0.0	41.0	16.2	16.0	8.4	70.1	90.6	42.0
25	13089	2286	NCAC 819	HYB	9	20	21	118	41.5	64.3	4.0	17.5	54.2	23.2	2.3	3.8	16.9	85.6	82.4	16.5	83.5	0.0	0.0	31.0	14.0	14.0	7.0	58.6	82.9	41.0
26	13090	2289	SAMARU 38 SEL 4	HYB	8	22	23	120	41.0	53.3	4.0	22.3	46.0	21.5	2.1	7.0	18.1	111.1	105.2	2.6	97.4	0.0	0.0	28.4	14.4	15.2	8.8	64.8	82.3	40.0
27	13092	2297	C 39	HYB	8	24	27	120	42.3	53.3	4.0	19.8	54.0	22.8	2.4	4.3	20.9	128.3	104.3	16.8	83.2	0.0	0.0	27.0	12.0	13.5	8.5	67.7	88.4	46.0
28	9052	2304	NCAc 1826	HYB	8	21	21	118	40.0	53.0	4.0	19.5	50.7	21.3	2.4	6.3	30.6	200.0	127.5	12.1	87.9	0.0	0.0	29.2	14.2	13.8	9.1	71.6	92.8	49.0
29	882	2308	NCAC 2145	HYB	8	21	22	116	40.0	51.8	4.0	11.3	52.2	22.3	2.3	4.3	32.7	187.5	126.8	19.6	80.4	0.0	0.0	32.8	14.2	17.4	10.0	56.1	85.5	50.0
30	885	2312	NCAC 2172	HYB	8	22	23	118	50.3	59.3	3.8	8.8	41.7	16.7	2.5	1.5	16.4	85.3	120.2	39.4	60.6	0.0	0.0	37.0	20.0	19.0	9.4	41.2	65.3	56.0
31	13094	2315	NCAC 2277	HYB	8	20	21	118	50.8	64.5	4.0	24.0	46.0	19.7	2.3	4.3	15.2	91.3	104.1	27.8	72.2	0.0	0.0	34.8	13.5	17.4	9.9	59.4	81.3	40.0
32	13095	2316	NCAC 2279	HYB	8	22	23	118	42.3	58.5	4.0	21.0	43.2	21.7	2.0	3.5	16.4	74.5	123.5	16.3	83.7	0.0	0.0	36.0	18.5	17.0	8.4	55.4	83.6	48.0
33	13096	2317	NCAC 2316	HYB	8	22	23	118	46.8	55.0	4.0	14.3	43.8	21.8	2.0	7.5	17.4	123.2	102.2	10.1	89.9	0.0	0.0	25.0	14.2	12.0	8.2	51.6	83.0	32.0
34	888	2319	NCAC 2377	HYB	8	21	22	118	45.8	64.0	3.8	20.0	50.2	22.5	2.2	6.5	25.4	166.3	115.2	25.7	74.3	0.0	0.0	30.4	14.8	16.2	8.2	58.7	83.1	51.0
35	889	2320	NCAc 2462	HYB	8	21	22	116	43.5	58.5	4.0	14.8	52.5	23.2	2.3	4.8	27.0	179.9	124.8	15.2	84.8	0.0	0.0	30.0	14.2	15.8	10.5	71.8	92.6	51.0
36	894	2327	NCAC 2479	HYB	8	22	23	116	44.0	58.3	4.0	17.5	54.7	21.5	2.5	4.3	32.1	183.9	121.9	19.0	81.0	0.0	0.0	32.0	16.4	16.8	10.0	70.3	91.1	52.0
37	13098	2328	NCAC 2480	HYB	8	22	23	116	43.3	57.3	4.0	21.0	51.2	22.5	2.3	5.3	29.6	157.7	115.4	12.5	87.5	0.0	0.0	34.4	15.1	15.4	8.4	66.7	91.3	50.0
38	13099	2331	VIRGINIA RED	HYB	8	23	27	118	51.8	58.5	4.0	24.0	51.8	23.7	2.2	3.0	12.0	62.5	109.2	29.6	70.4	0.0	0.0	31.8	16.8	16.4	10.2	31.8	79.4	36.0
39	897	2333	NCAC 2556	HYB	8	23	27	118	43.0	53.0	4.0	29.0	44.7	22.8	2.0	4.5	14.7	115.5	88.2	12.7	87.3	0.0	0.0	27.0	13.0	13.0	8.0	69.1	92.5	35.0
40	13100	2335	NCAC 2561	HYB	8	21	22	118	32.8	41.8	4.0	8.5	49.7	20.5	2.4	4.3	31.8	110.1	102.8	5.6	94.4	0.0	0.0	30.0	14.2	13.8	9.4	71.2	92.4	43.0
41	9059	2337	NCAc 2569	HYB	7	20	22	115	33.5	43.0	4.0	12.0	52.7	24.3	2.2	7.0	25.1	120.5	103.6	15.0	85.0	0.0	0.0	31.2	15.2	15.0	7.1	62.1	91.1	42.0
42	900	2339	NCAc 2690	HYB	8	19	21	118	43.3	59.5	4.0	23.3	56.7	22.7	2.5	9.0	28.4	113.6	129.6	30.6	69.4	0.0	0.0	32.0	14.0	13.5	8.5	69.3	91.8	61.0
43	13102	2345	V 45	HYB	9	20	21	115	45.8	56.0	4.0	15.3	50.0	22.7	2.2	4.5	23.5	144.3	112.3	13.9	86.1	0.0	0.0	33.2	16.1	14.2	8.4	60.6	90.4	44.0
44	9065	2353	White's Runner	HYB	9	20	21	120	49.3	67.8	4.0	27.3	54.3	24.0	2.3	8.0	45.2	144.7	177.6	10.3	89.7	0.0	0.0	37.0	16.0	19.0	9.5	45.6	97.9	45.0
45	9066	2354	Carolina bunch	HYB	8	21	22	120	46.5	68.8	4.0	24.3	55.2	23.7	2.3	4.5	16.6	95.1	80.6	35.4	64.6	0.0	0.0	26.4	13.1	13.0	7.4	63.8	86.7	38.0
46	13109	2374	GA 119072	HYB	8	21	22	116	42.5	64.8	4.0	34.0	46.5	19.7	2.4	7.3	31.6	206.4	103.1	7.1	92.9	0.0	0.0	27.0	12.0	14.0	8.0	69.5	82.4	46.0

SNO	NRCG	ICG	VAR	HBT	DTG	DIF	DFF	DTM	LMA	LPB	NPB	NSB	LLL	LLW	LWR	NIMP	PYP	PPMT	HPW	OSP	TSP	THP	FSP	PDL	PDW	SDL	SDW	SHE	SMK	HSW
47	13110	2376	3303	HYB	8	21	22	118	45.5	59.8	4.0	15.5	53.3	24.3	2.2	4.8	28.6	175.5	129.7	14.1	85.9	0.0	0.0	32.0	14.0	16.0	9.0	71.1	89.0	55.0
48	9069	2380	A. monticola	HYB	8	22	23	118	54.5	69.3	4.0	11.5	57.7	24.5	2.4	3.0	13.3	72.8	73.7	17.5	82.5	0.0	0.0	25.2	11.4	12.2	8.0	67.5	91.8	37.0
49	9070	2383	DHT 190	HYB	8	22	23	118	51.8	62.3	4.0	26.3	57.5	22.2	2.6	6.0	11.5	79.9	114.5	9.7	90.3	0.0	0.0	30.0	13.0	14.0	7.5	55.4	83.7	45.0
50	13112	2385	DHT 193	HYB	8	21	22	118	46.8	69.8	4.0	26.3	53.0	20.7	2.6	5.0	26.5	137.9	111.9	8.2	91.8	0.0	0.0	28.2	12.8	13.8	8.3	64.7	90.7	46.0
51	13114	2404	RCM 596-1	HYB	8	19	21	118	47.8	57.8	3.8	13.0	59.2	25.0	2.4	3.5	22.9	137.2	141.7	0.0	100.0	0.0	0.0	30.5	14.0	16.0	8.5	65.6	93.5	51.0
52	6673	2741	G.Narrow leaf	HYB	9	19	20	116	39.0	53.3	4.0	26.5	43.8	19.2	2.2	3.5	18.0	95.9	84.4	21.6	78.4	0.0	0.0	30.0	11.0	15.0	7.0	68.1	85.4	38.0
53	6678	4746	PI 298115	HYB	8	23	27	118	34.5	43.8	4.0	14.3	48.2	23.2	2.1	4.0	24.8	56.1	135.8	22.6	77.4	0.0	0.0	31.3	15.4	15.0	9.0	63.2	87.9	56.0
54	13116	4753	G 153	HYB	9	20	21	118	44.5	56.3	4.0	16.0	50.0	22.8	2.2	6.0	27.5	179.9	111.1	11.1	88.9	0.0	0.0	27.0	14.2	15.8	10.2	54.2	89.2	41.0
55	9945	4757	ICG 4757	HYB	7	20	22	115	43.3	53.3	4.0	7.5	45.5	20.0	2.3	3.8	25.9	134.7	146.2	14.4	85.6	0.0	0.0	33.4	16.8	18.4	8.8	63.8	92.8	64.0
56	13126	4777	KU NO.61	HYB	7	20	22	118	36.8	49.5	4.0	13.8	51.0	23.7	2.2	2.8	32.0	144.9	163.0	13.0	87.0	0.0	0.0	35.0	17.0	18.0	11.2	73.9	94.6	72.0
57	9947	4778	ICG 4778	HYB	8	19	21	115	35.5	44.3	4.0	5.5	52.0	21.7	2.4	2.8	31.9	174.3	152.3	12.1	87.9	0.0	0.0	34.4	16.4	16.0	10.9	58.9	93.8	65.0
58	13127	4780	KU NO.11	HYB	8	20	21	118	53.8	71.8	4.0	22.8	54.3	23.2	2.3	5.8	25.6	156.8	156.3	27.2	72.8	0.0	0.0	37.4	19.5	17.5	11.5	65.2	97.1	61.0
59	927	5013	NCAc 784	HYB	8	21	22	116	47.5	59.0	4.0	7.3	50.3	22.0	2.3	2.3	32.1	201.1	150.0	12.0	88.0	0.0	0.0	36.4	16.2	19.2	10.4	66.7	96.3	68.0
60	6683	5030	NCAc 1741	HYB	8	21	22	115	43.8	50.3	4.0	5.5	52.3	23.5	2.2	3.8	38.7	201.1	136.4	14.0	86.0	0.0	0.0	33.8	18.2	17.4	10.8	64.2	94.3	56.0
61	6684	5037	NCAc 2154	HYB	8	19	21	120	45.3	56.5	4.0	22.0	44.7	19.7	2.3	5.8	16.5	74.7	133.3	32.2	67.8	0.0	0.0	35.4	16.3	18.0	10.8	31.9	94.6	56.0
62	952	5129	NCAc 17892	HYB	8	21	22	118	43.0	58.3	4.0	21.8	56.2	26.0	2.2	6.8	23.6	116.4	120.2	30.3	69.7	0.0	0.0	34.4	14.7	14.3	7.2	60.3	93.7	44.0
63	13133	5164	NCAC 17587	HYB	8	21	23	116	45.0	55.0	4.0	19.0	42.0	23.8	1.8	4.7	32.7	213.3	79.8	21.0	79.0	0.0	0.0	23.4	12.3	12.4	9.7	68.7	97.1	32.0
64	988	5725	NCAC 17751	HYB	8	21	22	120	47.5	61.5	4.0	13.0	43.0	20.3	2.1	5.8	29.3	125.1	143.9	19.3	80.7	0.0	0.0	30.4	16.2	20.4	12.9	70.7	97.4	67.0
65	13135	5967	KANYOMA	HYB	7	22	23	120	52.0	66.3	4.0	12.8	48.8	22.7	2.1	3.8	29.0	189.5	120.4	17.6	82.4	0.0	0.0	32.3	14.2	15.5	9.0	68.5	95.5	47.0
66	9519	6121	NCAc 1455	HYB	8	22	23	118	42.3	61.0	4.0	19.0	53.7	22.7	2.4	4.8	30.2	88.5	116.2	28.6	71.4	0.0	0.0	34.0	16.2	17.5	9.0	63.1	92.2	50.0
67	13139	6183	S 183	HYB	8	23	27	120	43.3	55.3	4.0	14.3	57.3	24.3	2.4	6.5	22.6	147.6	109.8	21.6	76.5	2.0	0.0	25.4	14.0	14.4	8.2	71.4	95.0	40.0
68	13140	6229	RCM 596-1	HYB	9	18	20	118	46.5	56.5	4.0	10.3	60.2	25.7	2.3	3.8	25.6	146.9	137.6	11.0	89.0	0.0	0.0	30.3	16.8	15.2	9.8	74.0	93.7	48.0
69	1022	6764	NCAC 1705	HYB	9	22	26	118	37.8	46.8	4.3	11.0	41.5	18.0	2.3	2.8	14.8	71.2	103.6	29.5	70.5	0.0	0.0	32.2	14.8	14.8	7.2	57.8	94.0	43.0
70	13146	6826	C 35	HYB	8	21	22	118	43.3	50.8	4.0	12.0	40.0	17.0	2.4	3.8	22.7	139.1	138.9	17.9	82.1	0.0	0.0	30.2	16.8	17.5	11.0	72.7	95.8	61.0
71	13147	6862	NCAC 2491	HYB	8	21	22	120	36.0	44.8	4.0	12.0	37.2	16.7	2.2	3.8	17.5	90.9	111.8	37.6	62.4	0.0	0.0	24.0	14.0	15.0	8.0	65.3	93.5	41.0
72	9507	7237	ICG 7237	HYB	9	21	22	118	37.0	47.8	4.5	22.5	45.0	20.2	2.2	5.0	18.6	74.5	85.3	14.7	82.4	2.9	0.0	28.0	15.2	16.2	8.2	58.6	88.2	37.0
73	13153	7446	M 6-76 M	HYB	8	20	21	95	49.5	58.0	5.8	2.3	57.0	28.0	2.0	1.3	16.7	124.7	69.6	17.4	82.6	0.0	0.0	22.4	11.8	13.2	8.0	75.0	95.0	31.0
74	13154	7454	M 399-72 K	HYB	8	26	28	120	41.3	49.5	4.0	19.0	49.0	23.7	2.1	4.3	19.0	131.9	82.1	23.9	76.1	0.0	0.0	23.4	13.2	12.9	8.9	66.7	93.8	36.0
75	13155	7490	M 57-72 K	HYB	8	23	27	118	37.5	42.5	4.0	19.3	54.2	22.5	2.4	4.3	22.3	136.9	81.2	12.8	87.2	0.0	0.0	24.0	12.0	13.5	7.5	65.3	90.3	33.0

SNO	NRCG	ICG	VAR	HBT	DTG	DIF	DFF	DTM	LMA	LPB	NPB	NSB	LLL	LLW	LWR	NIMP	PYP	PPMT	HPW	OSP	TSP	THP	FSP	PDL	PDW	SDL	SDW	SHE	SMK	HSW
76	4734	7621	NCAc 17718	HYB	8	21	22	118	41.3	52.0	4.0	20.5	54.7	23.3	2.3	6.0	44.9	233.6	110.2	16.9	83.1	0.0	0.0	24.2	12.0	13.0	8.0	74.6	86.6	49.0
77	13157	7637	M 107-74 K	HYB	8	21	22	118	27.8	36.0	4.0	18.3	47.5	21.0	2.3	6.0	26.6	113.6	104.7	21.7	78.3	0.0	0.0	27.4	14.2	16.4	10.6	70.3	92.3	48.0
78	4751	7664	NCAc 17672	HYB	8	22	23	116	37.3	44.0	4.0	12.5	37.2	21.2	1.8	6.8	18.7	107.2	65.5	18.6	81.4	0.0	0.0	19.3	12.2	9.4	7.2	70.3	90.4	30.0
79	9790	7676	ICG 7676	HYB	8	20	22	118	39.5	47.3	4.5	20.3	47.2	20.3	2.3	4.3	30.1	184.5	124.8	18.3	81.7	0.0	0.0	30.0	13.0	15.5	7.5	55.9	96.1	45.0
80	13158	7696	EGRET	HYB	8	21	22	120	55.8	73.3	4.0	15.0	50.7	21.5	2.4	3.8	26.5	109.3	117.5	20.4	79.6	0.0	0.0	32.4	18.2	14.2	8.5	57.9	92.9	41.0
81	4802	7749	M 380-72	HYB	8	22	23	116	39.5	52.5	4.0	23.5	51.3	24.7	2.1	5.8	20.2	96.9	98.1	17.3	82.7	0.0	0.0	29.4	14.4	15.0	9.6	64.7	93.9	42.0
82	6699	7883	PI 315608	HYB	9	20	21	118	35.3	41.3	4.0	7.3	43.5	20.3	2.1	1.3	21.6	86.4	137.8	33.3	66.7	0.0	0.0	33.0	15.0	17.0	9.0	61.3	96.1	64.0
83	6705	7892	PI 393527 B	HYB	8	19	20	120	43.8	50.5	4.0	11.3	51.5	23.3	2.2	5.8	24.0	137.7	274.5	32.7	63.6	3.6	0.0	27.0	16.5	14.0	8.0	61.6	95.7	50.0
84	6708	7900	PI 414332	HYB	8	21	24	118	40.3	51.0	4.0	19.3	62.2	29.7	2.1	5.3	23.0	110.5	79.8	27.9	72.1	0.0	0.0	28.0	13.0	13.0	7.2	68.7	86.0	33.0
85	4921	8030	NCAc 17866	HYB	8	21	24	118	38.0	43.8	4.0	9.3	55.7	26.0	2.1	2.3	30.5	215.2	116.3	20.2	79.8	0.0	0.0	28.0	16.0	13.5	9.8	73.6	95.5	51.0
86	4978	8099	PI 270934	HYB	8	19	22	118	36.0	41.3	4.0	12.5	37.7	20.0	1.9	3.3	11.8	61.3	125.5	9.4	90.6	0.0	0.0	26.0	16.0	12.5	8.2	68.4	97.8	49.0
87	13167	9116	75-72	HYB	8	19	21	107	48.5	57.5	4.5	2.5	64.8	31.2	2.1	1.3	28.7	157.1	105.3	34.0	66.0	0.0	0.0	24.0	14.0	17.0	8.0	71.7	95.8	51.0
88	9524	10756	TGR 997	HYB	8	21	22	120	58.3	70.3	4.3	22.5	57.2	24.0	2.4	5.8	5.9	125.0	91.6	16.8	83.2	0.0	0.0	26.2	14.7	14.3	8.2	61.2	93.3	39.0
89	8967	10884	KSSc 399	HYB	8	19	22	118	36.3	49.8	4.0	25.0	51.5	24.5	2.1	3.8	11.7	129.0	97.3	21.8	78.2	0.0	0.0	26.3	14.3	15.2	10.0	68.2	95.9	47.1
90	13171	11269	RM 70-1	HYB	8	23	26	120	43.5	51.5	4.0	19.8	51.3	24.3	2.1	5.8	23.2	86.7	127.8	7.8	92.2	0.0	0.0	34.5	15.2	16.5	8.2	66.7	96.9	54.9
91	13115	2438	88/6/7	HYR	8	22	23	118	46.8	59.0	4.0	39.0	47.0	22.3	2.1	5.5	16.1	70.7	118.7	13.1	29.9	57.0	0.0	30.8	14.5	13.0	8.3	64.6	93.9	43.9
92	811	384	NCAc 1085	HYR	8	23	24	120	43.3	51.0	4.0	19.0	47.3	23.3	2.0	4.8	28.5	98.7	105.8	10.6	89.4	0.0	0.0	29.3	13.1	16.1	9.2	67.3	95.9	47.7
93	676	1637	NCAc 944	HYR	8	19	21	95	37.3	44.0	5.5	9.5	49.5	26.7	1.9	3.3	21.2	82.0	88.7	6.2	93.8	0.0	0.0	30.0	12.6	14.0	8.3	69.8	91.7	35.9
94	1703	1656	NCAC 2575	HYR	8	21	22	118	44.3	53.3	4.3	10.5	50.2	25.7	2.0	4.5	24.6	114.7	95.9	15.5	84.5	0.0	0.0	25.3	12.4	11.4	8.7	69.9	96.9	33.9
95	685	2271	NCAc 343	HYR	8	23	24	118	38.8	48.3	4.0	20.8	52.3	21.5	2.4	4.3	35.0	177.3	112.8	25.6	74.4	0.0	0.0	26.0	16.4	18.2	9.9	70.5	95.7	57.0
96	869	2273	NCAC 505	HYR	8	23	24	118	38.8	59.5	4.0	35.3	43.0	20.0	2.1	7.0	22.8	97.3	89.2	8.8	90.2	1.0	0.0	30.0	12.8	16.0	8.0	65.9	93.3	35.0
97	13085	2278	NCAC 595	HYR	8	23	24	118	35.3	67.3	4.0	32.0	53.5	23.7	2.3	6.3	23.9	121.3	105.3	15.9	84.1	0.0	0.0	30.8	13.1	15.1	7.4	67.2	93.8	47.3
98	13086	2281	BADAMI ZAMINI	HYR	8	21	22	118	40.3	59.3	3.8	24.3	50.8	22.3	2.3	4.5	13.2	72.0	101.2	32.9	67.1	0.0	0.0	35.5	16.0	18.0	8.5	65.1	94.4	43.9
99	13088	2285	NCAC 759	HYR	8	20	21	118	44.5	62.0	4.0	22.5	58.0	25.7	2.3	4.0	16.8	82.7	87.6	34.3	61.9	3.8	0.0	30.2	14.9	18.2	7.5	67.4	93.5	42.2
100	13091	2293	NCAC 886	HYR	8	22	23	118	58.8	76.3	4.0	44.5	45.2	21.3	2.1	7.0	16.1	77.3	88.9	9.3	90.7	0.0	0.0	31.2	14.3	16.4	8.4	58.3	91.1	36.1
101	4281	2296	NCAc 1107	HYR	8	21	22	118	44.5	55.8	4.0	23.8	49.5	21.3	2.3	4.0	29.0	81.3	120.0	21.7	78.3	0.0	0.0	32.0	14.5	19.8	9.9	65.2	97.8	55.1
102	13097	2326	NCAC 2475	HYR	8	21	22	120	37.5	56.8	4.0	39.0	52.5	22.3	2.4	6.3	21.4	125.3	85.9	15.2	82.8	2.0	0.0	29.2	12.2	14.4	8.4	65.9	96.4	38.3
103	898	2336	NCAC 2566	HYR	8	22	23	120	46.8	56.8	4.0	15.3	47.8	22.0	2.2	3.5	14.0	78.7	95.3	19.6	80.4	0.0	0.0	28.4	13.4	16.4	8.4	65.7	97.0	41.6
104	905	2352	NCAc 2785	HYR	8	22	23	118	41.0	56.3	4.0	39.0	42.3	20.5	2.1	6.5	19.7	86.7	74.3	18.6	81.4	0.0	0.0	24.4	11.4	11.0	7.5	66.7	96.4	35.0

SNO	NRCG	ICG	VAR	HBT	DTG	DIF	DFF	DTM	LMA	LPB	NPB	NSB	LLL	LLW	LWR	NIMP	PYP	PPMT	HPW	OSP	TSP	THP	FSP	PDL	PDW	SDL	SDW	SHE	SMK	HSW
105	13104	2360	G 68	HYR	7	23	24	118	47.8	59.8	4.0	13.5	47.3	21.3	2.2	2.8	37.9	166.7	125.0	14.4	40.4	45.2	0.0	23.0	11.5	10.5	7.2	69.2	95.6	41.6
106	13105	2361	GA 139	HYR	8	21	23	120	42.0	66.8	4.5	29.0	48.2	19.8	2.4	4.5	10.5	68.7	71.4	20.0	80.0	0.0	0.0	24.1	11.5	12.1	7.5	68.0	88.2	31.0
107	9000	2363	G 44	HYR	8	22	23	120	30.8	53.0	4.0	20.0	44.7	21.7	2.1	6.0	18.1	113.3	53.8	3.8	73.1	23.1	0.0	29.2	12.4	13.0	10.0	68.6	89.6	25.7
108	13107	2370	GA 124-B	HYR	8	22	23	120	39.3	58.0	4.0	32.3	53.5	22.2	2.4	6.0	20.6	115.3	105.9	11.9	47.5	40.6	0.0	29.0	12.0	13.0	8.0	62.6	88.1	31.6
109	702	2377	NCAC 2945	HYR	8	22	23	118	45.8	61.8	4.0	30.5	49.0	22.0	2.2	4.0	12.9	84.0	132.4	17.6	82.4	0.0	0.0	38.0	17.0	21.0	8.0	58.5	96.2	53.5
110	13113	2401	NCAC 2763	HYR	8	21	22	118	46.0	62.5	4.0	22.5	48.8	20.3	2.4	1.8	20.5	106.7	150.9	14.3	83.0	2.7	0.0	44.4	18.2	22.2	10.5	62.7	96.2	60.9
111	5187	4750	PI 337409	HYR	9	18	20	118	36.3	66.8	4.0	29.5	55.0	22.3	2.5	6.5	26.9	129.3	143.1	24.8	75.2	0.0	0.0	42.0	18.4	21.0	9.5	61.5	93.8	59.8
112	13119	4765	KU NO.225	HYR	8	22	23	118	42.8	60.5	4.0	27.3	49.7	20.2	2.5	3.8	17.5	102.7	94.6	12.5	87.5	0.0	0.0	28.2	12.3	15.2	8.4	69.8	93.2	44.0
113	13125	4773	KU NO.9	HYR	8	21	23	120	41.5	70.3	4.0	32.0	48.8	21.7	2.2	4.3	25.9	162.0	98.1	15.1	84.9	0.0	0.0	36.0	14.3	17.0	9.2	64.4	89.6	42.7
114	9517	5040	NCAc 2214	HYR	9	25	27	126	39.0	59.3	4.0	31.0	42.7	19.2	2.2	3.5	5.3	98.0	66.0	16.5	83.5	0.0	0.0	25.2	13.1	12.4	7.2	61.8	81.0	25.8
115	6686	5041	NCAc 2230	HYR	8	23	27	122	41.3	57.3	4.0	20.3	41.3	22.0	1.9	4.5	7.4	90.7	86.9	36.4	63.6	0.0	0.0	31.4	13.4	15.7	7.4	68.6	93.2	36.7
116	6532	5042	NCAc 2232	HYR	8	21	22	100	60.5	63.8	4.5	4.0	64.5	27.7	2.3	1.0	14.4	69.3	107.8	15.5	66.0	18.4	0.0	36.0	14.0	12.0	7.5	64.9	97.2	39.3
117	6687	5043	NCAc 2240	HYR	9	22	25	126	44.0	60.5	4.0	28.5	46.5	22.7	2.0	3.8	5.3	83.0	62.2	36.7	61.2	2.0	0.0	28.0	10.0	14.0	8.0	60.7	86.5	26.2
118	1699	5055	NCAC 2477	HYR	8	22	23	118	32.3	44.3	4.0	26.5	45.0	18.8	2.4	2.8	26.9	125.3	120.2	15.3	84.7	0.0	0.0	31.0	14.0	20.0	8.3	69.8	97.1	53.1
119	6691	6147	NCAc 2326	HYR	8	21	22	118	34.3	44.8	4.0	17.0	48.8	20.2	2.4	4.5	28.4	152.0	134.3	12.4	78.1	9.5	0.0	27.0	13.0	12.0	8.0	66.0	96.8	54.0
120	763	6317	NCAc 17888	HYR	8	19	21	120	45.0	57.5	4.0	20.5	54.3	22.0	2.5	7.8	17.0	74.7	109.2	21.1	78.9	0.0	0.0	30.0	13.0	15.0	8.5	60.5	97.2	42.3
121	9523	7625	M 1069-7K	HYR	8	23	27	118	25.0	35.3	4.0	12.5	49.2	21.0	2.3	6.0	10.0	126.7	68.8	24.1	75.9	0.0	0.0	21.0	10.5	12.0	7.5	61.0	93.6	33.1
122	4810	7803	NCAc 2460	HYR	8	21	22	118	27.3	45.0	4.0	38.0	50.0	22.2	2.3	7.8	29.1	124.1	107.2	15.3	84.7	0.0	0.0	29.0	13.0	14.5	7.5	65.5	93.6	45.7
123	4857	7891	PI 393527-A	HYR	8	21	22	118	39.5	50.5	4.0	27.5	54.5	22.7	2.4	9.0	23.4	109.3	132.9	6.8	93.2	0.0	0.0	28.0	17.0	14.0	9.0	57.7	94.6	46.2
124	4863	7899	PI 414331	HYR	8	22	23	118	37.8	48.8	4.0	27.3	52.0	25.0	2.1	3.8	15.8	65.3	76.5	20.6	79.4	0.0	0.0	22.0	15.0	11.0	8.0	64.1	92.0	33.9
125	9791	11080	ICG 11080	HYR	8	19	22	102	53.3	66.0	4.5	0.5	63.8	24.5	2.6	1.5	15.4	74.0	135.9	6.8	7.8	85.4	0.0	37.0	14.0	13.0	7.5	59.3	86.7	34.4
126	13169	11094	ZFA 3186-1	HYR	8	26	28	120	45.3	58.3	4.0	19.5	57.3	25.0	2.3	4.0	25.4	118.7	138.6	9.9	48.5	41.6	0.0	37.0	12.0	13.0	8.5	60.0	96.4	43.7
127	4153	2405	NCAC 2821	HYR	8	22	23	118	46.8	59.0	4.0	39.0	47.0	22.3	2.1	5.5	16.1	70.7	118.7	13.1	29.9	57.0	0.0	30.8	14.5	13.0	8.3	64.6	93.9	43.9
128	13134	5932	NCAC 1715	HYB	9	25	27	120	38.0	38.5	4.0	9.3	39.5	18.2	2.2	3.8	8.3	103.3	67.9	35.7	64.3	0.0	0.0	33.0	12.5	15.0	8.0	47.4	91.7	27.9
129	13137	6135	CUP 8	HYB	9	25	27	120	35.3	32.3	4.0	4.5	33.7	16.2	2.1	2.3	3.9	90.0	90.0	46.7	53.3	0.0	0.0	29.0	13.0	16.0	7.5	66.7	94.4	36.8
130	714	5045	NCAC 2243	FST	8	24	26	96	43.0	55.3	4.8	0.8	54.2	21.2	2.6	1.8	16.1	138.0	106.2	7.3	79.1	13.4	0.0	32.5	16.2	12.5	9.8	70.9	93.8	37.7
131	6677	4743	88/23/7	VUL	9	20	22	97	30.5	35.5	3.8	1.5	57.5	23.0	2.5	5.0	12.5	130.0	72.7	31.8	54.5	13.6	0.0	26.5	11.0	12.0	6.5	62.5	90.0	30.2
132	13103	2358	NCAC 2836	VUL	8	20	21	97	47.0	53.0	5.0	3.0	58.0	26.8	2.2	1.5	19.4	145.2	100.0	14.2	85.8	0.0	0.0	31.0	15.2	13.0	8.0	70.8	89.3	46.7
133	4559	7360	101/66/1	VUL	8	17	19	95	52.0	58.8	4.0	0.0	58.5	27.2	2.2	1.0	26.0	177.1	132.7	4.7	95.3	0.0	0.0	28.5	16.2	14.0	8.2	67.6	94.8	48.3

SNO	NRCG	ICG	VAR	HBT	DTG	DIF	DFF	DTM	LMA	LPB	NPB	NSB	LLL	LLW	LWR	NIMP	PYP	PPMT	HPW	OSP	TSP	THP	FSP	PDL	PDW	SDL	SDW	SHE	SMK	HSW
134	13005	263	CPI 10507	FST	8	17	19	93	43.0	47.3	4.0	0.0	54.2	21.2	2.6	1.3	15.5	95.3	104.7	4.7	41.1	47.7	6.5	37.2	14.5	15.0	8.2	75.0	95.2	30.9
135	1070	265	NCAc 405	FST	8	18	20	95	51.5	55.3	4.8	0.8	65.0	27.7	2.3	1.8	17.8	73.5	129.2	7.3	79.2	13.5	0.0	33.4	16.2	12.4	7.7	69.4	94.2	40.6
136	1071	266	NCAc 406	FST	7	18	18	95	52.0	55.8	4.5	0.0	60.7	25.7	2.4	1.0	16.1	122.1	106.7	6.7	83.8	9.5	0.0	32.2	17.1	12.0	9.1	71.4	93.8	37.7
137	1073	274	NCAc 490	FST	7	16	18	95	44.3	54.5	4.3	0.0	65.0	26.5	2.5	0.3	16.4	138.1	161.9	2.9	33.3	41.0	22.9	47.8	19.4	14.1	9.2	72.9	96.8	42.6
138	1074	276	NCAc 503	FST	7	18	20	95	53.3	61.0	4.3	0.0	65.7	28.5	2.3	0.8	20.9	189.5	136.7	2.0	33.7	61.2	3.1	36.4	13.9	13.1	8.4	76.9	93.2	42.4
139	13009	283	NCAC 524	FST	7	16	18	95	43.8	58.3	4.3	0.0	65.3	27.5	2.4	0.3	19.7	154.9	151.5	9.7	42.7	39.8	7.8	29.5	15.2	15.2	8.5	75.0	94.0	44.1
140	13012	291	SENEGAL 1120	FST	7	16	18	93	54.0	62.5	4.3	0.0	65.3	27.5	2.4	1.3	28.0	198.0	156.5	1.9	35.2	50.0	13.0	33.0	15.0	15.0	8.5	70.4	93.3	43.6
141	13013	296	MTUTU-A	FST	7	16	18	95	51.0	57.3	4.8	1.0	61.3	27.2	2.3	1.3	21.8	145.1	157.3	2.9	35.9	57.3	3.9	33.0	13.0	11.0	7.5	71.0	94.8	42.6
142	782	301	NCAc 583	FST	7	18	20	95	52.8	55.0	4.0	0.0	65.3	26.7	2.4	1.0	19.2	155.9	136.6	9.7	81.7	8.6	0.0	27.0	14.0	12.0	8.7	70.9	94.4	46.4
143	13016	320	NCAC 706	FST	7	16	18	93	54.0	60.0	5.3	1.5	65.7	27.7	2.4	0.8	18.6	158.9	147.6	4.8	67.6	27.6	0.0	35.0	14.0	13.0	8.5	72.3	93.8	42.4
144	794	322	NCAC 710	FST	7	24	25	95	59.3	65.0	5.0	3.5	70.3	32.5	2.2	0.8	16.2	121.1	105.9	4.9	67.6	20.6	6.9	34.0	12.5	13.0	7.0	69.4	93.3	40.6
145	5571	325	PI 152129	FST	7	18	18	95	50.8	53.8	4.0	0.0	63.5	27.0	2.4	1.5	21.3	164.4	158.8	3.5	38.8	54.1	3.5	42.4	16.8	15.8	8.9	68.1	94.6	43.3
146	13018	326	NCAC 721	FST	7	18	18	95	49.8	58.3	4.0	0.0	70.0	30.7	2.3	1.0	14.9	166.7	143.5	2.4	35.3	62.4	0.0	30.0	15.0	12.0	9.0	72.1	94.3	40.7
147	13025	353	GA 177	FST	7	20	22	95	56.5	70.3	5.0	3.5	61.3	22.0	2.8	2.0	18.4	169.6	148.7	1.3	32.9	61.8	3.9	34.4	16.2	14.2	7.8	64.6	94.5	40.7
148	13026	354	V 54	FST	7	20	22	95	62.3	76.5	4.0	2.5	62.2	28.0	2.2	1.8	15.2	119.5	128.1	9.0	53.9	28.1	9.0	40.4	18.4	14.4	8.0	62.3	97.2	45.7
149	13027	355	WHITE	FST	7	20	22	95	45.5	55.5	5.5	8.0	61.2	25.0	2.4	1.5	16.8	163.5	169.1	0.0	30.9	69.1	0.0	33.0	15.0	14.0	7.7	65.2	94.7	44.0
150	13028	357	NCAC 881	FST	7	19	21	93	37.0	46.3	5.0	0.0	57.7	24.8	2.3	1.8	22.8	185.7	115.1	7.5	63.2	29.2	0.0	34.0	13.4	14.2	7.9	73.8	96.7	41.0
151	13029	358	NCAC 884	FST	7	18	19	93	46.0	50.8	4.5	0.0	52.7	21.8	2.4	0.8	29.0	189.7	113.3	5.3	58.4	36.3	0.0	32.0	13.0	13.0	7.5	71.9	94.6	38.8
152	13031	362	ZANDI	FST	7	20	22	93	53.0	62.8	4.5	0.5	57.7	26.8	2.2	1.3	23.3	177.3	144.0	4.4	15.4	65.9	14.3	36.4	16.4	13.0	8.0	70.2	97.8	42.0
153	13032	364	CORDOFAN	FST	7	20	21	93	45.8	56.8	4.0	2.5	57.8	25.2	2.3	2.0	21.5	183.5	154.9	4.9	29.3	53.7	12.2	35.0	14.4	14.2	8.4	72.4	97.8	44.0
154	13034	366	LE 29	FST	7	15	18	95	52.8	59.5	4.5	0.0	63.8	28.0	2.3	1.3	26.4	189.7	159.6	4.5	56.2	39.3	0.0	31.0	14.0	12.0	9.0	65.5	96.8	40.7
155	13035	367	MANI GUAYCURU 1	FST	7	16	18	95	57.3	64.5	4.0	0.0	64.8	28.7	2.3	0.3	23.6	182.4	96.1	3.9	17.1	72.4	6.6	38.4	14.2	16.4	9.0	76.0	97.3	46.5
156	13038	370	DETOST ADERO	FST	7	16	18	93	49.3	55.5	4.0	0.0	59.2	27.3	2.2	0.8	23.3	183.3	147.8	1.1	33.7	65.2	0.0	35.0	14.0	16.0	9.0	72.1	98.0	41.9
157	13042	379	NCAC 1001	FST	7	16	18	95	43.5	54.3	4.3	0.0	63.2	26.2	2.4	1.3	22.4	131.2	149.4	2.3	57.5	34.5	5.7	31.4	15.2	15.4	9.2	73.1	94.7	45.3
158	13043	380	NCAC 1002	FST	9	18	20	93	41.0	48.0	4.5	2.5	60.0	25.3	2.4	2.3	18.5	93.6	132.3	16.7	52.1	31.3	0.0	26.4	15.2	11.4	8.2	67.7	95.3	40.7
159	13046	385	CPI 10496	FST	8	19	21	95	42.3	54.5	4.0	0.0	59.5	26.3	2.3	1.0	22.5	141.2	109.3	1.3	66.7	32.0	0.0	29.0	12.0	14.0	7.5	74.4	95.1	34.2
160	4214	389	NCAc 1286	FST	8	17	19	93	42.5	47.8	5.5	0.5	60.2	27.2	2.2	1.5	23.0	178.0	148.2	4.7	64.7	30.6	0.0	28.4	12.5	14.2	9.4	74.6	96.8	41.1
161	13049	391	TORO	FST	8	17	19	93	50.8	59.3	4.0	0.0	57.3	24.5	2.3	1.0	22.8	130.7	135.1	13.5	47.3	39.2	0.0	34.4	14.2	14.4	8.0	65.0	93.8	38.8
162	4296	392	NCAC 1302	FST	8	17	19	93	46.8	51.3	5.0	0.0	56.2	24.7	2.3	1.0	23.7	145.6	143.2	2.3	40.9	51.1	5.7	37.0	15.0	12.4	8.0	65.1	96.3	43.2

SNO	NRCG	ICG	VAR	HBT	DTG	DIF	DFF	DTM	LMA	LPB	NPB	NSB	LLL	LLW	LWR	NIMP	PYP	PPMT	HPW	OSP	TSP	THP	FSP	PDL	PDW	SDL	SDW	SHE	SMK	HSW
163	13052	398	VALENCIA	FST	8	17	19	93	50.8	59.0	4.8	0.0	60.7	26.7	2.3	1.3	21.6	158.5	145.3	5.3	21.3	70.7	2.7	30.4	12.2	12.4	8.7	73.4	97.5	40.3
164	4299	403	NCAC 2653	FST	9	16	16	95	49.0	55.5	4.0	0.0	59.0	26.0	2.3	0.5	19.2	191.7	123.6	9.4	39.6	50.9	0.0	34.4	16.2	13.2	8.4	72.5	95.8	42.7
165	1108	404	NCAc 2654	FST	9	16	18	95	47.8	52.5	4.5	2.0	57.3	24.0	2.4	1.8	19.5	179.5	136.7	6.1	54.1	39.8	0.0	30.0	13.0	14.0	8.0	70.1	98.9	42.2
166	1109	405	NCAc 2663	FST	8	17	19	95	47.0	58.8	5.3	0.5	59.5	24.8	2.4	2.0	19.8	168.5	151.6	10.8	30.1	59.1	0.0	32.4	16.4	13.2	8.4	62.4	95.5	43.5
167	1113	411	NCAc 2700	FST	8	17	17	93	53.8	68.3	5.0	0.5	56.2	25.0	2.2	2.0	20.0	170.4	148.7	6.4	30.8	53.8	9.0	40.0	17.4	13.0	9.0	65.5	93.4	39.3
168	13055	427	44-183	FST	8	17	19	95	53.5	66.5	4.5	0.0	63.8	27.8	2.3	1.0	19.0	175.1	115.6	9.4	45.8	43.8	1.0	28.8	15.2	13.0	8.4	55.9	83.9	37.6
169	13059	447	2293	FST	8	17	17	95	62.3	81.8	5.0	0.5	61.5	26.0	2.4	1.5	17.8	163.5	164.4	4.1	45.2	50.7	0.0	44.0	18.0	16.0	11.4	65.8	96.2	47.2
170	13060	452	NCAC 2927	FST	8	15	17	95	45.3	52.8	4.5	0.0	60.8	27.0	2.3	1.5	16.9	146.7	94.1	21.8	54.6	23.5	0.0	28.0	13.0	14.0	9.0	56.3	92.1	39.2
171	13061	460	RCM 462	FST	9	17	18	93	49.8	54.3	4.0	0.0	64.5	29.2	2.2	0.3	22.7	190.3	145.5	7.8	32.5	58.4	1.3	32.8	14.3	14.8	10.4	44.6	90.0	41.0
172	13062	462	RCM 467	FST	9	17	18	93	51.0	65.8	4.0	0.0	61.2	24.7	2.5	0.8	19.7	189.5	140.3	8.2	57.2	34.6	0.0	33.0	14.0	14.0	8.5	65.9	95.9	46.5
173	4220	463	NCAc 17089	FST	9	17	18	93	59.3	66.3	3.0	0.0	69.3	31.2	2.2	1.0	15.8	134.9	188.8	6.3	18.8	43.8	31.3	46.0	18.0	14.0	9.0	66.9	97.0	47.4
174	13063	469	WCG 131	FST	9	16	16	95	56.5	63.0	5.3	1.8	62.7	24.7	2.5	2.3	18.2	138.4	108.5	6.1	23.2	70.7	0.0	40.4	16.4	12.5	7.4	52.8	91.5	31.7
175	9110	470	WCG 169	FST	9	16	18	95	53.3	59.8	3.0	0.0	66.2	27.0	2.5	0.8	16.7	120.1	188.6	0.0	17.7	59.5	22.8	37.8	16.2	12.8	10.2	44.3	95.5	39.6
176	9125	1603	Krapovickas 4	FST	9	16	19	95	51.3	58.5	4.0	1.3	68.5	29.0	2.4	1.3	14.3	97.5	136.6	7.0	36.6	46.5	9.9	42.4	14.3	12.8	8.2	56.7	94.5	36.2
177	13066	1608	KINORALES	FST	9	18	20	95	37.8	42.8	5.5	3.5	56.7	26.5	2.1	1.3	18.5	93.9	125.3	4.0	75.8	20.2	0.0	33.0	14.2	14.0	9.0	61.3	96.1	43.5
178	13068	1613	SP 2B	FST	9	16	16	95	47.5	61.0	4.3	0.0	62.2	27.0	2.3	1.3	18.4	137.1	95.7	5.2	54.3	40.5	0.0	36.0	14.0	13.0	8.1	76.6	95.3	37.5
179	1151	1615	NCAC 414	FST	9	16	19	93	43.3	53.7	4.0	1.0	62.7	28.7	2.2	1.3	18.3	110.0	95.7	4.3	82.6	13.0	0.0	29.0	14.2	12.8	8.0	77.3	97.6	39.6
180	4290	1627	NCAC 568	FST	9	18	16	95	44.0	55.3	5.3	1.0	56.3	25.0	2.3	2.3	21.7	144.7	134.9	15.1	41.9	43.0	0.0	35.4	16.0	13.2	8.5	71.6	95.2	43.8
181	1164	1660	NCAC 2666	FST	9	14	16	95	53.0	65.3	4.3	0.0	54.2	22.3	2.4	1.8	17.5	102.4	154.8	5.5	26.0	53.4	15.1	38.0	16.0	14.0	8.9	70.8	93.8	44.2
182	9130	1664	NCAc 2679	FST	9	18	18	95	33.8	39.3	4.0	0.0	58.7	24.5	2.4	1.5	16.2	106.0	100.0	9.2	67.0	23.9	0.0	29.4	14.2	13.0	8.4	74.3	95.1	37.4
183	9131	1665	Gemana	FST	9	16	18	95	38.3	48.3	4.0	0.0	55.8	24.3	2.3	0.8	15.7	115.2	132.6	10.9	29.3	56.5	3.3	30.4	14.2	13.0	9.0	67.2	95.1	40.1
184	13075	1683	G 90 A	FST	9	18	20	93	44.0	52.8	4.5	0.0	53.3	24.0	2.2	1.3	15.3	108.3	83.6	18.0	74.6	7.4	0.0	28.4	14.1	12.0	8.0	58.8	93.3	31.4
185	851	1696	NCAc 16026	FST	8	19	20	95	53.5	57.3	4.0	0.0	61.8	27.0	2.3	1.8	17.7	118.3	120.3	14.9	85.1	0.0	0.0	28.0	16.0	12.0	8.1	61.8	92.7	43.6
186	1177	1697	NCAc 17090	FST	9	18	20	94	54.8	62.8	3.8	0.0	61.7	29.2	2.1	1.8	16.5	101.5	118.4	0.0	21.9	72.8	5.3	35.0	14.0	12.0	8.0	54.1	93.2	32.6
187	6663	1703	NCAc 17127	FST	9	18	19	97	58.3	64.3	4.0	0.0	68.2	26.3	2.6	0.8	17.0	90.8	169.9	0.0	8.4	71.1	20.5	43.0	15.0	16.0	10.0	63.8	93.3	40.7
188	6664	1704	NCAc 17129	FST	9	18	19	96	47.5	51.0	3.5	2.0	65.8	22.5	2.9	0.3	15.4	98.8	178.0	8.5	68.3	23.2	0.0	44.8	15.2	14.0	9.4	61.6	95.6	39.0
189	5177	1707	NCAc 17132	FST	8	18	20	95	55.8	61.0	3.8	0.0	71.8	29.0	2.5	1.5	18.2	111.7	208.2	0.0	12.4	80.4	7.2	58.0	16.0	18.4	9.2	65.8	96.2	52.0
190	1179	1709	NCAc 17134	FST	8	19	21	95	59.0	68.0	4.0	0.0	66.2	25.3	2.6	1.8	24.4	71.6	160.2	4.9	10.7	73.8	10.7	33.0	15.0	14.0	8.0	61.8	93.1	43.3
191	5178	1710	NCAc 17135	FST	9	18	19	95	46.8	52.8	3.5	0.0	74.7	30.8	2.4	0.8	17.8	118.5	194.3	0.0	15.9	75.0	9.1	56.0	16.4	15.2	8.2	67.3	93.9	53.1

SNO	NRCG	ICG	VAR	HBT	DTG	DIF	DFF	DTM	LMA	LPB	NPB	NSB	LLL	LLW	LWR	NIMP	PYP	PPMT	HPW	OSP	TSP	THP	FSP	PDL	PDW	SDL	SDW	SHE	SMK	HSW
192	9135	1713	Peru No. 3	FST	9	16	18	93	34.3	42.8	4.5	0.5	45.8	20.7	2.2	1.3	14.1	148.4	90.2	9.8	86.1	4.1	0.0	30.0	12.0	14.0	7.5	72.7	93.8	41.8
193	13101	2338	KRAPOVICKAS 5	FST	9	18	21	95	60.5	67.0	4.0	0.0	67.5	27.5	2.5	2.8	6.9	96.0	86.1	24.1	33.3	38.0	4.6	37.3	14.4	12.4	8.4	40.9	92.1	31.7
194	13118	4764	KU NO.220	FST	9	18	20	97	42.3	44.5	4.0	0.0	56.2	24.8	2.3	1.3	13.3	111.3	129.9	4.7	39.3	50.5	5.6	33.0	13.0	12.0	8.0	74.1	97.1	39.7
195	13124	4772	KU NO.8	FST	8	17	18	93	44.5	53.5	4.5	0.5	52.8	23.5	2.2	1.0	18.9	138.5	144.9	0.0	23.5	64.3	12.2	40.0	14.0	12.0	7.5	71.8	96.1	41.2
196	13130	4788	KU NO.189	FST	8	18	19	95	43.3	51.7	4.0	2.7	53.3	23.3	2.3	3.0	18.5	147.7	116.1	4.3	52.7	43.0	0.0	37.4	15.0	15.4	8.0	69.4	93.3	39.8
197	6682	4790	Krap strain 16	FST	8	19	21	97	56.5	60.8	3.8	0.0	57.5	28.3	2.0	1.5	18.2	82.4	162.8	0.0	11.6	83.7	4.7	46.0	14.0	15.0	7.0	61.4	90.7	42.2
198	9949	4791	ICG 4791	FST	9	18	19	95	43.5	50.3	4.0	0.3	56.8	26.5	2.1	0.0	16.6	110.9	122.2	6.8	35.9	53.8	3.4	33.4	14.2	11.0	7.4	68.5	95.9	37.6
199	13136	6090	NCAC 664	FST	8	15	17	95	47.5	56.8	5.5	0.5	55.0	24.8	2.2	1.0	19.5	111.6	133.6	10.3	45.8	40.2	3.7	32.4	12.3	13.5	8.7	71.3	97.1	44.6
200	13138	6140	NCAC 2209	FST	9	18	20	95	40.0	45.3	4.5	0.5	54.2	23.0	2.4	0.5	15.8	121.9	118.5	9.7	46.0	38.7	5.6	31.0	15.0	13.0	8.0	61.2	95.6	39.8
201	10774	6201	BC 119	FST	9	18	19	95	49.8	58.5	4.8	0.5	60.5	26.5	2.3	1.3	18.1	113.7	143.6	4.0	24.8	65.3	5.9	36.5	12.3	14.0	8.0	68.3	92.9	35.3
202	13141	6271	WCG 149	FST	9	18	18	97	46.5	56.8	4.0	0.0	57.3	25.8	2.2	0.3	15.0	120.3	149.5	9.3	50.5	40.2	0.0	32.4	15.2	16.2	10.0	59.3	95.3	50.6
203	13142	6277	WCG 166B	FST	8	19	20	95	44.5	58.0	4.3	0.0	57.7	26.0	2.2	1.0	15.8	113.5	170.8	6.7	51.7	40.4	1.1	35.0	14.0	14.0	9.0	71.1	95.4	53.0
204	6692	6280	NCAc 17124	FST	8	20	21	95	54.5	58.5	3.5	0.0	67.0	27.8	2.4	1.3	16.5	116.7	181.7	0.0	13.0	69.6	17.4	45.5	15.0	15.0	8.2	59.8	96.8	42.0
205	13143	6355	RCM 533	FST	8	19	20	95	48.3	55.3	4.7	0.0	60.8	25.2	2.4	0.7	17.2	144.7	142.2	6.9	50.0	43.1	0.0	21.4	12.5	12.0	7.4	69.1	96.5	45.9
206	13144	6691	ROGUE DE PLODIV	FST	8	19	19	95	47.0	59.8	4.3	2.8	62.8	25.0	2.5	1.8	22.9	161.7	134.5	10.3	34.5	50.0	5.2	34.0	15.0	14.0	9.0	67.9	96.2	43.9
207	13145	6709	PERU NO.2	FST	7	20	21	95	54.3	68.8	3.5	0.0	72.7	36.2	2.0	1.8	13.0	93.6	122.0	20.3	72.9	6.8	0.0	30.0	16.0	15.0	8.5	66.7	96.9	52.2
208	11247	6726	WCG 135	FST	8	17	18	93	47.5	58.8	4.0	0.0	55.5	24.7	2.2	1.0	21.0	170.7	152.8	2.8	26.9	57.4	13.0	33.0	15.0	15.0	9.0	72.1	90.8	41.1
209	4471	6775	PI 262058	FST	8	17	18	95	48.3	53.0	4.0	1.8	58.3	26.3	2.2	1.0	20.9	153.1	171.3	5.7	21.8	66.7	5.7	33.0	14.0	15.0	8.5	70.5	95.2	48.1
210	1527	6960	PI 262007	FST	7	18	19	95	55.3	63.0	4.0	2.8	53.2	24.2	2.2	2.3	16.7	126.7	101.8	8.8	61.1	30.1	0.0	30.0	13.0	15.0	8.0	73.0	95.2	32.6
211	13148	7205	WCG 115	FST	7	19	21	95	68.8	74.5	4.0	1.5	70.0	29.8	2.3	0.8	14.5	112.1	112.1	3.4	53.4	37.1	6.0	40.0	14.0	12.4	8.0	66.9	90.8	37.2
212	13149	7296	203/66	FST	8	19	20	93	61.5	63.0	5.0	0.0	67.0	28.8	2.3	1.5	15.8	155.6	140.2	10.7	38.4	47.3	3.6	36.4	15.0	12.4	8.9	73.9	94.8	45.7
213	13150	7320	NCAC 17656	FST	9	18	19	95	50.0	68.5	4.0	0.0	59.2	28.3	2.1	0.5	16.2	116.9	113.2	3.3	9.9	76.0	10.7	36.0	14.0	14.0	8.0	59.9	90.2	28.6
214	13151	7340	WCG 182	FST	8	19	21	95	56.5	70.8	4.0	0.0	75.7	29.8	2.5	1.5	16.5	127.9	171.0	3.7	16.8	57.9	21.5	42.0	15.0	16.4	8.0	62.8	81.7	44.9
215	13152	7353	PERU NO.9	FST	9	19	20	95	49.0	59.8	3.5	0.0	72.5	28.7	2.5	0.0	18.0	127.2	175.6	0.0	11.6	65.1	23.3	39.0	16.0	15.4	8.6	62.9	94.7	38.7
216	4603	7404	V 20	FST	9	18	19	95	56.8	73.0	4.0	0.0	74.2	30.3	2.4	0.8	20.5	101.3	149.5	6.9	20.8	58.4	13.9	36.0	16.0	15.0	7.5	62.9	89.5	42.0
217	4486	7433	NCAc 17518	FST	9	18	19	95	61.0	75.8	4.5	0.0	74.0	25.8	2.9	1.8	23.4	153.2	175.0	2.2	9.8	78.3	9.8	38.0	16.0	17.0	8.5	59.0	94.7	44.4
218	9747	7620	ICG 7620	FST	8	19	21	95	56.3	63.0	4.0	0.5	55.7	25.5	2.2	1.5	19.6	120.0	171.8	0.0	16.7	67.9	15.4	41.4	16.6	15.4	8.4	61.2	89.0	40.0
219	13156	7628	WCG 170	FST	8	19	21	95	59.5	65.8	4.0	0.0	76.0	30.8	2.5	0.5	17.2	112.5	128.7	9.3	15.7	71.3	3.7	33.0	15.0	14.0	7.5	61.2	92.9	33.6
220	13159	7712	PERU NO.9	FST	8	19	21	93	60.0	67.5	3.0	0.0	72.7	30.8	2.4	1.0	16.9	72.0	172.8	0.0	18.5	76.5	4.9	42.5	17.3	16.2	8.6	59.3	96.4	41.3

SNO	NRCG	ICG	VAR	HBT	DTG	DIF	DFF	DTM	LMA	LPB	NPB	NSB	LLL	LLW	LWR	NIMP	PYP	PPMT	HPW	OSP	TSP	THP	FSP	PDL	PDW	SDL	SDW	SHE	SMK	HSW
221	13160	7777	SAM COL. 186	FST	7	21	22	90	42.3	50.5	4.5	0.0	73.5	31.0	2.4	0.8	13.2	82.5	141.7	14.6	67.7	17.7	0.0	32.0	15.0	15.0	7.5	60.3	92.7	52.5
222	4849	7881	PI 215696	FST	8	21	23	95	46.0	52.3	4.5	0.0	66.2	28.2	2.3	0.5	10.6	121.1	87.6	7.2	40.2	52.6	0.0	31.2	14.3	11.4	7.4	52.9	86.7	25.1
223	4850	7882	PI 314817	FST	8	19	20	95	51.3	59.0	4.0	0.0	61.3	23.7	2.6	0.5	24.7	204.1	125.0	0.0	11.6	84.8	3.6	32.4	13.2	12.0	8.4	67.9	94.7	31.8
224	6700	7885	PI 381622	FST	8	19	21	95	57.5	72.0	3.5	0.3	55.8	26.7	2.1	0.3	17.3	89.9	130.5	0.0	24.2	75.8	0.0	32.8	15.3	12.0	8.4	64.5	92.5	32.9
225	6529	7886	PI 390593	FST	9	18	19	95	53.5	70.0	4.0	0.0	67.0	27.3	2.5	1.0	17.8	113.7	144.3	0.0	8.5	83.0	8.5	40.0	13.0	13.7	7.4	60.8	79.6	34.5
226	6703	7889	PI 393517	FST	9	18	20	95	45.8	59.5	4.3	0.0	65.3	27.5	2.4	0.8	21.7	104.1	117.0	2.7	9.8	87.5	0.0	28.4	14.3	13.4	8.2	55.7	82.2	31.2
227	4859	7893	PI 393531	FST	9	18	20	95	50.8	63.3	3.5	0.0	60.3	25.3	2.4	0.8	15.7	81.7	132.4	0.0	4.8	89.5	5.7	38.0	15.0	12.3	7.3	56.1	84.6	31.6
228	4861	7896	PI 393646	FST	9	19	20	95	38.0	49.8	3.8	0.5	65.5	29.0	2.3	0.8	21.0	106.3	152.0	6.0	21.0	65.0	8.0	35.4	14.8	14.3	8.0	59.2	88.9	37.0
229	6707	7897	PI 405132	FST	8	20	21	93	50.0	58.0	4.0	0.7	63.3	26.2	2.4	0.7	8.8	70.3	117.3	0.0	33.1	64.6	2.4	30.0	15.2	11.0	7.7	57.0	90.6	31.1
230	4873	7924	PI 268491	FST	8	18	19	93	56.3	64.8	4.5	0.0	61.0	27.5	2.2	0.5	18.1	106.3	131.3	6.1	48.7	45.2	0.0	29.4	14.3	12.4	8.4	67.5	93.1	38.1
231	13161	7927	MUBENDI	FST	7	18	20	93	41.8	47.5	4.0	0.0	60.0	24.8	2.4	1.0	16.8	125.2	140.7	3.4	22.0	66.9	7.6	40.3	14.9	14.4	8.4	72.3	94.2	43.0
232	4498	8000	PI 268492	FST	7	20	20	93	48.5	51.5	4.0	0.0	56.2	24.5	2.3	0.5	22.8	160.9	148.6	6.5	24.3	64.5	4.7	30.5	15.0	14.4	8.1	74.2	86.4	40.6
233	1587	8003	Tesa bunch	FST	8	18	19	93	48.8	64.3	4.5	3.3	61.2	26.0	2.4	1.3	22.9	107.1	142.1	14.0	29.9	54.2	1.9	37.2	14.2	13.0	7.5	77.0	94.0	44.4
234	4934	8047	PI 268525	FST	8	15	17	93	48.5	54.3	4.8	2.0	59.7	25.7	2.3	1.0	22.7	102.9	140.8	7.1	18.4	66.3	8.2	39.4	13.2	12.4	8.0	74.6	89.3	40.0
235	13162	8105	RCM 449-3	FST	7	18	20	93	34.8	43.0	4.3	0.0	61.5	26.2	2.3	0.5	24.1	176.7	128.6	2.0	65.3	32.7	0.0	37.6	13.6	13.3	7.3	72.2	84.6	41.3
236	6540	8257	NCAc 17099	FST	8	19	20	93	47.5	58.3	4.0	0.5	60.7	25.7	2.4	0.0	16.4	133.3	138.5	1.8	13.8	73.4	11.0	36.4	16.2	13.2	8.4	71.5	97.2	36.3
237	13166	8599	TYPE NO.7	FST	7	16	18	95	46.5	58.0	4.3	0.0	60.3	26.2	2.3	0.5	29.1	151.2	136.1	9.8	36.1	49.2	4.9	32.4	13.4	11.9	7.7	68.1	97.3	40.5
238	13168	9185	75-16	FST	8	15	17	95	49.0	50.8	4.3	0.0	67.8	29.5	2.3	0.5	17.1	100.1	135.1	11.5	77.9	10.7	0.0	31.0	16.0	14.0	8.0	46.3	86.6	36.4
239	10995	10005	SP 425 FLESH	FST	8	18	20	95	55.8	63.0	4.0	0.0	64.3	25.5	2.5	0.5	13.9	85.5	118.4	12.0	76.0	12.0	0.0	38.2	15.4	14.1	7.1	58.1	89.5	27.2
240	11589	10039	SPZ 482 DARK PU	FST	8	20	21	95	62.8	68.5	3.5	0.0	65.0	28.3	2.3	0.3	15.8	96.8	132.3	1.1	5.4	68.8	24.7	40.1	15.2	15.0	7.4	52.8	89.2	29.6
241	11007	10048	SPZ 487 FLESH	FST	9	18	20	93	45.0	58.5	3.8	0.0	66.8	25.0	2.7	0.5	18.5	125.7	136.8	4.2	0.0	80.0	15.8	40.0	15.6	14.7	8.1	66.2	90.7	31.8
242	11594	10057	SPZ 492 PURPLE	FST	9	18	20	95	45.8	52.8	4.0	0.0	55.7	23.2	2.4	0.3	26.5	151.7	141.1	3.7	8.4	66.4	21.5	36.1	15.1	13.2	8.1	68.2	95.1	32.7
243	11009	10058	SPZ 493 FLESH	FST	9	18	20	95	48.5	60.8	4.0	0.0	59.3	25.0	2.4	0.3	16.5	140.8	118.9	0.0	0.0	82.0	18.0	37.0	14.4	11.4	7.9	60.0	80.5	29.5
244	11595	10059	SPZ 493 PURPLE	FST	8	19	20	93	43.8	54.0	4.0	0.0	59.2	24.8	2.4	0.0	17.9	157.6	118.3	0.0	15.6	75.2	9.2	36.4	14.2	13.8	7.1	63.6	87.8	26.9
245	11598	10063	SPZ 496 PURPLE	FST	8	19	21	95	45.3	59.5	3.0	0.0	62.2	25.7	2.4	0.3	26.9	200.7	144.6	0.0	0.0	79.3	20.7	37.0	14.2	14.7	9.2	62.9	95.5	33.0
246	11600	10067	SPZ 499 PURPLE	FST	9	18	20	95	43.5	62.3	3.5	0.0	65.0	23.5	2.8	0.0	23.6	144.8	142.2	2.8	5.5	78.9	12.8	35.4	14.0	13.0	7.5	67.7	90.5	33.2
247	11012	10070	SPZ 501 PURPLE	FST	8	19	19	93	53.0	65.0	3.5	0.0	64.3	26.3	2.4	0.3	21.1	227.7	155.8	0.0	11.5	79.8	8.7	35.8	15.1	12.4	7.0	60.5	94.9	37.7
248	11032	10450	TINGO MARIA	FST	8	19	20	95	57.8	70.5	4.0	0.0	65.3	29.8	2.2	1.0	16.3	73.9	124.8	3.2	48.8	48.0	0.0	34.0	14.2	12.2	8.1	64.1	96.0	31.2
249	11604	10890	SPA 406 RED	FST	7	18	19	93	56.0	65.5	3.8	0.0	60.5	24.3	2.5	0.0	16.6	174.7	166.7	4.6	9.3	52.8	33.3	40.0	14.7	13.3	9.0	65.6	96.6	38.7

SNO	NRCG	ICG	VAR	HBT	DTG	DIF	DFF	DTM	LMA	LPB	NPB	NSB	LLL	LLW	LWR	NIMP	PYP	PPMT	HPW	OSP	TSP	THP	FSP	PDL	PDW	SDL	SDW	SHE	SMK	HSW
250	11605	10918	SPZ 459 FLESH	FST	7	18	20	95	54.5	66.5	3.5	0.0	63.8	26.5	2.4	0.5	19.9	175.2	123.7	2.3	7.6	78.6	11.5	37.4	15.3	14.0	8.1	59.9	80.4	28.6
251	11611	10935	SPZ 476 DARK PU	FST	7	18	19	95	53.3	64.3	2.0	0.0	68.0	27.2	2.5	0.8	14.1	137.6	142.1	2.9	11.4	82.9	2.9	34.4	14.0	15.4	9.1	65.3	91.5	49.1
252	11918	10949	SPZ 486 LIGHT P	FST	7	20	21	95	65.5	73.0	3.8	0.0	66.3	28.5	2.3	0.8	17.0	133.7	181.8	0.0	0.0	45.5	54.5	50.4	15.4	20.2	9.5	61.4	95.3	35.0
253	11612	10966	SPZ 496 FLESH	FST	7	19	22	95	51.3	62.8	2.8	0.0	62.8	26.8	2.3	0.0	21.0	210.0	161.8	5.9	65.4	28.7	0.0	37.4	14.0	12.8	7.6	65.9	95.2	37.2
254	9740	10974	ICG 10974	FST	7	20	21	95	48.0	56.5	3.3	0.0	61.0	26.5	2.3	1.0	24.9	166.0	158.0	9.2	62.6	28.2	0.0	35.1	14.7	12.0	7.2	67.6	92.1	38.3
255	11581	10975	SPZ 503 DARK PU	FST	8	20	21	95	50.3	59.8	3.5	0.0	63.0	26.7	2.4	1.5	26.3	73.6	123.8	7.1	36.5	56.3	0.0	40.0	15.2	13.1	8.2	63.5	94.9	38.3
256	11614	11073	SPZ 459 PURPLE	FST	8	19	21	95	49.8	71.0	4.0	0.0	55.5	24.3	2.3	0.5	21.5	123.3	136.5	3.2	5.6	78.6	12.7	33.4	14.6	13.0	8.0	59.3	96.1	35.2
257	9746	11075	ICG 11075	FST	9	18	20	93	63.5	69.0	2.3	0.0	66.5	27.2	2.4	0.0	18.0	136.5	211.9	0.0	4.0	70.3	25.7	46.0	14.9	14.0	7.5	65.4	95.0	45.5
258	11615	11108	SPZ 503 PURPLE	FST	9	18	20	93	46.8	64.0	3.5	0.0	60.5	25.2	2.4	0.0	22.0	182.1	143.9	0.0	2.7	85.8	11.5	38.2	15.2	11.8	8.0	66.2	90.1	34.6
259	13170	11182	SP 403 TAN	FST	8	15	17	95	51.3	64.5	4.0	0.0	54.8	26.5	2.1	1.0	30.1	176.7	128.9	2.1	7.0	69.0	21.8	38.0	14.0	12.1	7.6	65.0	89.1	31.7
260	11582	11186	SPZ 488 GASP	FST	9	17	19	94	40.3	54.8	2.8	0.0	60.5	24.7	2.4	0.0	17.3	64.4	190.8	0.0	0.0	69.7	30.3	40.0	15.4	14.7	8.0	60.7	89.8	35.6
261	11622	11282	SPA 411	FST	8	19	20	95	49.5	57.3	4.3	0.0	59.2	25.2	2.3	0.3	18.6	71.9	133.3	0.0	23.0	39.1	37.9	36.4	16.3	12.0	7.5	62.1	90.3	31.9
262	13172	11285	SPZ 473 GASP	FST	9	18	19	95	42.8	59.3	4.8	0.0	58.2	26.8	2.2	2.0	22.8	51.6	130.2	0.0	6.9	62.1	31.0	36.2	13.8	13.8	8.0	64.2	90.7	29.0
263	13173	11485	P 2435	FST	8	21	22	95	49.0	57.8	3.5	0.0	55.0	26.7	2.1	0.8	11.8	52.0	109.8	0.0	38.2	61.8	0.0	40.8	15.2	15.2	7.0	58.0	76.9	29.7
264	13174	12112	SPZ 485 LPL	FST	7	21	22	96	58.3	74.0	3.0	0.0	58.7	25.5	2.3	0.8	16.8	71.9	195.9	0.0	15.1	78.1	6.8	52.4	18.2	17.4	9.2	66.4	90.5	49.4
265	5176	1705	NCAc 17130	FST	7	21	22	96	55.5	65.0	2.5	0.0	62.7	28.7	2.2	0.3	21.2	96.1	204.9	1.2	6.1	69.5	23.2	46.0	16.0	16.0	8.0	67.9	96.5	46.3
266	1520	6903	PI 268988	FST	7	18	20	95	46.8	49.0	5.0	1.0	60.7	29.3	2.1	0.8	29.3	140.7	121.4	5.3	42.0	51.1	1.5	34.4	14.2	14.0	9.3	74.8	93.3	39.3
267	4212	361	NCAc 963	FST	7	20	21	95	51.8	49.5	4.0	0.0	55.8	26.5	2.1	0.3	24.9	132.7	120.0	4.0	52.0	44.0	0.0	34.4	12.2	13.0	8.3	74.7	97.3	41.3
268	4206	279	NCAc 515	VUL	8	19	20	94	44.3	48.3	4.0	0.0	54.3	29.3	1.9	0.0	19.8	115.9	91.3	16.3	73.8	10.0	0.0	24.4	14.2	13.2	8.0	71.2	96.2	36.5
269	13036	368	MANI NEGRO	VUL	8	19	21	94	39.5	47.8	4.0	0.0	52.5	26.8	2.0	0.3	27.4	149.6	100.0	15.1	79.4	5.6	0.0	30.2	12.7	13.6	7.8	73.8	95.7	38.3
270	1172	1679	NCAc 2838	VUL	8	19	21	94	41.3	51.0	4.0	0.5	51.7	27.3	1.9	0.0	23.7	186.1	79.9	15.2	84.8	0.0	0.0	25.3	12.4	12.0	8.2	76.2	96.4	38.0
271	13079	1712	V 109	VUL	7	20	20	95	56.8	69.3	3.3	0.0	61.5	28.0	2.2	0.5	19.5	137.6	142.3	0.0	16.9	75.4	7.7	35.4	15.3	13.8	8.0	62.9	92.9	35.5
272	13128	4783	KU NO.60	VUL	7	20	21	99	47.3	59.5	4.5	0.0	57.3	28.7	2.0	0.5	15.7	125.3	83.8	14.4	68.8	16.9	0.0	30.4	13.7	12.4	8.0	68.7	95.7	32.2
273	13006	268	GA 167	VUL	7	20	20	90	42.3	51.8	4.0	0.5	43.0	26.3	1.6	0.0	19.4	147.1	62.3	9.5	90.5	0.0	0.0	21.4	10.9	10.0	7.0	73.7	97.0	26.5
274	13007	275	GA 181	VUL	7	20	22	95	52.0	53.5	4.0	0.0	66.5	31.5	2.1	0.5	17.2	188.1	89.3	10.7	89.3	0.0	0.0	23.4	12.5	12.2	8.0	72.9	96.9	35.6
275	13008	282	NCAC 520	VUL	7	18	20	94	50.3	63.5	4.0	0.0	62.2	26.0	2.4	0.3	21.5	160.5	105.6	9.0	55.9	35.0	0.0	34.1	13.5	12.8	8.1	77.5	96.6	39.6
276	1079	286	NCAC 529	VUL	7	18	20	96	49.0	57.0	4.0	0.0	60.0	27.8	2.2	0.5	19.2	168.7	115.9	10.6	89.4	0.0	0.0	31.4	14.2	13.2	7.3	67.3	97.1	46.0
277	13010	289	SPANISH 2B	VUL	7	20	21	95	45.5	55.0	5.3	0.5	52.8	30.3	1.7	0.0	20.3	159.6	93.9	7.5	92.5	0.0	0.0	29.5	13.2	14.5	8.4	67.4	96.8	42.9
278	13011	290	NCAC 542	VUL	7	20	20	94	42.0	52.0	4.5	0.0	59.5	35.2	1.7	0.0	24.3	177.9	119.4	5.8	94.2	0.0	0.0	28.4	14.0	14.2	9.2	73.5	97.5	49.6

SNO	NRCG	ICG	VAR	HBT	DTG	DIF	DFF	DTM	LMA	LPB	NPB	NSB	LLL	LLW	LWR	NIMP	PYP	PPMT	HPW	OSP	TSP	THP	FSP	PDL	PDW	SDL	SDW	SHE	SMK	HSW
279	9182	294	MPUTU-C	VUL	7	20	21	93	39.8	50.0	5.0	0.0	45.7	23.8	1.9	0.0	15.0	147.9	83.8	15.2	83.8	1.0	0.0	23.5	11.4	12.4	9.8	75.8	96.0	40.0
280	13014	310	GA 199	VUL	7	20	21	94	50.3	57.3	4.0	0.0	65.0	30.7	2.1	0.5	15.0	126.3	81.2	12.4	87.6	0.0	0.0	28.4	13.2	13.2	8.2	75.5	95.6	37.9
281	4236	311	NCAc 608	VUL	8	19	20	94	45.8	61.5	5.3	0.0	61.2	26.7	2.3	0.3	18.3	136.8	97.8	11.8	88.2	0.0	0.0	25.4	12.6	12.8	7.7	74.4	96.0	43.9
282	13015	316	GA 163	VUL	7	18	20	95	49.0	55.8	5.3	0.0	57.5	30.0	1.9	0.0	23.2	179.5	94.1	6.6	93.4	0.0	0.0	26.3	12.4	14.2	8.2	75.0	91.7	43.5
283	13017	323	BAKU FOIRE	VUL	7	20	21	95	41.8	51.0	4.5	0.0	55.5	28.0	2.0	1.0	20.8	147.2	100.6	9.2	90.8	0.0	0.0	30.8	13.1	13.2	8.2	68.3	96.4	41.4
284	13019	327	CATETO	VUL	7	20	21	97	47.3	51.3	4.8	0.3	50.0	28.0	1.8	0.3	19.3	162.5	97.7	8.7	91.3	0.0	0.0	29.0	13.5	15.0	8.0	71.4	96.7	43.6
285	4238	329	NCAc 726	VUL	7	20	20	94	44.0	53.3	5.0	2.0	57.0	27.7	2.1	0.0	20.4	174.4	96.7	8.9	91.1	0.0	0.0	28.5	12.9	14.2	8.4	76.4	97.0	42.6
286	4239	333	NCAc 746	VUL	7	20	21	94	53.8	61.8	5.5	0.5	57.5	30.3	1.9	0.3	19.5	161.5	96.8	12.4	87.6	0.0	0.0	26.5	12.3	13.8	7.9	72.2	91.5	43.0
287	9185	334	NCAc 751	VUL	7	20	22	95	54.5	63.5	4.8	0.0	62.3	32.7	1.9	0.3	20.0	171.1	80.1	7.6	92.4	0.0	0.0	28.8	12.1	14.2	8.0	87.6	95.8	41.2
288	13020	341	ACETEIRO CHICO	VUL	7	20	22	90	46.5	52.3	4.3	0.0	46.8	21.5	2.2	0.5	20.6	161.7	66.7	8.0	92.0	0.0	0.0	23.4	11.4	10.4	7.1	75.9	96.0	30.0
289	13021	344	LE 36	VUL	7	20	22	92	47.5	55.0	4.0	0.0	52.0	24.7	2.1	0.8	15.6	116.5	77.5	9.5	90.5	0.0	0.0	24.3	11.8	12.2	7.2	77.3	94.7	32.7
290	13022	348	NCAC 821	VUL	7	20	22	95	51.8	58.3	4.0	0.8	59.2	30.3	2.0	0.5	20.2	132.3	119.4	11.7	62.2	26.1	0.0	38.2	14.2	16.4	8.2	73.5	95.6	47.9
291	13023	350	NCAC 831	VUL	8	19	21	95	45.8	52.8	4.0	0.0	59.5	25.8	2.3	0.5	19.0	83.6	98.2	12.3	87.7	0.0	0.0	25.5	14.7	12.5	7.8	70.0	96.4	39.8
292	13024	352	NCAC 845	VUL	8	19	21	93	57.0	65.8	4.5	1.5	60.0	28.0	2.1	0.3	16.6	135.2	76.4	10.3	89.7	0.0	0.0	24.8	12.4	11.2	6.9	72.3	96.4	32.6
293	1107	359	NCAC 888	VUL	9	18	19	93	44.0	52.0	4.5	0.0	46.7	22.0	2.1	0.3	16.3	95.5	86.2	10.8	89.2	0.0	0.0	26.2	12.7	12.6	8.2	75.5	97.4	39.1
294	13030	360	NCAC 892	VUL	8	20	21	95	43.5	57.8	3.5	0.0	60.2	29.0	2.1	0.0	17.4	74.3	94.5	15.3	84.7	0.0	0.0	25.1	12.2	12.2	7.1	74.6	93.8	34.9
295	13033	365	MANI BLANCA 61	VUL	8	19	20	93	44.0	51.5	4.3	6.3	41.2	18.2	2.3	0.0	13.5	53.9	69.8	9.4	90.6	0.0	0.0	26.4	11.6	11.3	7.2	73.9	93.9	29.6
296	13037	369	MANI BLANCO 26A	VUL	8	20	21	93	48.0	63.3	4.0	1.3	56.5	26.8	2.1	0.0	19.1	104.7	68.0	8.6	91.4	0.0	0.0	25.2	12.1	12.2	8.1	74.7	93.8	28.3
297	13039	374	NCAC 967	VUL	8	19	20	93	51.5	57.8	4.5	0.5	55.3	26.2	2.1	1.0	18.2	111.3	68.8	9.8	90.2	0.0	0.0	24.8	12.3	12.0	7.7	69.5	92.5	28.2
298	13040	377	NCAC 990	VUL	8	19	20	94	44.8	54.8	5.5	2.0	56.7	25.5	2.2	1.3	14.3	120.3	70.5	21.0	77.0	2.0	0.0	25.4	11.0	12.0	7.5	74.5	93.3	29.5
299	13041	378	SH 130	VUL	7	20	21	95	55.0	62.5	4.3	1.5	57.7	28.2	2.0	0.5	12.7	113.6	102.7	14.4	9.6	75.9	0.0	29.0	12.4	14.0	8.0	70.3	96.3	37.7
300	13044	381	A 30	VUL	7	21	22	93	52.0	60.5	4.5	2.5	53.5	27.7	1.9	0.8	17.6	142.8	69.6	7.5	92.5	0.0	0.0	23.4	13.0	11.9	6.9	70.1	96.6	29.0
301	13045	382	A 18	VUL	7	20	21	95	48.8	59.8	5.0	3.5	55.3	27.3	2.0	0.8	20.2	118.5	97.0	8.9	91.1	0.0	0.0	28.4	14.0	13.0	8.0	69.0	96.3	38.5
302	13047	386	CPI 11996	VUL	7	20	21	93	40.3	52.5	4.5	1.0	59.7	27.0	2.2	0.0	14.4	109.2	83.4	4.3	95.7	0.0	0.0	25.4	13.4	13.5	8.9	73.9	96.2	32.5
303	13048	388	CPI 12154	VUL	8	19	20	93	50.0	61.3	4.8	0.0	55.8	25.3	2.2	0.3	27.2	159.3	160.6	11.5	88.5	0.0	0.0	26.5	12.8	11.4	8.0	72.5	97.5	37.4
304	13050	394	RED SPANISH	VUL	8	19	20	93	59.8	73.5	5.0	1.5	60.8	28.7	2.1	1.0	12.9	84.4	81.0	8.2	91.8	0.0	0.0	26.0	11.0	13.0	7.5	72.7	95.6	36.7
305	13051	396	NCAC 1333	VUL	8	19	20	93	46.8	53.3	5.0	2.3	49.5	29.3	1.7	0.5	23.0	119.7	97.5	8.1	91.9	0.0	0.0	30.4	14.3	13.5	8.6	70.8	94.1	43.0
306	819	400	NCAC 2600	VUL	8	19	21	94	53.8	59.3	4.5	3.8	53.5	27.5	1.9	0.0	14.6	107.3	118.4	3.7	96.3	0.0	0.0	32.0	14.0	16.0	8.5	66.3	96.9	47.9
307	13053	402	SP 2B	VUL	7	20	22	94	44.7	55.3	5.0	2.7	54.3	31.2	1.7	0.7	20.4	130.8	106.4	8.6	91.4	0.0	0.0	30.4	14.2	14.0	9.1	73.2	97.2	46.1

SNO	NRCG	ICG	VAR	HBT	DTG	DIF	DFF	DTM	LMA	LPB	NPB	NSB	LLL	LLW	LWR	NIMP	PYP	PPMT	HPW	OSP	TSP	THP	FSP	PDL	PDW	SDL	SDW	SHE	SMK	HSW
308	13054	410	NCAC 2698	VUL	7	20	22	95	51.0	74.0	4.0	0.0	72.5	30.7	2.4	0.0	24.8	129.2	87.6	9.0	91.0	0.0	0.0	36.4	13.1	14.2	7.0	78.7	97.0	38.5
309	9187	426	Mfoka-A	VUL	8	19	21	94	47.5	60.5	5.5	2.5	54.3	25.0	2.2	0.5	17.4	129.7	107.1	7.1	53.2	39.7	0.0	24.2	12.1	11.9	8.0	61.5	96.4	40.6
310	5573	428	NCAc 2816	VUL	8	19	21	93	51.3	57.5	4.0	0.8	56.3	25.3	2.2	0.0	17.6	143.5	84.7	8.0	92.0	0.0	0.0	26.2	12.0	12.4	6.9	70.3	95.9	38.2
311	5574	431	PI 152108	VUL	7	21	22	95	64.0	75.3	4.5	2.5	69.2	32.3	2.1	0.8	16.9	80.9	89.0	7.6	92.4	0.0	0.0	26.7	12.4	14.1	8.2	68.6	95.8	39.8
312	13056	432	GA 270-8	VUL	8	19	20	95	52.0	67.0	4.0	1.5	60.8	27.0	2.3	0.0	8.1	66.1	52.9	79.4	20.6	0.0	0.0	22.2	12.2	13.0	8.4	57.8	94.2	35.4
313	13057	438	PORTO ALEGRE	VUL	8	20	21	93	57.3	65.0	4.5	1.0	56.3	29.2	1.9	0.8	40.8	250.1	70.5	8.3	91.7	0.0	0.0	25.4	11.9	11.2	8.0	72.9	96.0	33.1
314	13058	444	MTUTU-B	VUL	7	20	21	93	52.3	61.5	4.0	0.5	59.7	27.0	2.2	0.5	13.8	134.1	76.0	6.2	93.8	0.0	0.0	24.8	11.9	12.0	8.2	68.5	96.8	31.1
315	9190	456	NCAc 2953	VUL	8	20	21	94	45.8	56.3	4.0	2.5	55.0	28.3	1.9	1.0	16.7	127.1	78.7	11.1	88.9	0.0	0.0	28.2	13.2	13.1	7.1	67.8	95.8	32.8
316	13064	473	V 26	VUL	7	20	21	94	52.5	58.8	4.5	1.0	66.3	27.7	2.4	0.0	8.0	64.1	98.7	20.8	56.0	23.3	0.0	32.4	14.2	12.3	7.7	63.1	90.9	33.6
317	5007	476	Chico	VUL	8	19	19	86	29.5	34.8	5.0	0.0	43.3	21.2	2.0	0.5	10.2	71.7	49.8	24.4	75.6	0.0	0.0	28.0	9.9	12.2	7.2	77.7	93.1	24.3
318	9225	1605	Pei-Kang-Pe-You-Don	VUL	9	19	20	91	52.5	58.0	4.8	0.5	59.3	26.2	2.3	0.8	16.5	114.7	93.3	20.1	79.9	0.0	0.0	30.2	12.2	14.1	8.2	65.2	97.5	40.7
319	13065	1606	LUNG TAN YOU DO	VUL	8	22	23	93	49.3	57.8	4.0	2.8	61.7	27.0	2.3	0.8	15.7	119.5	84.3	4.0	96.0	0.0	0.0	31.1	14.2	13.6	8.0	54.5	96.7	39.0
320	13067	1609	SCHWARZ 21	VUL	9	20	22	93	60.3	66.8	4.0	0.0	56.0	25.5	2.2	0.8	13.5	88.1	106.2	10.7	89.3	0.0	0.0	29.0	12.6	13.4	7.9	66.0	96.0	41.7
321	1680	1612	NCAC 399	VUL	8	20	21	93	50.0	58.0	4.5	0.8	54.2	24.2	2.2	0.3	18.2	159.9	120.4	11.4	49.7	38.9	0.0	34.4	14.0	12.8	8.1	70.1	97.2	43.7
322	13069	1616	GA 159	VUL	9	20	21	93	45.0	54.0	4.0	1.5	55.0	28.2	2.0	0.5	16.6	119.5	97.7	16.3	83.7	0.0	0.0	30.0	14.0	12.2	8.2	67.9	96.5	41.4
323	9228	1617	NCAc 429	VUL	7	21	22	93	50.5	57.5	4.0	1.0	65.7	30.8	2.1	0.8	30.6	179.5	113.7	7.7	92.3	0.0	0.0	26.4	14.2	13.0	8.0	71.2	97.1	49.6
324	13070	1623	DOI	VUL	8	20	21	90	43.8	47.8	4.0	1.0	53.0	24.3	2.2	0.3	17.5	140.1	78.2	4.5	95.5	0.0	0.0	22.4	13.0	10.5	8.4	75.6	96.9	35.2
325	13071	1628	BILB	VUL	7	21	23	92	49.5	56.8	5.0	4.0	57.2	26.7	2.1	0.8	18.3	153.3	104.2	8.9	91.1	0.0	0.0	29.0	12.0	15.0	7.0	75.4	97.3	48.1
326	1158	1636	NCAC 889	VUL	8	19	21	90	45.5	59.3	4.0	3.0	59.5	27.3	2.2	0.8	17.5	149.2	146.8	22.5	77.5	0.0	0.0	22.5	10.5	11.0	8.0	76.1	96.8	34.9
327	9235	1644	Maseni	VUL	8	19	21	92	50.5	56.5	4.0	1.5	58.8	26.7	2.2	1.0	20.1	118.1	96.7	2.8	97.2	0.0	0.0	26.2	13.0	13.5	8.2	67.8	97.5	39.8
328	9236	1662	NCAc 2673	VUL	8	21	22	93	48.5	55.5	4.5	2.5	54.8	26.2	2.1	1.0	17.2	151.1	108.0	9.1	90.9	0.0	0.0	28.4	12.3	13.4	8.2	69.8	96.2	41.0
329	9237	1669	NCAc 2737	VUL	9	20	21	94	41.0	46.3	4.0	2.5	53.3	24.2	2.2	0.8	13.2	121.9	102.5	21.5	78.5	0.0	0.0	29.0	13.0	15.0	8.0	59.3	90.9	43.3
330	1169	1674	NCAC 2753	VUL	8	21	22	95	47.8	52.8	5.0	2.0	53.2	28.5	1.9	1.0	19.4	119.2	91.5	9.6	90.4	0.0	0.0	29.4	13.2	13.8	8.0	71.6	96.6	37.8
331	1688	1677	NCAC 2820	VUL	8	20	21	93	48.3	56.8	4.0	1.3	55.3	24.2	2.3	0.5	12.5	113.2	69.2	9.5	90.5	0.0	0.0	24.0	11.5	10.5	7.5	76.9	96.7	32.2
332	13074	1681	GA 195	VUL	7	22	24	95	44.7	53.0	4.7	2.0	61.0	25.7	2.4	0.7	11.3	114.1	84.9	6.1	93.9	0.0	0.0	27.4	15.2	13.5	8.4	60.5	96.7	34.4
333	13076	1685	MTUTU-C	VUL	7	22	24	95	47.8	54.0	4.0	0.0	54.0	22.7	2.4	1.0	13.0	98.9	71.7	15.0	84.1	0.9	0.0	24.2	12.0	11.0	7.5	75.3	97.5	35.0
334	13078	1699	WCG 156	VUL	8	21	23	95	46.0	53.5	4.0	0.3	63.0	27.5	2.3	0.5	15.0	85.9	79.8	9.2	90.8	0.0	0.0	26.4	13.5	14.4	8.4	67.4	96.8	35.8
335	9238	1711	DHT 191	VUL	8	21	23	93	44.3	52.0	4.0	0.0	52.0	24.7	2.1	0.5	18.1	127.7	77.0	4.4	95.6	0.0	0.0	25.4	13.0	10.4	7.2	74.5	98.3	35.7
336	9344	2272	GA 165	VUL	8	21	22	92	48.5	56.5	4.0	1.0	47.3	22.7	2.1	0.5	14.1	105.2	100.8	12.5	87.5	0.0	0.0	30.0	14.0	14.0	7.7	62.0	93.8	39.7

SNO	NRCG	ICG	VAR	HBT	DTG	DIF	DFF	DTM	LMA	LPB	NPB	NSB	LLL	LLW	LWR	NIMP	PYP	PPMT	HPW	OSP	TSP	THP	FSP	PDL	PDW	SDL	SDW	SHE	SMK	HSW
337	13093	2310	NCAC 2158	VUL	8	21	23	97	48.0	58.8	4.5	4.0	55.8	27.2	2.1	1.8	23.7	113.6	153.3	14.8	85.2	0.0	0.0	42.4	16.4	16.5	9.4	56.7	97.2	53.1
338	9347	2359	Clark 8	VUL	9	20	21	93	46.8	52.0	4.0	0.0	60.7	27.5	2.2	2.8	17.8	116.0	82.9	6.1	93.9	0.0	0.0	24.5	11.2	12.0	8.2	63.3	95.8	32.7
339	13106	2364	GA 198	VUL	8	19	20	89	42.5	49.8	4.0	0.5	58.7	23.0	2.6	1.0	18.3	105.2	108.3	15.9	84.1	0.0	0.0	28.0	13.0	14.0	8.0	66.5	96.5	43.3
340	13111	2378	RCM 439	VUL	8	20	21	93	46.0	53.3	4.0	1.5	50.3	24.2	2.1	0.5	21.2	124.4	80.6	26.5	73.5	0.0	0.0	27.4	12.0	13.0	8.0	75.2	97.1	41.8
341	9444	3516	US 16-B	VUL	8	20	22	92	53.0	57.5	4.5	2.3	66.5	26.7	2.5	1.0	15.5	150.7	110.9	12.2	87.8	0.0	0.0	29.0	13.0	12.0	7.7	69.3	97.3	47.9
342	6536	4749	PI 337394F	VUL	9	19	20	93	47.8	53.3	4.0	0.0	56.5	24.0	2.4	1.3	18.9	123.5	80.3	13.5	86.5	0.0	0.0	25.2	12.3	13.2	8.2	70.1	95.7	35.0
343	7320	4751	T-900 (krinkle leaf	VUL	8	17	18	89	41.3	48.0	4.0	0.8	39.3	18.8	2.1	0.5	12.7	104.8	59.9	11.2	88.8	0.0	0.0	21.0	9.5	11.0	7.0	77.2	98.2	29.2
344	6681	4756	Ku# 191	VUL	8	20	21	93	45.5	54.0	4.8	1.8	56.3	27.3	2.1	0.5	17.4	132.1	103.8	3.3	95.7	0.9	0.0	25.9	14.4	12.5	8.5	68.0	96.6	44.7
345	9946	4758	ICG 4758	VUL	9	20	21	95	45.3	53.3	4.3	0.0	61.3	28.2	2.2	0.8	17.8	111.5	116.2	5.4	94.6	0.0	0.0	24.8	12.3	11.2	7.3	72.2	97.9	52.8
346	13117	4759	KU NO.159	VUL	9	21	22	95	44.0	48.3	4.0	0.8	50.8	24.0	2.1	0.0	21.8	128.1	108.2	17.0	83.0	0.0	0.0	27.0	14.5	13.0	8.5	69.5	97.1	46.6
347	13120	4766	KU NO.235	VUL	9	19	20	94	48.0	50.0	4.5	2.3	57.0	26.3	2.2	0.0	17.7	122.5	75.0	5.4	94.6	0.0	0.0	26.8	11.7	12.4	8.2	73.9	98.0	34.7
348	13121	4767	KU NO.236	VUL	8	21	23	94	47.3	52.0	4.0	3.3	59.2	27.0	2.2	0.7	20.7	154.8	98.9	5.4	94.6	0.0	0.0	29.0	13.0	14.0	7.5	73.8	96.3	43.0
349	13122	4768	KU NO.237	VUL	8	21	23	93	44.5	50.8	4.0	1.0	48.8	22.3	2.2	1.0	19.2	135.7	73.4	5.9	94.1	0.0	0.0	24.4	14.0	13.0	8.2	72.5	96.0	36.8
350	13123	4770	KU NO.203	VUL	9	18	20	95	27.5	32.0	4.5	2.0	45.7	20.5	2.2	1.3	11.1	97.7	102.3	20.5	79.5	0.0	0.0	29.0	13.5	14.0	9.0	77.0	97.1	50.6
351	13129	4785	KU NO.134	VUL	8	21	22	94	44.5	55.8	5.3	2.0	56.8	25.8	2.2	0.3	19.4	118.9	69.3	9.8	90.2	0.0	0.0	22.0	11.0	11.0	7.5	73.2	96.3	34.5
352	9540	4787	KU No. 144	VUL	7	22	23	95	55.0	62.0	5.0	3.0	57.7	24.8	2.3	1.0	22.7	151.6	100.5	6.0	94.0	0.0	0.0	27.2	13.2	13.0	8.0	74.1	96.4	40.3
353	1200	5100	NCAc 16820	VUL	8	20	21	95	54.0	71.5	4.3	0.0	58.8	25.5	2.3	1.3	22.2	198.7	79.6	6.2	93.8	0.0	0.0	22.0	11.0	11.0	7.5	74.3	95.5	34.0
354	13131	5144	NCAC 2308	VUL	8	25	27	118	76.5	77.5	4.0	6.8	45.8	18.2	2.5	0.3	5.5	85.0	91.9	24.4	75.6	0.0	0.0	28.4	13.2	15.2	8.4	55.6	91.3	41.4
355	13132	5156	F 1-79	VUL	8	21	22	93	43.3	51.0	4.0	0.0	60.5	24.2	2.5	0.5	23.9	188.3	82.4	7.4	92.6	0.0	0.0	24.4	11.7	11.4	8.0	77.9	97.3	35.7
356	6696	7633	UF 71513	VUL	7	20	23	95	49.0	51.8	4.0	1.0	60.5	23.5	2.6	1.0	22.0	181.5	103.8	7.6	71.8	20.6	0.0	41.4	15.2	15.2	8.2	75.7	96.1	41.8
357	6706	7895	PI 393643	VUL	8	19	20	95	60.0	74.0	4.0	0.0	61.2	25.2	2.4	0.8	19.4	157.6	144.8	2.1	3.1	74.0	20.8	34.0	13.0	10.5	7.5	69.1	95.8	32.2
358	1657	7906	PI 268802	VUL	7	20	22	95	49.0	58.3	4.0	3.0	56.8	26.0	2.2	1.3	24.8	208.1	84.2	9.8	90.2	0.0	0.0	25.2	13.0	12.4	8.2	74.0	96.5	38.4
359	4491	7930	PI 268741	VUL	8	19	21	93	49.8	55.3	4.3	0.5	59.0	24.2	2.4	0.3	16.8	183.5	80.9	5.9	94.1	0.0	0.0	24.0	11.0	12.0	7.6	76.4	96.0	37.7
360	13163	8230	MANYEMA TANGANY	VUL	8	20	21	93	51.5	57.5	4.0	1.5	59.0	26.5	2.2	0.5	27.3	200.5	87.6	3.4	96.6	0.0	0.0	21.0	11.0	11.0	8.0	74.2	96.5	39.0
361	13164	8450	RG 23	VUL	8	20	21	93	51.3	57.0	4.0	1.3	64.0	28.5	2.2	0.5	16.5	160.7	103.1	8.5	91.5	0.0	0.0	26.4	12.4	12.0	9.0	70.7	95.7	44.2
362	13165	8472	RG 89	VUL	8	20	21	94	53.5	60.3	5.0	3.5	62.7	28.3	2.2	0.8	22.1	173.7	96.0	9.6	90.4	0.0	0.0	24.0	12.0	12.0	7.5	72.5	95.4	41.5
363	9575	8662	Acc # 727	VUL	8	20	21	93	51.3	53.8	4.5	1.8	57.3	25.3	2.3	0.8	21.1	166.1	158.8	11.8	88.2	0.0	0.0	26.4	13.2	12.4	8.0	72.6	95.9	46.2
364	9577	8664	Acc # 731	VUL	9	19	20	93	45.3	53.5	4.8	3.0	57.5	26.0	2.2	0.8	16.4	144.3	109.8	8.0	92.0	0.0	0.0	30.0	13.0	14.0	9.0	78.9	84.5	48.4
365	6407	8977	PI 268573	VUL	8	20	21	93	48.8	52.8	4.5	2.8	48.8	26.0	1.9	1.0	22.4	167.3	78.8	5.1	94.9	0.0	0.0	22.4	10.4	11.4	7.9	75.0	95.7	35.8

SNO	NRCG	ICG	VAR	HBT	DTG	DIF	DFF	DTM	LMA	LPB	NPB	NSB	LLL	LLW	LWR	NIMP	PYP	PPMT	HPW	OSP	TSP	THP	FSP	PDL	PDW	SDL	SDW	SHE	SMK	HSW
366	11676	5048	NCAC 2313	VUL	9	25	28	115	64.5	64.8	4.0	9.0	49.3	20.7	2.4	2.5	5.1	93.0	92.2	39.1	60.9	0.0	0.0	30.4	14.2	15.2	10.0	66.1	94.9	33.1
367	9062	2343	FLA 76-10	VUL	8	25	26	97	52.0	57.0	4.0	3.8	51.5	27.2	1.9	0.8	28.3	128.0	94.1	5.9	94.1	0.0	0.0	25.4	11.3	10.0	6.8	62.2	93.3	33.1