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Mode of inheritance of resistance to ascochyta blight (*Ascochyta rabiei* [Pass.] Labr.) in chickpea (*Cicer arietinum* L.) and its consequences for resistance breeding†

(*Keywords: Cicer arietinum* L., ascochyta blight, quantitative vertical resistance, breeding)

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Abstract. A disease-rating data set collected for ascochyta blight (*Ascochyta rabiei* [Pass.] Labr.) on chickpea (*Cicer arietinum* L.) in different environments and with different isolates of the pathogen showed that resistance against the disease is quantitative, with a significant vertical component. Lower mean environmental disease ratings will enhance effective selection for resistance. It is proposed that gene pyramiding, using diverse germplasm and pathogenic isolates be used to combat the disease.

1. Introduction

Ascochyta blight (*Ascochyta rabiei* [Pass.] Labr.) is a serious foliar fungal disease of chickpea (*Cicer arietinum* L.). It appears from the literature that the crop pathosystem is extremely complex. Not only is the variability of the pathogen very wide (Reddy and Kabbabeh, 1985; Jan and Wiese, 1991; Porta-Puglia, 1992), but the varietal response of chickpea to the disease can also vary over the full range of the often-used scoring scale from 1 to 9 (Reddy and Singh, 1990). There are unresolved questions regarding the mode of inheritance of resistance to ascochyta blight; whether the resistance is horizontal or vertical, whether its control is monogenic or polygenic, and whether it is qualitative or quantitative (Gowen *et al.*, 1989; Malik, 1990; Reddy *et al.*, 1992). We have assembled a data set with disease ratings recorded at different locations and with different pathogen isolates for a group of 19 varieties. We now present the analysis of these data in an attempt to answer the above questions.

2. Materials and methods

Nineteen different chickpea varieties were grown in ascochyta blight nurseries at five locations in India, one in Pakistan, and in a growth room (20 ± 1°C and 90–100% RH) at ICRISAT Asian Center, Patancheru, India. The trials had at least two replications. The varieties were sown in October–November 1990 in the nurseries and in 1991 in the growth room. The plot size in the nurseries was 1 row of 4 m length, and the spacings between and within rows were 30 cm and 10 cm respectively. In the field, disease incidence was enhanced by spreading debris from ascochyta blight-infested chickpea plants between the plant rows and by spraying spore suspensions on the plants, thus exposing the crop to populations of the pathogen. For the growth room, 80 seeds were sown in plastic trays in sterilized river sand in the open, and the trays were transferred to the growth room approximately 2 weeks after sowing, followed by inoculation of the seedlings by spraying spore suspensions of four different single spore isolates at 2×10^6 spores ml^{-1} on the young plants. The isolates were obtained from blight infected plants of cultivar Pb7, collected from Gurdaspur, Hisar, Ludhiana, New Delhi and Sriganganagar, India, and grown on potato dextrose agar. Disease scores were taken during the podding stage in the nurseries, and at 2 weeks after inoculation in the growth room. The scoring was done on a scale of 1–9 as described by Nene *et al.* (1981) and Reddy and Singh (1990), where 1 = no symptoms, and 9 = plants killed. For data analysis we calculated means, standard deviations and correlation coefficients, and a variance analysis was conducted, using the two replication data sets, to quantify the contribution arising from vertical resistance (Vanderplank, 1984).

3. Results and discussion

The disease scores, their means, standard deviations and the correlation between the latter two are presented in Table 1. The varieties represented a wide range of responses to the fungus. Table 2 shows the correlation coefficients for the disease scores of different locations and isolates. The values for corresponding growth room isolates and locations are shown in bold. They appeared to be high and significant. Tables 3a and 3b give the analysis of variance for the complete data set and for the plant growth data separately, showing that the effects of variety, location and isolate and their interaction were highly significant. In Figure 1 we portray the ranking differences of the varieties grown at New Delhi and Sriganganagar. The mean individual disease scores ranged from 2·5 to 9·0, the varietal means from 4·48 to 9·00, and the location means from 4·71 (Ludhiana) to 8·03 (Islamabad). There was a notable, significant negative correlation between mean locational disease rating and corresponding standard deviation, indicating that varietal differences are obscured by higher locational disease pressure. Therefore breeding can be done more effectively under 'medium' disease pressure with the presently available levels of resistance where varieties can express even more subtle resistance differences. Looking at the columns in Table 1 it is apparent that all ratings between 2 and 9 are represented in continuous variation. This applies

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Table 1. Ascochyta blight severity rating on a 1–9 scale for 19 chickpea varieties grown at seven different locations and inoculated with four different isolates of the pathogen

Variety		Location and isolate[a] 1	2	3	4	5	6	7	8	9	10	Mean	SD
1	ICC 1065	7·5	9·0	9·0	9·0	4·5	9·0	8·0	9·0	8·0	8·0	8·10	1·32
2	ICC 1400	4·5	5·0	4·5	4·5	6·0	7·5	5·0	6·0	4·7	5·3	5·30	0·91
3	ICC 1472	6·0	9·0	4·0	4·5	6·5	9·0	6·7	9·0	4·7	5·0	6·44	1·86
4	ICC 12967	5·0	9·0	8·0	9·0	5·5	9·0	8·0	9·0	7·0	7·0	7·65	1·45
5	ICC 13416	4·0	9·0	6·5	5·0	5·5	8·5	5·0	9·0	7·0	5·0	6·45	1·75
6	ICC 13816	4·5	5·5	5·0	3·5	5·5	6·0	5·0	5·5	5·0	4·7	5·02	0·66
7	ICCL 86446	6·5	5·5	9·0	7·0	4·5	9·0	8·0	6·0	8·0	8·0	7·15	1·43
8	ICCL 86447	4·0	5·0	3·3	5·0	5·0	6·5	4·7	5·0	3·7	5·0	4·72	0·85
9	ICCV 89445	5·0	5·0	3·0	5·5	6·0	8·0	5·0	7·0	5·0	4·7	5·42	1·29
10	ICCX 790151	4·5	4·5	3·0	6·5	3·5	8·0	5·0	5·0	3·3	5·0	4·83	1·44
11	ICCX 800839	6·0	7·0	3·0	3·5	6·5	8·0	7·0	7·0	4·0	3·7	5·57	1·73
12	ICCX 800859	4·5	4·0	3·0	3·5	4·5	8·0	3·0	5·0	5·0	4·3	4·48	1·36
13	ICCX 810457	6·0	6·0	3·3	5·0	4·0	9·0	8·0	7·0	5·0	5·7	5·90	1·65
14	ICCX 810737·1	5·0	7·0	3·3	7·0	4·5	8·5	8·0	9·0	7·3	7·7	6·73	1·76
15	ICCX 810737·2	4·0	5·5	4·0	5·5	7·0	9·0	5·0	7·0	4·0	6·7	5·77	1·56
16	ICCX 810800	3·5	4·5	2·5	5·5	5·0	6·5	4·3	6·0	4·0	5·0	4·68	1·13
17	ICCX 810974	5·0	4·0	2·5	6·5	5·0	8·0	4·0	6·0	3·3	5·0	4·93	1·53
18	ICCX 830677	4·0	5·5	3·5	5·0	5·5	6·0	3·7	5·0	5·0	5·3	4·85	0·79
19	Pb 7	9·0	9·0	9·0	9·0	9·0	9·0	9·0	9·0	9·0	9·0	9·00	0·00
	Mean	5·18	6·26	4·71	5·79	5·45	8·03	5·92	6·92	5·42	5·80		
	SD	1·34	1·81	2·29	1·73	1·21	1·03	1·77	1·56	1·70	1·44		

[a] 1 – Gurdaspur, India; 2 – Hisar, India; 3 – Ludhiana, India; 4 – New Delhi, India; 5 Sriganganagar, India; 6 Islamabad, Pakistan; 7–10 – Patancheru, India, growth room; 7 – isolate from 1; 8 – isolate from 2; 9 – isolate from 3; 10 – isolate from 4.

$r_{mean/SD\ (location\ and\ isolate)} = 0{\cdot}551$.

$r_{mean/SD\ variety} = 0{\cdot}112$

Table 2. Correlation matrix for ascochyta blight severity ratings of Table 1 against locations and isolates[a]

1	1·0000								
2	0·5554	1·0000							
3	0·6364	0·6551	1·0000						
4	0·5456	0·4642	0·6703	1·0000					
5	0·3785	0·4021	0·2574	0·0764	1·0000				
6	0·5865	0·5389	0·4662	0·5052	0·1378	1·0000			
7	**0·7820**[b]	0·6924	0·6382	0·6139	0·1995	0·6598	1·0000		
8	0·5175	**0·8989**	0·5181	0·5268	0·3738	0·6886	0·7016	1·0000	
9	0·6496	0·6754	**0·8595**	0·6471	0·2195	0·4887	0·7010	0·6504	1·0000
10	0·6281	0·4754	0·7529	**0·8376**	0·2113	0·5397	0·7218	0·5300	0·8077
	1	2	3	4	5	6	7	8	9

[a] Locations and isolates 1–10 as in Table 1.

[b] Bold values are correlations between location and location isolate used in the plant growth room.

to field and plant growth room ratings. As discrete classification is not possible here (Harrabi and Halila, 1992), and ratings within homozygous material vary, it is concluded that the trait of resistance to ascochyta blight is to be treated quantitatively. Table 2 shows that the disease scores of the four isolates in the growth room correlate well with those of the corresponding locations (values shown in bold). This confirms that the growth room is suitable for screening purposes. However, the disease scores of different locations do not always correlate well. Also the different isolates used in the growth room show relatively low correlations in several instances, for example for Hisar–New Delhi ($r = 0{\cdot}53$). Obviously the ranking is not constant as shown in Figure 1 for New Delhi and Sriganganagar as locations, where $r = 0{\cdot}08$. Apparently the resistance had an important vertical component as expressed in the reversed ranking. The results of the analyses of variance in Tables 3a and 3b quantify the contribution of vertical resistance to the total variance to be 30·8% and 23·9% respectively, the latter value excluding a possible environmental effect.

There is much controversy in the literature on the inheritance of resistance to ascochyta blight. Pieters and Tahiri (1986), while breeding for horizontal resistance, observed in Morocco that the percentage of chickpea pod infection by ascochyta blight remained 'fairly constant' over 3 years. It was concluded by the two authors that the control of resistance was oligogenic and additive. Gowen *et al.* (1989) concluded that the observed ranking stability for chickpea cultivars for isolate pathogenicity suggests that resistance is polygenic. Results of international screening nurseries of chickpea

Table 3a. Analysis of variance of ascochyta blight severity ratings of 19 different varieties (V) at seven different locations and with four different isolates (LI) in two replications (R) as in Table 1

	df	SS	SS%	MS	F
R	10	4	0·3	0·4	
V	18	598	44·3	33·3	84·2***
LI	9	262	19·3	29·1	73·7***
V × LI	162	417	30·8	2·6	6·5***
Residual	180	71	5·3	0·4	
Total	379	1352	100·0		

***Significant at $P = 0.001$.

reported by Reddy *et al.* (1992) give the impression that the resistance against ascochyta blight is qualitative and vertical because of the classification into resistant and susceptible, and the reversals from location to location. A number of genetic studies also give that impression as they report monogenic dominant or recessive inheritance of ascochyta blight resistance, e.g. the studies of Singh and Reddy (1983) in segregating F_2 populations and Singh and Reddy (1989) in F_2 populations and a limited number of F_3 progenies. Nene (1982) rightly concluded from such study results that incorporation of resistance into a high-yielding background should be fairly simple and easy. In a recent study Dey and Gurdip Singh (1993) identified one recessive and five dominant genes for ascochyta blight resistance but they also concluded from generation mean analyses' results that the genes did not follow simple Mendelian inheritance but were influenced by inter-allelic interactions. Malik (1990), in his study of the inheritance of resistance in chickpea to ascochyta blight, attempted to fit simple and more complicated Mendelian models to his extensive data sets, but no generalization could be made, and from his biometrical models he concluded that the genetic control of the quantitative variation of resistance was complex. 'Loss' of resistance in chickpea as observed and reported for varieties such as C 12/34, C 235, C 727 and CM 72 (Nene and Reddy, 1987; Singh and Reddy, 1989) seems to confirm that we are dealing partly with vertical resistance and a limited number of major genes.

The results presented here show that quantitative vertical resistance plays a significant role in the chickpea–ascochyta blight pathosystem (Robinson, 1987).

Malik and Rahman (1992) reviewed the options for ascochyta blight resistance breeding. Among these they mention breeding for horizontal resistance, an approach attempted at ICARDA, but abandoned as good results were not achieved (Singh *et al.*, 1992). Another option mentioned

Table 3b. Analysis of variance of ascochyta blight severity ratings of 19 different varieties (V) in ICRISAT's growth room with four different isolates (I) in two replications (R) as in Table 1

	df	SS	SS%	MS	F
R	1	0·2	0·06	0·24	
V	18	309·1	73·19	17·17	270·4***
I	3	7·4	1·76	2·48	39·1***
V × I	54	100·8	23·86	1·87	29·4***
Residual	75	4·8	1·13	0·06	
Total	151	422·4	100·00		

***Significant at $P = 0.001$.

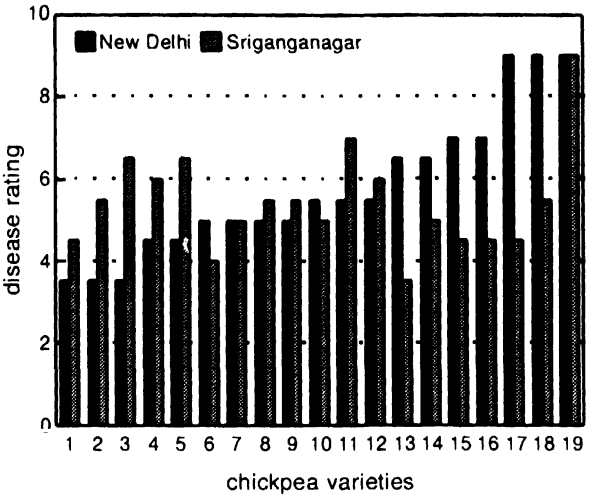

Figure 1. Ascochyta blight disease ratings for varieties tested at New Delhi and Sriganganagar arranged in ascending order for New Delhi. Varieties as in Table 1.

was gene pyramiding. To a certain extent, this is being done by crossing resistant varieties of different origins. We suggest that gene pyramiding as described by van Rheenen *et al.* (1992) may be appropriate as varieties show differential reactions to isolates (Table 1). By increasing the number of isolates and varieties the base of the pyramid can be broadened.

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References

DEY S. K. and GURDIP SINGH, 1993. Resistance to Ascochyta blight in chickpea—genetic basis. *Euphytica*, **68**, 147–153.

GOWEN, S. R., ORTON, M., THURLEY, B. and WHITE, A., 1989. Variation in pathogenicity of *Ascochyta rabiei* on chickpeas. *Tropical Pest Management*, **35**, 180–186.

HARRABI, M. and HALILA, H., 1992. Breeding for combined resistance to ascochyta blight and fusarium wilt in kabuli chickpea in Tunisia. In K. B. Singh and M. C. Saxena (eds) *Disease Resistance Breeding in Chickpea. Proceedings of the consultative meeting on breeding for disease resistance in kabuli chickpea* (6–8 March 1989, Aleppo, Syria), pp. 98–109.

JAN, H. and WIESE, M. V., 1991. Virulence forms of *Ascochyta rabiei* affecting chickpea in the Palouse. *Plant Disease*, **75**, 904–906.

MALIK, B. A., 1990. Genetics of resistance to *Ascochyta rabiei* in chickpea (*Cicer arietinum* L.), PhD thesis (Islamabad, Pakistan: Quaid-I-Azam University), 148 pp.

MALIK, B. A. and RAHMAN, M. S., 1992. Breeding for ascochyta blight resistant desi chickpea in Pakistan. In K. B. Singh and M. C. Saxena (eds) *Disease Resistance Breeding in Chickpea. Proceedings of the consultative meeting on breeding for disease resistance in kabuli chickpea* (6–8 March 1989, Aleppo, Syria), pp. 77–85.

NENE, Y. L., 1982. A review of ascochyta blight of chickpea. *Tropical Pest Management*, **28**, 61–70.

NENE, Y. L. and REDDY, M. V., 1987. Chickpea diseases and their control. In M. C. Saxena and K. B. Singh (eds) *The Chickpea* (Wallingford, UK: CAB International), pp. 233–270.

NENE, Y. L., HAWARE, M. P. and REDDY, M. V., 1981. Chickpea diseases, resistance-screening techniques. *ICRISAT Information Bulletin*, No. 10, 11 pp.

PIETERS, R. and TAHIRI, A., 1986. Breeding chickpea for horizontal resistance to ascochyta blight in Morocco. *FAO Plant Protection Bulletin*, **34**, 99–105.

PORTA-PUGLIA, A., 1992. Variability in *Ascochyta rabiei*. In K. B. Singh and M. C. Saxena (eds) *Disease Resistance Breeding in Chickpea. Proceedings of the consultative meeting on breeding for disease resistance in kabuli chickpea* (6–8 March 1989, Aleppo, Syria), pp. 135–143.

REDDY, M. V. and KABBABEH, S., 1985. Pathogenic variability in *Ascochyta rabiei* (Pass.) Lab. in Syria and Lebanon. *Phytopathologia Mediterranea*, **24**, 265–266.

REDDY, M. V. and SINGH, K. B., 1990. Relationship between ascochyta blight severity and yield loss in chickpea and identification of resistant lines. *Phytopathologia Mediterranea*, **29**, 32–38.

REDDY, M. V., SINGH, K. B. and MALHOTRA, R. S., 1992. Multilocation evaluation of chickpea germplasm and breeding lines for resistance to ascochyta blight. *Phytopathologia Mediterranea*, **31**, 59–66.

ROBINSON, R. A., 1987. *Host Management in Crop Pathosystems* (New York: Macmillan), 263 pp.

SINGH, K. B. and REDDY, M. V., 1983. Inheritance of resistance to ascochyta blight in chickpea. *Crop Science*, **23**, 9–10.

SINGH, K. B. and REDDY, M. V., 1989. Genetics of resistance to ascochyta blight in four chickpea lines. *Crop Science*, **29**, 657–659.

SINGH, K. B., REDDY, M. V. and HAWARE, M. P., 1992. Breeding for resistance to ascochyta blight in chickpea. In K. B. Singh and M. C. Saxena (eds) *Disease Resistance Breeding in Chickpea. Proceedings of the consultative meeting on breeding for disease resistance in kabuli chickpea* (6–8 March 1989, Aleppo, Syria), pp. 23–54.

VAN RHEENEN, H. A., REDDY, M. V., KUMAR, J. and HAWARE, M. P. 1992. Breeding for resistance to soil-borne diseases in chickpea. In K. B. Singh and M. C. Saxena (eds) *Disease Resistance Breeding in Chickpea. Proceedings of the consultative meeting on breeding for disease resistance in kabuli chickpea* (6–8 March 1989, Aleppo, Syria), pp. 55–70.

VANDERPLANK, J. E., 1984. *Disease Resistance in Plants* (New York: Academic Press, Inc.), pp. 60–61.