Pulses Production in Semi-Arid Regions of India

Constraints and Opportunities

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Pulse production in India is characterised by diversity of crops and their regional specificity based on adaptation to prevailing agroclimatic conditions.

Pulses as a group can utilise limited soil moisture and nutrients more efficiently than cereal crops and for that reason farmers have chosen them to grow under highly adverse conditions. The process of differential resource allocation to pulse crops operates at agro-ecological niche allocation and at individual farmers level, out of necessity, and not out of choice or preference.

At present more than 92 per cent of the area under pulses is confined to unirrigated areas, and in future the bulk of pulse production will continue to come from unirrigated areas. Therefore, any plan for increasing pulse production in the country should be based on a long-term approach for improv[illegible] productivity of these crops under rainfed farming conditions rather than on the use of high inputs.

Crop productivity comparisons made under unirrigated conditions between pulses and cereals do not support the general belief that pulses suffer from inherent low productivity. Rather the low productivity of pulses is due to the low input conditions associated with the complex socio-economic and agroclimatic problems of rainfed agriculture.

Long neglect of rainfed areas has resulted in poor institutional development and, therefore, there is considerable lag in developing strong traditions of scientific thinking and research, and training of scientists to work in these areas.

This para deals in detail with agroclimatic, socio-economic and biological constraints of pulse production and gaps in transfer of technology in rainfed areas.

I

Introduction

PRODUCTION of pulses in India has remained static for over two decades. With increasing population this has resulted in a sharp decline in the per capita availability of pulses in contrast with cereals. In the past pulses received little attention in terms of re[illegible]rch and development efforts [illegible]arma and Mehra, 1981] since major emphasis was laid on cereals which are a staple food and constitute 70 per cent of the food requirement of the people. However, with improved cereal supply, increase in pulse production is being emphasised.

Outstanding success in the production of wheat and rice, based on (1) development of fertiliser responsive, high yielding varieties, (2) water management and application of high doses of fertiliser, (3) pest and disease control, is proposed also as the model for research and development goals in pulses. This is evident from the fact that more often than not one hears that low yields of pulses are because these energy rich crops are grown under the conditions of energy deprivation "low input management" [Swaminathan, 1981 and Jeswani and Saini, 1981] and proposed development measures lay heavy emphasis on increasing the area of pulses in command areas under irrigated agriculture. The approach may appear logical in terms of high assured dividends on inputs under irrigated conditions but hardly scratches the surface of the problem because at present more than 92 per cent of the area under pulses cultivation is confined to unirrigated lands. In the foreseeable future this situation is unlikely to change and the bulk of pulse production will continue to come from unirrigated areas. Therefore, any attempt to increase pulse production in the country should have a definite long term approach for improved productivity of these crops under rainfed conditions. This would help the small farmer of semi-arid area and would not further accentuate the social and economic imbalances caused by the wheat revolution in irrigated areas [Hanumantha Rao, 1975]. This presentation deals with the constraints to and opportunities for pulse production in the semi-arid regions of India.

Pulses as a group can utilise limited soil moisture and (nutrients), more efficiently than cereal crops and mainly for this reason these crops are grown in areas left after satisfying the demand for cereals, since in such conditions pulses with whatever yield levels give better returns. This is their strength not weakness for which farmer has chosen pulses to grow under highly adverse conditions. This process of differential resource allocation to pulse crops operates at agro-ecological niche allocation and at individual farmers level out of necessity and not out of choice or preference.

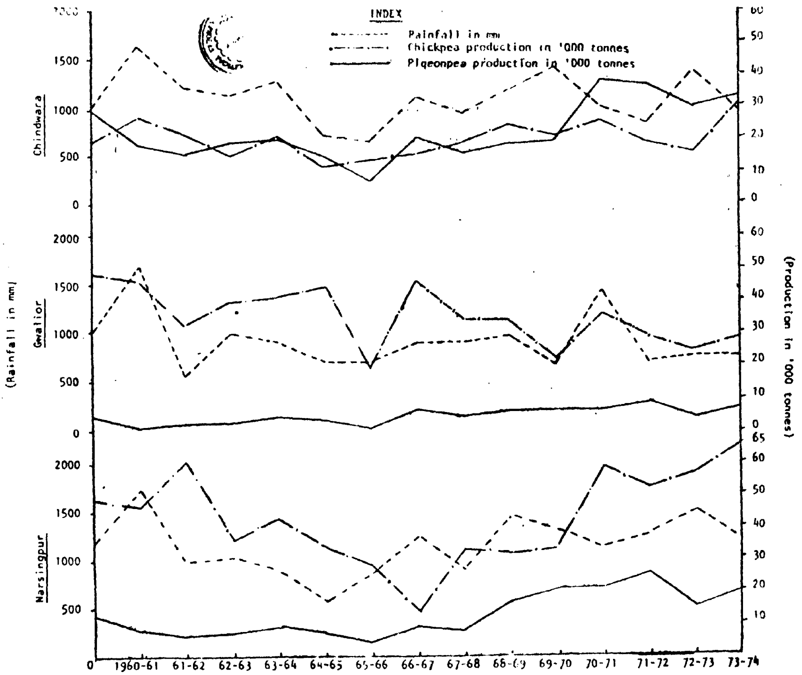
Growing aeson on soil moisture availability in different soil types and under different cropping systems varies a great deal in rain-fed areas. Different species of pulses with maturity ranging from 65 to 300 days can easily be adapted to specific situations and provide sufficient flexibility of choice in farming systems. Area and production of pulse crops in different states indicates their relative importance in a particular region and their contribution towards the total pulse production (Table 1).

II

Constraints to Production in Semi-Arid Areas

Table 1 shows that the states of Bihar, Uttar Pradesh, Madhya Pradesh, Punjab, Haryana, Maharashtra, Rajasthan, Gujarat, Andhra Pradesh, Karnataka and Tamil Nadu between lat 10°N to 30°N contribute 86 per cent

FIGURE 1



of total pulse production. These vast areas have a wide range of agro-climatic conditions which are best utilised by growing a specific pulse crop. Consideration of a particular crop in a location specific situation can be done best at the individual state level. Pigeonpeas and chickpeas, which occupy 47.1 per cent of the pulse area and contribute 61.7 per cent of the pulse production deserve special attention. Therefore, an attempt is being made to identify the constraints of production particularly of these crops at agroclimatic, biological and socio-economic levels.

AGROCLIMATIC CONSTRAINTS

Pigeonpeas are planted with the onset of rains and make most of their vegetative growth under more than adequate soil moisture conditions but depend heavily on residual soil moisture during dry winter months, when flowering and grain formation occur.

In contrast chickpeas are grown on residual receding soil moisture in post rainy season and therefore, soil moisture is the critical factor in chickpea production from the very beginning of plant establishment to grain development and maturity.

Soil moisture dependent productivity of these crops is reflected by the relationship between the average annual rainfall and production (Fig 1).

(i) Pigeonpea

Reddy and Virmani [1981] have analysed the characteristics of rainfall of the pigeonpea growing areas and have observed the following salient features:

(1) Pigeonpea growing areas are located between 600 to 1,400 mm mean annual rainfall.

(2) The mean rainfall for pigeonpea growing areas in Maharashtra, Andhra Pradesh and Karnataka is around 662 mm, while in rest of pigeonpea growing areas it is over 900 mm.

(3) In higher rainfall areas rainy days are more than 50, while other areas have 40 rainy days. Bulk of the total rainfall (80-90 per cent) is received during the rainy season from June to October.

(4) The coefficient of variation of the annual rainfall is 20 to 35 per cent. This means that the amount of annual rainfall and number of rainy days vary widely from year to year.

(5) Generally the pigeonpea growing areas in Maharashtra, Karnataka and Andhra Pradesh have inadequate rainfall in relation to potential evapotranspiration demands.

Soil type: Availability of adequate soil moisture for crop growth depends not only on the amount and distribution of rainfall but also on the water holding capacity of the soil and soil depth.

Major pigeonpea growing areas are confined to Indogangetic alluvium and deep vertisols. However, growing of pigeonpeas on light loams and alfisols is not uncommon particularly in southern Madhya Pradesh, Maharashtra, Andhra Pradesh and Karnataka.

On shallow light loam and alfisols in general residual soil moisture becomes a limiting factor in the post rainy season when the crop is in the

TABLE 1: RELATIVE SHARE OF INDIVIDUAL PULSE CROPS IN AREA OF TOTAL PULSES IN INDIA (AVERAGE 1969-72)

Crop	Per Cent Share in Area	Per Cent Share of Area and Production of Major Pulse Growing Regions
Chickpea	36.5	Uttar Pradesh (27/31), Madhya Pradesh (21/17), Punjab-Haryana (19/23), Rajasthan (19/18).
Khesari	7.6	Bihar (42/48), Madhya Pradesh (40/36), West Bengal (11/13)
Lentil (Masur)	3.3	Madhya Pradesh (38/30), Uttar Pradesh (25/30), Bihar (19/22)
Pea	4.1	Uttar Pradesh (82/92), Madhya Pradesh (9/3), Bihar (7/5)
Total rabi pulses	51.5	
Pigeonpea	10.6	Maharashtra (23/16), Uttar Pradesh (22/36), Madhya Pradesh (19/21), Karnataka (12/9), Andhra Pradesh (8/3), Bihar (6/7)
Blackgram (Urad)	8.1	Madhya Pradesh (30/27), Maharashtra (22/18), W. Bengal (12/12), Andhra Pradesh (9/9), Uttar Pradesh (8/8)
Greengram (Mung)	7.7	Andhra Pradesh (26/21), Maharashtra (26/21), Rajasthan (11/16), Madhya Pradesh (11/14).
Moth Beans (Moth)	7.9	Rajasthan (99/99), Uttar Pradesh (1/1).
Horsegram (Kulthi)	7.7	Karnataka (31/38), Andhra Pradesh (27/18), Maharashtra (15/15), Tamil Nadu (14/12), Madhya Pradesh (12/13)
Total Kharif pulses	42.0	
Other pulses	6.5	
Total	100.0	

Source : Table prepared from data reported in Chopra and Swamy (1975).

Note : Figures in parentheses indicate per cent share in area/per cent share in production by the state to total area and production in India.

critical phase of grain formation and development.

In deep vertisols and in Indogangetic alluviam region intermittent waterlogging during monsoon has adverse effect on crop growth.

The problem of moisture stress in post rainy season on soils with poor water holding capacity has been tackled to some extent by selecting early maturing varieties to fit the length of growing season. However, little has been done to adopt the technology which can solve the problem of excess water during monsoon, particularly in areas with deep vertisols. High rainfall areas (1000 mm and above) having deep vertisols in central Madhya Pradesh can be exploited for pigeonpea production with advantage if land and water management techniques suited to drain excess water are adopted.

Temperature: During the rainy season, minimum and maximum temperatures in pigeonpea growing areas range between 21.2 to 33.3°C, while average temperature range is between 25.6 and 29.6°C. In the post rainy season, in parts of Bihar, Uttar Pradesh and northern Madhya Pradesh night temperatures drop to around 0°C and threaten the crop with frost damage.

(ii) Chickpeas

Chickpea production areas overlap a great deal with those of pigeonpea and therefore share common agroclimatic features. As discussed earlier, receding soil moisture is a limiting factor in the productivity of chickpeas throughout the chickpea growing areas but is becomes much more important in areas of southern Madhya Pradesh, Maharashtra, Gujarat, Karnataka and Andhra Pradesh, where winter is short and comparatively warmer and potential evaporation is far in excess of annual rainfall.

During late December to early February occurrence of frost in areas above 20°N lat is a serious threat to the chickpea crop. Damage is severe if the occurrence of frost coincides with early pod development stage. Since, there are varietal differences for tolerance to frost, damage by frost can be minimised by selecting tolerant varieties.

Well drained clay loams with adequate soil moisture are best for getting good chickpea yields. However, the crop is grown on the moderately heavy grey and brown alluvial soils of the upper Gangetic basin and on the black cotton soils in central Madhya Pradesh, Maharashtra, Andhra Pradesh and Karnataka. Production is greatly reduced on saline and alkaline soils. Differences in tolerance to these adverse soil conditions have been observed in chickpea germplasm.

SOCIO-ECONOMIC ASPECTS OF PULSE PRODUCTION

(i) Structure of pulse production in the country and its implications

Table 2 shows that over the period of 24 years the share of pulses in the area and production of food grains has declined. The data given in Tables 3 to 5 show that the decline in chickpea area and production off-set the slight increase in the area and production of other pulses. As can be seen from Table 4 the drastic decline in chickpea area took place in major chickpea growing states of Uttar Pradesh, Punjab, Haryana and Bihar. There is a strong indication of shift of chickpea towards dry and unirrigated areas like Rajasthan and Madhya Pradesh. Similar trends can be observed for pigeonpea (Table 3).

Position of pigeonpea, chickpea and other pulses given in Tables 3, 4 and 5 also shows that major pulse production is being concentrated in the states of Madhya Pradesh, Maharashtra and Rajasthan on unirrigated lands.

High degree of diversity: Pulse production in India is characterised by a very high degree of diversity as indicated both by the number of crops and their spatial distribution into varied agroclimatic conditions. As shown in Table 1, there are nine major pulse crops and every one of them, except three, occupies broadly equal proportions of the area allocated to pulses. Furthermore, most of these crops are region specific in the sense that a single state or a cluster of a few states account for the bulk of the area (and the production) of a specific pulse crop. Pulses such as moth, pea, lentil, khesari and even chickpea indicate their regional distribution pattern.

This diversity has several implications. In the first place it puts serious limits to single pulse-based growth strategies for promotion of pulse production in the whole country. It would appear that there is a great need for diversified and regionally oriented focus to pulse development programmes. However, in view of the meagre resources available to pulses as a group, this diversified approach may mean spreading the resources too thinly and in turn making the effort inconsequential. This dilemma, may partly explain the

TABLE 2: SOME INDICATORS OF CHANGING PLACE OF PULSES IN INDIAN AGRICULTURE

Particulars	Relative Position of Different Pulses during Two Periods, I-1954-55 to 1956-57 and II-1975-76 to 1977-78							
	Chickpea in Period		Pigeonpea in Period		Other Pulses Period		Total Pulses in Period	
	I	II	I	II	I	II	I	II
Share in gross cropped area (%)	6.8	4.8	1.6	1.5	7.2	7.6	15.6	13.9
Share in total area of food grains (%)	8.7	6.4	2.1	2.1	9.3	10.2	20.1	18.7
Share in total food grain production (%)	8.4	4.6	2.7	1.6	4.0	3.9	15.7	10.1
Share in total area of pulses (%)	43.3	34.2	10.5	11.1	46.1	54.7	100.0	100.0
Share in total production of pulses (%)	53.4	45.9	17.2	15.8	29.4	38.2	100.0	100.0
Index of area (1954-57=100)	100.0	84.6	100.0	112.6	100.0	127.0	100.0	107.1
Index of production (1954-57=100)	100.0	96.8	100.0	103.3	100.0	146.3	100.0	112.5

Source : "Estimates of Area and Production of Principal Crops in India", reports of Directorate of Economics and Statistics, Ministry of Agriculture, Government of India. Various years.

TABLE 3: POSITION OF PIGEONPEA IN IMPORTANT PIGEONPEA GROWING STATES IN INDIA, DURING PERIOD I, 1954-55 TO 1956-57 AND PERIOD II, 1975-76 TO 1977-78

State	Per Cent Share of P'pea in GCA* of State in Period		Per Cent Share of State in India's Pigeonpea				Per Cent Change Period II over Perio I in Pigeonpea	
			Area		Production			
	I	II	I	II	I	II	Area	Production
Andhra Pradesh	1.3	1.6	6.8	7.6	2.4	1.7	25.8	3.3
Bihar	1.5	0.9	6.5	3.8	4.0	3.5	--36.0	--9.1
Karnataka	2.6	2.9	11.7	11.9	4.8	9.3	12.2	100.9
Madhya Pradesh	2.2	2.4	16.7	19.3	15.8	18.5	30.0	20.8
Maharashtra	2.2	3.3	22.9	24.8	21.4	18.5	21.9	--12.1
Uttar Pradesh	3.0	2.3	27.2	20.1	46.3	39.6	--17.0	—11.6
India	1.6	1.5	—	—	—	--	12.6	3.3

Source : "Estimates of Area and Production of Principal Crops in India", various years.

Note : Punjab, Haryana, and Rajasthan have been excluded from this table as they do not devote even 1 per cent their Gross Cropped Area to Pigeonpeas.

* Gross Cropped Area.

absence of any major thrust in research on pulses, which in turn is partly responsible for their stagnation.

Dominance of single crop and crop zone: The structure of pulse production is also characterised by the dominance of one crop, *viz*, chickpea, which accounts for more than one-third of total pulse area in India. The prospects of dominant crop or crop growing area passing through adverse circumstances for pulses can significantly reduce the area and production of pulses in total. The decline of chickpea in particular and pigeonpea and other crops in major pulse growing states like Uttar Pradesh, Punjab, Haryana and Bihar clearly supports this possibility.

Seasonal distribution of pulses: More than 51 per cent of the pulse area is planted in the post rainy season, largely on residual soil moisture. As mentioned earlier, because of their capacity to withstand adverse soil moisture conditions, these crops are the crops of the poor resource base of unirrigated areas. Any improvement in resource base, e g, through provision of irrigation, pulses out the pulses.

This clearly shows that the present structure of pulse production and its consequences in terms of growth or stagnation are the outcome of the basic constraints of agroclimatic factors.

(ii) Socio-economic constraints

The socio-economic constraints of pulses largely emerge from the interaction of the features of agroclimatic factors, farming systems and the characteristics of the pulse crops themselves. Pulses not only constitute an important component of the food chain of self-provisioning farmers, but they offer important and low cost options for the purposes of fertility management (through cereal legume rotation or intercropping), risk diffusion (through intercropping and crop diversification) and utilisation of dificient land resource base (through putting pulse in soil moisture conditions not suited to any other crops).

However, despite their important functions, pulses have only subsidiary status in the total farming systems of peasants. The subsidiary status of the pulses in traditional farming systems is reflected through the pattern of resource allocation to these crops.

There are several reasons for the subsidiary status of pulses:

(1) Cereals are the main staple food of the farmers, they get priority over pulses.

(2) Pulses are not considered [illegible] major cash crops because more than 50 per cent of the production is consumed at the farmer's family level and hence have lower priority than other traditional cash crops.

(3) Pulses by their very nature are capable of making use of a deficient resource base, therefore they are allocated to poor resources base.

(4) Low stability of production as compared to cereals due to number of diseases and insect pests.

(5) Poor keeping quality in storage and highly fluctuating post-harvest prices and other associated problems of local level marketing.

Table 6 summarised the details of pulses in the traditional farming systems. The farm level data from two villages, each in three agroclimatic

TABLE 4: POSITION OF CHICKPEA IN IMPORTANT CHICKPEA GROWING STATES IN INDIA DURING PERIOD I, 1954-55 TO 1956-57 AND PERIOD II, 1975-76 TO 1977-78

State	Per Cent Share of Chickpea in Gross Cropped Area of State		Per Cent Share of State in India's Chickpea				Per Cent Change in Period II over Period I in Chickpea	
			Area		Production			
	I	II	I	II	I	II	Area	Production
Andhra Pradesh	1.0	0.6	1.3	0.9	0.7	0.5	–38.6	–29.6
Bihar	5.2	2.0	5.4	2.9	3.6	2.4	–55.3	–35.5
Karnataka	1.6	1.6	1.7	2.2	0.9	1.2	7.9	26.4
Madhya Pradesh	8.4	9.0	15.3	23.5	15.0	19.0	31.7	23.2
Maharashtra	2.2	2.3	4.9	5.6	3.0	2.8	– 3.0	– 9.2
Punjab-Haryana	26.3	12.4	25.7	18.0	30.9	22.2	–40.8	–30.6
Rajasthan	10.6	11.0	14.1	23.0	14.6	26.0	38.1	71.9
Uttar Pradesh	12.4	7.2	27.4	20.8	27.8	22.8	–35.9	–20.4
India	6.8	4.8					–15.5	– 3.2

Source : "Estimates of Area and Production of Principal Crops in India", various years.

Note : Gross cropped area of the country as a whole has increased by more than 20 per cent during this period. The same has increased by 22 and 34 per cent in states of Madhya Pradesh and Rajasthan.

TABLE 5: POSITION OF OTHER PULSES (OTHER THAN CHICKPEA AND PIGEONPEA) IN THE MAJOR PULSE GROWING STATES IN INDIA DURING PERIOD I (1954-55 TO 1956-57) AND II (1975-76 TO 1977-78)

State	Per Cent Share of Other Pulses in GCA* of State in Period		Per Cent Share of State in India's Other Pulses				Per Cent Change in Period II over Period I in Other Pulses	
			Area		Production			
	I	II	I	II	I	II	Area	Production
Andhra Pradesh	8.4	8.6	10.2	8.3	6.3	6.7	3.8	53.6
Bihar	12.7	10.0	12.3	8.8	11.8	11.5	–9.0	42.2
Karnataka	8.4	7.4	8.6	6.1	7.5	6.0	–8.9	16.5
Madhya Pradesh	9.7	10.9	16.7	17.9	14.5	16.2	36.7	62.9
Maharashtra	2.8	8.8	7.9	13.5	7.2	11.8	118.5	138.6
Punjab-Haryana	2.9	1.0	2.7	0.9	24.0	1.3	–57.9	–21.0
Rajasthan	12.8	13.8	16.0	18.2	10.0	12.3	44.3	81.4
Uttar Pradesh	5.6	3.7	11.6	6.6	21.1	11.6	–27.2	16.5
India	18.0	7.6	—	—	—	—	27.0	46.3

Source : "Estimates of Area and Production of Principal Crops in India", various years.
Note : * Gross Cropped Area.

zones within peninsular India, collected by ICRISAT since 1975 have been presented to illustrate the status of pulses in farmers' fields.

BIOLOGICAL CONSTRAINTS

(i) Physiological limitations

(a) **Photosynthetic efficiency and crop productivity.** There is a general feeling that pulses suffer from inherently low yield potential and are a physiologically inefficient group of plants compared to C_4 cereals such as sorghum and maize [Swaminathan, 1972; Jeswani and Saini, 1981]. However, Good and Duncan [1980], reviewing the comparative advantages of C_4 and C_3 groups of plants, argued that C_3 and C_4 plants seem to compete on fairly even terms in hot dry environments and the fact that C_3 plants usually do better in cool climates, suggests that C_3 plants have their own advantages. They concluded that "we need a much greater understanding of the functions of C_3 and C_4 plants and the nature of photo-respiration, which may be a good thing under some conditions, before we can contemplate changing the efficiency of the CO_2 fixing reaction by plant breeding". Moreover, there is no evidence to show that pulses have lower photosynthetic rate than the C_3 cereals, *viz.* wheat and barely [Sinha, 1977], where major breakthroughs in yields have been demonstrated. There is considerable variation between varieties of pulse crops in photosynthetic rate but these differences have not been shown to be associated with differences in yield.

Crop productivity comparisons are relevant only if they are made with reference to the growing conditions of the crops being compared. Pigeonpea and chickpea yields in the districts of important pulse growing states, where most of the area is rainfed, are comparable with wheat (Table 7). Also the data given in Table 8 show that average yield of pigeonpea in different districts of the country ranges from 51 to 2,924 kg/ha. The wide range in average yield of the districts indicates that pigeonpea is grown in highly diverse agroclimatic conditions, soil types and cropping systems. Nevertheless, the fact that 38 of 56 districts of Uttar Pradesh average over 1,000 kg/ha and state average is around 1,400 kg/ha clearly shows that the yield potential of the crop is not inferior to any cereal crop under rainfed conditions (Table 7 and 8).

A somewhat similar situation emerges in chickpea, where average district yield ranges between 150 and 1,880 kg/ha and average yield in several districts is over 1,000 kg/ha (Table 9). Moreover chickpea yield of 3,000-4,000 kg/ha are not uncommon from large experimental plots given 2-3 irrigation (ICRISAT Annual Report, 1978-79). An even higher yield level of 4,625 kg/ha has been reported from Pantnagar University (Report of 2nd International Chickpea Nursery, 1976-77, ICRISAT).

Yield levels in short duration pulses such as mung bean, urd beans, cowpea and lentil, repored from the trials in All-India Co-ordinated Pulse Improvement Programme (AICPIP) are around 2,000 kg/ha and above (Table 10). Considering the short duration of the crops, these yield levels are also not low in comparison to cereals grown under rainfed conditions.

(b) Problem of Flower drop: Pulses in general have a high rate of flower drop or abortion. In pigeonpeas over 80 per cent of the flowers produced on a plant are shed and often the suggestion has been made that pigeonpea yields can be increased substantially by controlling this phenomenon either by breeding lines which retain a large proportion of flowers producing pods or through physiological manipulations, such as spray of hormones which reduce flower drop.

Physiological studies at ICRISAT, involving removal of flowers and young pods of pigeonpea, have shown that plants compensate for the loss of flowers and young pods by setting pods from later formed flowers, which otherwise would have dropped [Sheldrake *et al* 1979a]. This compensatory mechanism provides substantial plasticity of adaptation to intermittent adverse conditions such as moisture stress or insect attack

TABLE 6: SOME DETAILS OF PULSES AT FARM LEVEL IN THREE SEMI-ARID TROPICAL REGIONS OF INDIA

Details	Akola (Maharashtra)	Sholapur (Maharashtra)	Managubnagar (AP)
Per cent share of pulses in GCA*	4.8	18.2	1.5
Per cent area of intercrops involving pulses	81.7	50.3	64.4
Per cent of pulse crop irrigated	15.0	5.9	—
Per cent plot where crop rotation involved pulses/pulses mixture	79.2	71.3	69.5
Per cent of pulse plots with deep and medium deep soils	65.2	32.2	17.0
Per cent of pulse plots with shallow and poor soil	34.8	57.8	83.0
Per cent of pulses marketed (pigeonpea only)	41.6	49.9	9.2

Source : ICRISAT Village Level Studies [Jodha *et al*, 1977]
Note : *Gross Cropped Area when pulse is grown as sole crop or as a main crop in the intercrop.

TABLE 7: AVERAGE YIELD OF WHEAT, CHICKPEA AND PIGEONPEA IN SOME DISTRICTS OF UP, MP AND MAHARASHTRA

State	District	Average Yield (kg/ha)		
		Wheat*	Chickpea	Pigeonpea
Uttar Pradesh	Agra	2327	1039	2355
	Allahabad	1434	874	2558
	Banda	946	762	1651
	Hamirpur	1085	533	1196
	Jalon	1431	615	1985
	Kanpur	2013	978	2059
	Mainpuri	1809	1101	2924
Madhya Pradesh	Hosangabad	736	525	1030
	Jabalpur	691	507	929
	Narsingpur	1092	636	1046
	Sagar	837	676	667
Maharashtra	Akola	608	246	577
	Osmanabad	761	411	429
	Parbhani	903	303	695
	Pune	1065	338	746
	Wardha	804	157	1044

Source : Agricultural Situation in India, August 1980.
Note : *Include yield from irrigated as well as rainfed areas.

vhich are common in warm-rainfed reas of central and peninsular India.

Also investigations on the effect of hading and partial and complete deoliation of pigeonpea plants have shown hat pod set is related to available ssimilate supply within the plant. 'here appears to be a built-in threhold or pod set, which results in setting ewer pods than the plants are capable f filling. The tendency of withholding art of the assimilate in its woody stem s reserve seems to be related with he perennial nature of pigeonpeas. laximum utilisation of assimilates in lling the available sink of a large umber of flowers may be possible only f an annual pigeonpea type is developd [Sheldrake and Narayanan, 1979]. Unortunately, there is no natural variaility for this character in available igeonpea germplasm.

High temperatures and limitations of soil moisture greatly increase flower abortion and drop in chickpea and pigeonpea respectively. Therefore, these are major factors for reducing yields in dry warm areas, where temperature and soil moistue conditions are often not favourable towards the end of the season and even if good plant growth is obtained grain yields are poor.

In other pulses the degree of compensation for loss of early formed flowers is limited by their short duration, during which the plant has to complete its life cycle.

A number of trials on chickpea and pigeonpea in the AICPIP over several years have shown no consistent benefit of hormonal sprays in increasing flower retention and thereby grain yield.

(c) Response to irrigation and fertiliser application: The question of lack of response to irrigation in pulses is always viewed against the background of wheat and rice, where yield responses to irrigation, in association with high doses of fertiliser, are dramatic. Experimental results clearly show that chickpea and pigeonpea give increased yield if receding soil moisture is judiciously supplemented by irrigation.

At ICRISAT Centre, grain yield increased in response to irrigation by nearly 50 per cent in sole pigeonpea and was more than doubled in intercropped pigeonpea with two irrigations given at vegetative and flowering stage after the harvest of the cereal crop (Table 11). The winter rainfall during this year was only 7 mm. In another year during which the winter rainfall was 160 mm, little or no response to irrigation was observed. In both years the soil profile was full of water at the time when the cereal crop was harvested.

In areas where the temperature and evaporation are high and precipitation low during the growing season (ICRISAT Centre) large responses to irrigation in grain yield of chickpea have also been obtained (Table 11). Similar responses have been observed at other places such as Jaikwadi and Purna Command Area Projects (Maharashtra, Karnataka). However, in northern parts of India where temperatures and evaporation are low with good amount of winter rainfall, responses to irrigation have not been very large. Saxena and Yadav [1975] have reported response to one irrigation at flowering on sandy and loamy soils with low water holding capacity and a negative response on very heavy soil.

Since pulses have evolved towards efficient use of atmospheric nitrogen through fixation by soil rhizobia in root nodules, supply of high doses of nitrogen by application of chemical fertilisers puts the plants inherent system to disuse. This results in substitution of the nitrogen supply source, rather than supplementation and hence the net result is a small response to added nitrogen.

As such, it is an excellent system of biological recycling of chemical nutrients and replenishing soil fertility under low input conditions. In the light of foreseable world energy crisis, major emphasis should be placed on making the natural nitrogen fixing system more efficient than replacing it by systems responding to chemically applied nitrogen.

In the absence of significant and consistent responses to soil application of N fertiliser, attempts have been made to supplement N and P supply

TABLE 8: PRODUCTION LEVELS OF PIGEONPEA IN DIFFERENT STATES OF INDIA, 1978-79 SEASON

Sl No	State	Area 1000 ha	Average Yield kg/ha	Highest District Average Yield kg/ha	Lowest District Average Yield kg/ha	No of Districts with over 1000 kg/ha
1	Andhra Pradesh	204.9	216	430	126	0/21
2	Assam	6.4	702	800	648	0/10
3	Bihar	88.8	646	1196	300	1/31
4	Gujarat	131.5	566	1000	560	1/13
5	Haryana	7.4	1044	1750	545	2/4
6	Himachal Pradesh	0.2	565	NA	NA	NA
7	Karnataka	315.0	621	1069	263	2/18
8	Kerala	3.0	249	NA	NA	NA
9	Madhya Pradesb	487.1	646	1057	355	4/46
10	Maharashtra	675.8	591	1044	312	1/25
11	Meghalaya	0.2	591	NA	NA	NA
12	Orissa	69.8	546	800	385	0/13
13	Punjab	7.7	519	NA	NA	NA
14	Rajasthan	44.8	319	995	51	0/23
15	Tamil Nadu	105.6	460	816	197	0/13
16	Tripura	0.6	412	NA	NA	NA
[illegible]	Uttar Pradesh	499.0	1403	2924	489	38/56
18	West Bengal	12.7	661	1000	500	1/14
19	Dadra and Nagar Haveli	2.0	485	NA	NA	NA
		2662.5	719			

Note : NA=Not Available.

Source : *Agricultural Situation in India*, August 1980, Vol 35: 420-423.

TABLE 9: PRODUCTION LEVELS OF CHICKPEA IN DIFFERENT STATES OF INDIA, 1978-79 SEASON

Sl No	State	Area (1000 ha)	Average Yield (kg/ha)	Highest District Average Yield (kg/ha)	Lowest District Average Yield (kg/ha)	No of Districts with over 1000 kg/ha
1	Andhra Pradesh	63.3	302	500	150	0/19
2	Assam	3.2	471	520	400	0/10
3	Bihar	217.6	557	1880	279	4/31
4	Gujarat	66.0	894	1200	500	1/17
5	Haryana	1061.0	979	1159	739	4/11
6	Himachal Pradesh	36.6	682	NA	NA	NA
7	Jammu & Kashmir	4.4	597	685	208	0/4
8	Karnataka	178.7	415	600	238	0/18
9	Madhya Pradesh	1868.7	593	894	250	0/46
10	Maharashtra	406.2	342	425	157	0/24
11	Manipur	0.2	500	NA	NA	NA
12	Meghalaya	0.1	954	NA	NA	NA
13	Orissa	43.7	495	733	400	0/13
14	Punjab	349.0	808	1250	571	2/12
15	Rajasthan	1745.9	909	1293	309	5/26
16	Tamil Nadu	8.8	590	600	580	0/11
17	Tripura	0.4	342	NA	NA	NA
18	Uttar Pradesh	1659.7	762	1153	200	12/55
19	West Bengal	100.6	649	1000	424	1/12
20	Delhi	3.3	848	NA	NA	NA
		7871.4	741			

Note : NA=Not Available.

Source : *Agricultural Situation in India*, August 1980, Vol 35 : 416-419.

by application of urea and Diammonium phosphate by foliar sprays at the critical stages of grain filling when rhizobial activity seem to decline. However, the results are inconsistent [Saxena and Yadav, 1975: and Saxena, 1982] and do not provide high optimism for increasing production on large scale in farmer's fields.

Phosphate requirements of chickpea and pigeonpea, are low, ranging between 8 to 20 P/ha [Saxena and Sheldrake, 1980; and Sheldrake and Narayanan, 1979b] and response to applied P is limited to soils extremely poor in phosphate and to North Indian locations [Saxena and Yadav, 1975].

(d) Response to Rhizobium inoculation: Rhizobium inoculation of legume crops has long been considered an important factor for increasing yield and is receiving emphasis in the Government of India's strategy for increasing production levels of pulse crops. Consequently, many microbiological laboratories have started producing Rhyzobium culture and substantial funds are being provided to developmental agencies for transport and distribution of the culture. However, experimental results do not indicate clear cut increase in pulse yield by Rhizobium inoculation. The situation can be conveniently summarised as follows:

(1) Responses to rhizobial inoculation have been inconsistent from experiment to experiment and from location to location, both in case of pigeonpea and chickpea [Saxena and Yadav, 1975; ICRISAT Annual Report, 1979-80].

(2) Considerable variation in the efficiency of rhizobial strains has been observed for both chickpea and pigeonpea rhizobia.

(3) Inoculants produced are mostly of poor quality in terms of sufficient number of viable rhizobia. Often storage and transport of inoculant under ambient conditions are thought to adversely affect the number of viable rhizobia. However, a study at ICRISAT has shown that there is no change in chickpea rhizobia number in sterile pea. base inoculant upto 15 weeks during storage and transport under ambient temperature conditions [Rupela, pers comm].

(4) In chickpea, response to inoculation is limited to paddy-fallows and to fields with low numbers of chickpea rhizobia [Rupela and Dart, 1980, Thomson *et al*, 1982].

(5) Rhizobium inoculant applied on chickpea seed sown into residual moisture does not move to the root in the absence of irrigation water and therefore does not help in increasing nodulation even in soils with low rhizobial counts [Rupela, 1982 pers. comm].

In the light of the above facts there is a great need for careful study and application of various aspects of rhizobial inoculation in pulses grown in India for centuries.

(e) Plant type limitations: The concept of efficient plant type is relevant only in the context of the environment it exploits for its growth and economic production. As discussed at the beginning, pulses have to perform

TABLE 10: YIELD LEVELS OF DIFFERENT SHORT SEASON PULSES REPORTED IN TRIALS OF AICPIP, 1980-81

Sl No	Crop	Yield (kg/ha)	Location	State	Source
1	Mungbean	2485	Talod	Gujarat	AICPIP Report
		1938	Anand	Gujarat	
		1844	Akola	Maharashtra	
2	Urd bean				
		3188	Hissar	Haryana	
		2011	Pantnagar	UP	AICPIP Report
		2003	Anand	Gujarat	
		1829	Warangal	AP	
		1642	Akola	Maharashtra	
3	Cowpea				
		2170	Gurdaspur	Punjab	AICPIP Report
		2064	S K Nagar	Gujarat	
		1859	Bangalore	Karnataka	
		1877	Vamban	Tamil Nadu	
4	Lentil				
		2546-2911	Jabalpur	MP	JNKVV Pulse Imp Report
		1944	Ludhiana	Punjab	PAU Pulse Imp Report
		1894	Fardkot	Punjab	
		1680	Kanpur	UP	CSA University Pulse Imp Report

TABLE 11: RESPONSE TO IRRIGATION INGRAIN YIELD (KG/HA) IN CHICKPEA [SAXENA, N P, AND SARDAR SINGH, UNPUBLISHED DATA] AND PIGEONPEA [SARDAR SINGH AND SHARMA D, UNPUBLISHED DATA] GROWN ON VERTISOL AT ICRISAT CENTRE, HYDERABAD

Treatment	Chickpea	Pigeonpea	
		Sole	Intercrop
Non-irrigated	1347	1270	810
Irrigated*	3042	1860	1660

*Chickpea : Four irrigations at 31, 43, 65 and 92 days after sowing
Pigeonpea : Two irrigations, one at vegetative (October) and another at flowering (December)

in a hostile environment (high temperature, limited soil moisture, low inputs, poor management and competition with companion crops, etc). The variation in these factors is so large from location to location that any specificity of environment and relevant plant type in a large group of pulses is a challenge to be met only by the slow natural process of adaptation. In the absence of adequate knowledge of the physiological processes affecting plant growth under the infinite permutations and combinations of agro-ecological situations in which pulses are grown, any conscious effort to develop a specific type is as risky as the vulnerability of genetic uniformity of a monoculture over a vast area. The approach of developing a plant type is relevant to irrigated agriculture, where control of the environmental factor soil moisture results in a common system or factors of production applicable over a large area.

In recent years considerable emphasis has been placed on the development of short-statured, determinate, very early pigeonpea types and tall erect non-lodging chickpea for irrigated areas. Early duration pigeonpeas which fit the multiple cropping systems of irrigated areas, have proved useful. However, the productivity of the tall-erect type chickpea does not appear to be better than the conventional spreading types [Table 12 — Singh, 1981 Saxena; 1982, pers comm].

In dryland agriculture the following characteristics seem to have advantage in the adapted pulse varieties.

(1) Ability to recover from intermittent soil moisture stress or excessive rains or damage caused by insect pests.
(2) Duration fitting the soil moisture availability as defined by evapotranspirational demand.

The comparatively long growth period and woody perennial nature of pigeonpea ensures recovery from intermittent soil stress, while production of a large number of flowers over a prolonged period found in most pulses provides a mechanism to escape the peak period of insect incidence and allows the plant to produce some grain.

Non-synchronous flowering in pulses is considered inconvenient and impractical for effective control of insect pests through insecticide spray. However, it needs onsideration in the light of technological and economic developments likely to take place in the near future, which would determine whether large scale plant protection measures are feasible in SAT areas. It may be cautioned here that synchronous varieties are likely to fail without insect protection or if flowering coincides with the highly unpredictable soil moisture stress periods.

Besides the extra cost involved, the problems of environmental pollution and ecological balance need to be kept in mind before one opts for the strategy of production based on total protection by insecticide spray.

(f) Problem of low harvest index: Pulse crops in general have poor harvest indices (Table 13). Improvement in the harvest index of cereal crops in recent years has resulted in very high yield levels. However, it may be noted here that the advantage of high harvest index in cereal crops has been realised only under assured moisture supply conditions.

Studies in chickpeas have shown considerable variation in harvest index and Virmani et al (1973) have shown that selection for harvest index can result in increased yield. However, in diverse environments (Hissar and Hyderabad) Saxena and Sheldrake [1980] observed that higher harvest indices are not always associated with high yields. Both in chickpea and pigeonpea, harvest indices are strongly influenced by growth duration of the cultivars. However, irrespective of harvest index, the cultivar duration best suited to the soil moisture environment gives the highest yield. For example, at Hyderabad medium duration pigeonpeas having low harvest index give higher yields than early and late pigeonpea types. On the other hand, at Hyderabad, early duration chickpeas having high harvest indices give higher yields than the late types with lower harvest indices while the reverse is true at Hissar.

Early varieties of pigeonpeas, which are grown on assured moisture supply in low rainfall areas of north India, have higher harvest indices than the medium and late types suited to rainfed conditions of central and peninsular zones and the north plain zones respectively. Among the varieties within a particular maturity group there is little genetic variation in harvest index.

Agronomic manipulation by late planting in the months having short days reduces the vegetative period and results in increased harvest index

TABLE 12: MEAN GRAIN YIELD (AVERAGE OF NORMAL AND HIGH PLANT DENSITY) OF TALL, INTERMEDIATE AND CONVENTIONAL (SPREADING) CHICKPEA TYPES

Plant Type	Aleppo, Syria*	ICRISAT, India**
Conventional (Spreading)	2340	2313
Intermediate	1933	2048
Tall erect	1988	1744

Note: * Singh, 1981: and
** Saxena, 1982

TABLE 13: HARVEST INDICES IN PULSES

Crop		Harvest Index (Per cent)	Source
Chickpea	Hyderabad	40-60	Saxena (1982)
	Hissar	35-40	
Pigeonpea	Early	25-35	
	Medium	20-25	
	Late	16-22	
Mung	—	20-25	Sinha (1977)

Note : These estimates do not account for leaf loss during growth.

However, delayed rabi plantings of medium and late duration pigeonpea ypes on residual soil moisture have nvariably given lower yields and are ikely to suffer from moisture stress because of limited root growth. Kharif crops of mung beans and urd beans, which have assured moisture supply and a defined short growth period, are ikely to have better yield potential f varieties with an improved harvest ndex are grown with apagronomy and particularly with appropriate plant density.

(ii) *Diseases*

Pulses suffer from a number of diseases. In the past little attention was given to disease pathogens and their distribution in different agro-ecological regions with the exception of chickpea and pigeonpea wilts. Development of pigeonpea varieties resistant to wilt started many years ago but on a very limited scale and therefore in farmers' fields pigeonpea wilt is a serious problem even today.

The problem of chickpea wilt eluded solution for a long time since more than one pathogen and also soil moisture conditions were associated in producing wilt symptoms which was popularly knon as "chickpea wilt complex." Recently Nene [1980] has elucidated the different components involved in wilt like disorders and established that *Fusarium oxysporum* Schlecht, emend inyd and Hans, is the case of chickpea wilt. Other fungi such as *Rhizoctoria bataticola* (Taub) Butler, *Fusarium solani* (Mark) Sacc and *Sclerotium rolfsii* Sacc, are associated with root rots. With the identification and definition of the symptoms of each of the disorders, it has been possible to identify sources of resistance to a particular pathogen and develop resistant varieties.

Ascochyta blight (*Ascochyta rabiei* (Pass) Lab) and Botrytis gray mold (*Botrytis cinerea* Pers ex Fr) are important diseases of chickpea in northern regions of the country.

Information on the incidence of different pulse diseases in the agro-ecological regions of the country is limited and scanty except in case of pigeonpea wilt and sterility mosaic disease (Fig 3).

The state-wise per cent incidence of wilt and sterility mosaic disease may appear low but individual field incidence varies between 0 and 100 per cent. This means total loss to certain farmers and varying degrees of yield loss over a large area.

In the past 3-4 years sterility mosaic has become a serious threat to pigeonpea production in Bihar, UP, and Tamil Nadu and requires immediate attention. Important diseases of other pulse crops are given in Table 14.

It may be pointed that considering the low resource base of the farmers in the SAT areas, built-in disease resistance for relevant diseases in pulse varieties would be the practical approach rather than control of diseases through fungicide treatment. The development of resistant varieties will be discussed separately.

(iii) *Insect pests*

A large number of insect species attack pulse crops at various stages of crop growth but pests attacking at the reproductive stage are of major economic importance. Among a number of pod-boring species *Heliothis armigera* (gram caterpiller) does the maximum damage of both chickpea and pigeonpea crops in central and peninsular regions, while damage by pod-fly (*Melanagromiza obtusa*), particularly in late maturity pigeonpea types, grown in UP, Bihar, where weather is relatively warm, application of insecticide spray or dust is essential to save the crop from pod borer damage which is needed to get reasonably good yield of pigeonpea and chickpea. At present one or two sprays of monocrotophos (45 per cent EC, 0.04 per cent) or endosulphan (35 per cent EC, 0.07 per cent) at flowering are recommended. However, dusting or spraying of DDT or BHC are the common insecticide treatments used by the farmers due to their lower cost.

Subsidies on insecticides and spray equipment emphasises the importance plant protection measures are receiving in the Government of India's pulse development programme. However, there has been little concern with the effects of heavy large scale insecticide sprays on the populations of predators and parasites of *H armigera*. Scientists at ICRISAT and several other research stations have identified a large number of parasites and predators which have considerable importance in influencing pod borer populations in existing farming systems [Bhatnagar and Davies, 1981]. The long term approach for controlling pod borer damage in chickpea and pigeonpea should certainly consider the effects large scale insecticidal spraying will have on such biological factors.

Work on host plant resistance and the development of varieties resistant to pod borer is in the preliminary stage. There are indications of substantial levels of resistance in desi chickpea type and lower levels in pigeonpeas. There is a long way to go before one can achieve reduced borer damage through the use of resistant varieties in farmers' fields.

Integrated pest management based on judicious insecticide use and biological pest control through appropriate cropping systems and use of varieties which are either less susceptible or escape damage, require emphasis.

In mung bean, urd bean and cowpeas stem fly is the major problem at the seedling stage while pod-boring insects cause considerable loss later. Insecticidal control has been recommended by AICPIP but is in limited use at the farmers level.

III

Research Results and Available Technology

DEVELOPMENT OF IMPROVED VARIETIES

Breeding programmes on pulses suffer from the fact that often a breeder is burdened with the problem of varietal improvement of a number of pulse crops and as a result he is not able to pay adequate attention to any particular crop.

Since plant breeding is a numbers game, success in developing improved

TABLE 14: IMPORTANT DISEASES OF MUNGBEAN, URD BEAN, COWPEA AND LENTIL.

Sl No	Crop	Diseases	States
1	Mungbean and	Mungbean yellow mosaic	Punjab, Haryana, UP, Bihar, Northern MP, Tamil Nadu, Karnataka
	Urd bean	Powdery mildew Cercospora leafspot	Maharashtra, MP, AP, Punjab, Haryana, TN, UP
	Cowpea	Mosaics powdery mildew bacterial blight root rot	
3	Lentil	Wilt rust blight	MP, UP, Punjab.

TABLE 15: CONTRIBUTION OF TEST ENTRIES FROM DIFFERENT REGIONS TO THE AICPIP TESTS, 1981-82

Crop/Test	Entries	Test Sites	Contributing Sites	Contributing States
Pigeonpea				
EACT	17	25	8	UP (3); Haryana (4); Delhi (2); Punjab (1); Maharashtra (2); ICRISAT (5)
ACT-1	9	29	5	UP (2); Maharashtra (3); T Nadu (1); ICRISAT (3)
ACT-2	16	26	8	Maharashtra (4); ICRISAT (6); UP (3); MP (1); AP (1); Karnataka (1)
Chickpea				
GIET	46	34	8	Punjab (6)· Haryana (6);Delhi (14); Rajasthan (7); Maharashtra (2); MP (1); ICRISAT (5)
GCVT	47	67	14	Punjab (6); Haryana (3); Delhi (15); Rajasthan (3); UP (2); MP (3); Maharashtra (1); Bihar (1); Karnataka (1); ICRISAT (4)
Cowpea				
CVT	14	21	5	Delhi (4); Rajasthan (4): Punjab (3); WB (1); Karnataka (2)
Mungbean				
MCVT	17	46	5	Punjab (8); Delhi (5); UP (2); Orissa (1); Maharashtra (1)
Urd bean				
UCVT	10	51	4	Punjab (6); UP (3); Haryana (1)

varieties depends on effective evaluation of a large number of diverse germplasm lines of the crop concerned and their utilisation in a fair size breeding programme. Except for a few institutions in the country facilities to achieve this are non-existent. This can be well inferred from the fact that there are no initial evaluation trials in any of the kharif pulse crops being tested in AICPIP, because the number of entries available for evaluation in any zone are so few that these can be easily accommodated in advanced uniform variety trials of the crops concerned. Further, the participation of the number of research stations in contributing test entries also reveals that only few stations have active breeding programme, while all others are just testing sites (Table 15).

In the past, pulses have received low priority in terms of financial allocation for research and developmental activity in comparison with cereal crops, which were in perpetual short supply and were the basic need. It was not until the Fourth Five-Year Plan that Rs 7.5 million were proposed for research on pulse crops [Sharma and Mehra, 1981]. Limited scope and opportunities in the field of pulse research in the past failed to attract good caliber plant breeders and other scientists. Therefore, there is a considerable lag in developing strong traditions of scientific thinking and research, and training of scientists, particularly in areas where rainfed farming is predominant. Table 15 shows the regional imbalance in terms of research output. Also it shows that area specific problems of rainfed agriculture in central and peninsular India are not being solved where the problem actually exists.

Nevertheless, a large number of varieties of different pulse crops have been identified and released at national and regional levels. Their impact on yield levels in the farmers' fields is difficult to assess and realise because till recently there has been no organised seed production and distribution system for the pulse crops. In recent years this has received attention and attempts are being made to produce a sufficient quantity of good seed of improved pulse varieties through National and State Seed Corporations.

The major problem of pulses seed production is the limited demand of any particular variety as varieties are adapted to specific agroclimatic regions. Such a potentially low seed demand structure is not economically attractive for a seed industry. Moreover, new varieties have low demand because of their marginal advantage in yielding ability over the existing land races cultivated under adverse rainfed conditions.

Only varieties having resistance diseases and pests and improved potential will be able to generate sufficient regular demand for seed produced on a commercial scale. However, strong regional seed production organisation backed by equally strong regional research efforts is essential for the speedy flow of new improved varieties from research stations to the farmer's field.

ELIMINATION OF YIELD-ERODING FACTORS

(a) Development of disease resistant varieties

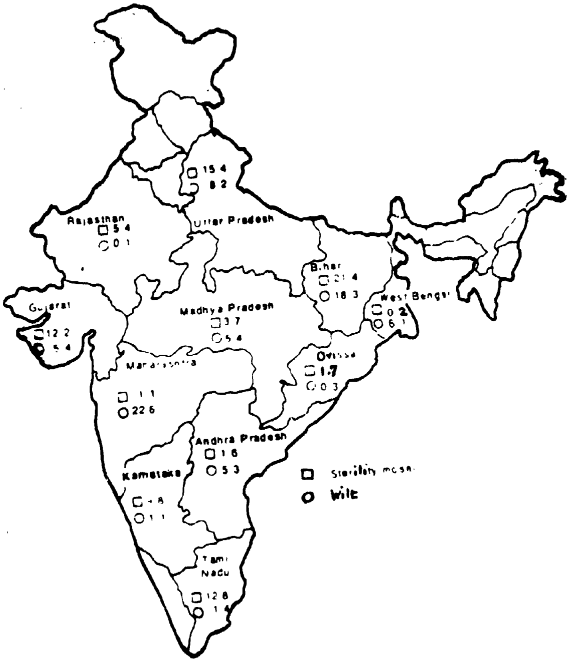
Progress towards the development of disease resistant varieties has been encouraging. In pigeonpeas, besides well known sources of wilt, a large number of resistant sources have been identified at ICRISAT and made available to national programmes [Nene *et al*, 1981a]. Attempts are being made to determine the distribution of physiological races the modes of inheritance of resistance, to rationalise the breeding of wilt resistant varieties of pigeonpea.

For sterility mosaic of pigeonpea also a large number of resistant sources have been identified at ICRISAT for the first time and have been supplied to national programmes. Soon, a good number of resistant varieties in different maturity durations should be available for use in farmers' fields.

Besides these two major diseases, resistance to a specific isolate of phytophthora blight has been identified. Efforts are being made to develop high yielding pigeonpea varieties resistant to all the three diseases.

In chickpea, a large number of varieties and germplasm lines have been found to be resistant to wilt [Nene *et al*, 1981b] and since resistance is controlled by one or two genes [Kumar and Haware 1982; and Upadhyaya *et al*, in

FIGURE 2: PREVALENCE OF PIGEONPEA STERILITY MOSAIC (Z) AND WILT IN INDIAN STATES (1975-80). KANNAIYAN *et al*, 1981



preparation] it should be possible to develop resistant varieties adapted to any specific region.

Besides chickpea wilt, sources of resistance have been identified for dry root rot caused by *Rhizoctonia bataticola;* black root rot, coused by *Fusarium solani* and *Ascohyta* blight [Nene *et al*, 1981b] Attempts are being made to develop multiple disease resistant varieties to stabilise yield in farmers' fields.

In mung bean and urd beans breeding for mung bean yellow mosaic virus has been successful and a number of resistant varieties have been developed at the Agricultural Universities of Pantnagar and Ludhiana [Singh, 1981]. However, little progress has been made towards developing varieties resistant to powdery mildew and Cercospora leaf spot diseases, common in central and peninsular India.

(b) *Resistance to insects*

Insects cause serious reduction in yield of pulse crops, particularly in central and peninsular India. However, our knowledge and understanding of host-plant-resistance is highly limited at present. Therefore, breeding for insect resistance has not advanced much.

(c) *Tolerance to soil salinity and waterlogging*

Adverse soil conditions such as waterlogging and soil salinity drastically reduce chickpea and pigeonpea yields in certain areas. However, by and large, the existing land races and adapted widely grown varieties of chickpea have tolerance to salinity and pigeonpea are tolerant to salinity and waterlogging. Screening of germplasm of chickpea for salinity and of pigeonpea for both waterlogging and salinity has shown clear-cut genetic differences for tolerance to these factors. It is likely that new varieties developed from hybridisation between the adapted and non-adapted types may not have enough tolerance to these factors. To avoid this, there is a need to monitor newly developed varieties for their performance in screening nurseries for soil salinity for chickpea and waterlogging and soil salinity for pigeonpea.

IV

Development of Crop Management Practices

Development of crop management practices for pulse crops grown under unirrigated conditions in semi-arid regions have the following ingredients:

(i) Definition of the crop season based on soil moisture and evapotraspirational demand of the area.
(ii) Choice of appropriate pulse crop species and variety fitting the defined cropping season.
(iii) Appropriate cropping system — mono, mixed, relay, double — for efficient use of available residual soil moisture.
(iv) Management of soil moisture — drainage in heavy vertisols during the monsoon and conservation of soil moisture for the period.
(v) Insect pest management.

The traditional farmer has a pretty good idea of the crop season and so his choice of a crop species or variety fits very well the crop season of a particular region. However, in certain situations diversification and introduction of unconventional grain legume crops may also prove useful. In recent years successful introduction of soyabeans in MP on deep black soils with high soil moisture during monsoon is a good example.

Introduction of *Phaseolus acutifolius* (Tepary bean), a drought resistant crop, may be equally useful in realising yield levels better than any other grain legume under limited soil moisture supply [Nabhan and Felger, 1978].

A number of national research institutes and the ICRISAT have developed a useful rainfed agricultural technology based on conservation of soil moisture, drainage of excess water and efficient use of residual soil moisture. Since, the element of location specificity is quite high in SAT areas, the success of any proposed alternative to the existing farmers' practices depends on the accuracy with which these alternatives take into account the prevailing agroclimatic factors. Virmani [1979] has amply emphasised this aspect. He has clearly shown that though locations such as Hyderabad and Sholapur may have similar gross agroclimatic parameters such as potential evaporation, length of growing season, coefficient of variation of rainfall, moisture index they differ considerably in the distribution of these parameters, particularly soil moisture environment during the season and therefore cannot be recommended the same technological approach.

Though there is growing awareness of the need for accurate agroclimatic data for short-term periods, particularly related to soil moisture at present the facilities to collect and analyze the data on an extensive scale are limited.

V

Gaps in Transfer of Technology

Proper monitoring and management of soil moisture is the kay to the development of appropriate technology for rainfed areas. Pulse production is well linked with the production and availability of cereal food in such areas.

One way of influencing the production of pulses is by ensuring an adequate supply of cereal food from irrigated surplus areas. Another way is through general improvement of production technology of cereals as well as of pulses in rainfed areas. Since the first approach has practical logistic limitations it would have an indirect influence. This is evident from the fact that the area of pulses is increasing in the states of MP, Maharashtra and Rajasthan where irrigation potential is limited.

As regards the influence of the second factor on pulse production there is little evidence to suggest any appreciable improvement in the production levels of cereal crops through the improvement of production technology in rainfed areas. Moreover, pulses suffer from the added disadvantage of high insect damage.

It is no doubt true that historically resource allocation for development of appropriate technology for rainfed agriculture has been poor and rightly so considering the immediate returns. Nevertheless, over a long period of time a large number of research institutes and projects have experimented and developed useful elements of dryland farming technology.

The mute question today is, what are the reasons for the gap in transferring this technology to the farmers' fields?

The question of managing soil moisture, which is the kingpin of the technology, involves amendments (grading, land shaping, drainage, erotion control methods) which transcend individual field boundries and involve community and group action. Often trained effective field extension services to motivate such an action are inadequate. Capital requirement for equipment and technical know-how for large scale adoption of such measures is very high. Also institutional and infrastructural development to fulfil the requirements is lacking in most rainfed areas.

Experience of demonstration and on-farm research projects has clearly shown that the problems of rainfed farming are highly complex and require solution to problems specific to a location. The institutional and technical support required to implement the technology is very high. This is often not available because basic facilities of life are poor in dry rainfed areas and have no attraction for trained qualified personnel.

Experience of on-farm research at ICRISAT in Thadnapally, District, Sangareddy, Andhra Pradesh, shows that with adequate institutional support and easy supply of inputs, and necessary credit facilities ensured by different government agencies, the improved technology can be effectively transferred with substantial gain in productivity of rainfed crops. However, it seems that in the background of the existing social fabric, isolated spots of adoption of improved technology will be difficult to sustain, since it has high demand on farmers' time and labour during specific periods.

Since the whole process is slow and time consuming and has the element of uncertainty, scientists and developmental agencies concerned with the development of rainfed agriculture technology often seek an easy way out and advocate increasing production of pulses in irrigated agriculture. This dampens the enthusiasm and commitment of workers dealing with rainfed agriculture and also shifts the emphasis on resource allocation and priorities.

The task of developing and implementing rainfed farming technology in which pulses have an important role to play is challenging and demanding. The problem should be appreciated in the right perspective and resource allocations in terms of finances and technological services should be commensurate with the requirements of the task. To achieve this there is a need for social will, commitment and policy decision.

In the present circumstances the development of varieties capable of giving superior performance to the existing land races needs to be emphasised as the first step. At first it would not be possible to realise the full potential of the adapted improved seed under traditional farming systems, but any increment in yield due to improved seed without additional expenditure is likely to usher in the necessary change in the farmers' resources and gradually lead to adoption of improved management practices and full realisation of the production potential.

The process of increasing production in rainfed agriculture for that matter of pulses is certainly a long drawn affair, but it has to start at some point and why not now!

VI

Conclusions

Pulse production in India is characterised by diversity of crops and their regional specificity based on adaptation to prevailing agroclimatic conditions.

Pulses as a group can utilise limited soil moisture and nutrients more efficiently than cereal crops and for that reason farmers have chosen them to grow under highly adverse conditions. The process of differential resource allocation to pulse crops operates at agro-ecological niche allocation and at individual farmers level, out of necessity and not out of choice or preference.

At present more than 92 per cent of the area under pulses is confined to unirrigated areas, and in future the bulk of pulse production will continue to come from unirrigated areas. This is evident from the shift in acreage from traditionally major pulse growing areas, once they received irrigation, to predominantly unirrigated tracts. Therefore, any plan for increasing pulse production in the country should be based on a long-term approach for productivity of these crops under rainfed farming conditions rather than on the use of high imputs, an outstanding success, in the production of wheat and rice in irrigated areas.

Crop productivity comparisons made under unirrigated conditions between pulses and cereals do not support the general belief that pulses suffer from inherent low productivity. Rather the low productivity of pulses is due to the low input conditions associated with the complex socio-economic and agroclimatic problems of rainfed agriculture.

Long neglect of rainfed areas has resulted in poor institutional development and, therefore, there is considerable lag in developing strong traditions of scientific thinking and research, and training of scientists to work in these areas.

The paper deals in detail with agroclimatic, socio-economic and biological constraints of pulse production and gaps in transfer of technology in rainfed areas.

The task of developing and implementing rainfed farming techology in which pulses have an important role is challenging and demanding. The problem should be appreciated in its right perspective and resource allocation, and technological services support should commensurate with the requirements of the task. To achieve this there is a need for social will, strong commitment and policy decision.

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