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Potential of Short-Duration Chickpea Varieties

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ABSTRACT: Discussions with chickpea scientists and a review of reports and data from more than 1200 international trials and nursery sets, indicated that damage to chickpea by diseases and drought were the main causes of lower than expected yields and trial failures. Incorporation of resistances to multiple stresses through breeding is a long-drawn process. Most losses to chickpea productivity occur during the reproductive phase. The advent of extra-short-duration varieties developed for short-season, tropical environments has provided a means of escaping these losses. A similar strategy of reducing crop duration may increase and stabilize yields in long-season, sub-tropical environments. It is proposed that this may be achieved by incorporating genes for earliness, determinancy and chilling tolerance.

The green revolution in cereals in India has relegated chickpea and other pulses to less well-endowed lands (Kelley and Parthasarty 1994). As the increase in genetic potential and stability of chickpea productivity has not been able to match that of what, farmers prefer wheat with its higher yield and returns, particularly on their more productive lands. Consequently the area under chickpea cultivation in the country fell by 9 lakh ha between 1971 and 1991. India's share of world chickpea production fell from 80 per cent to 65 per cent during this period. However, chickpea is still cultivated on a large area primarily because of its drought tolerance relative to other crops, and its favourable market prices.

With a mean productivity of 5 to 6 kg/ha per day, chickpea (*Cicer arietinum* L.) is among the lowest yielding food crops. Seed yields of 6 t/ha have been reported indicating that the potential for high yield does exist (Saxena 1990). However, such reports are rare. About 90 per cent of chickpea cultivation in India is on receding soil moisture under rainfed conditions (Sharma and Jodha 1984). As such, terminal drought stress, and associated heat stress, are major limitations to higher productivity (Johansen et al. 1994). Adequate or excessive soil moisture during flowering and podding induces luxuriant vegetative growth and consequent poor pod development especially in sub-tropical regions. Little improvement in the mean productivity of this crop was achieved in the past three decades (FAO 1993). Breeding and management indicates success towards improved chickpea productivity (van Rheneen 1991). In the present paper we analyze the reasons for low productivity of the crop and suggest ways of minimizing losses caused by the major biotic and abiotic stresses.

The causes of unstable productivity of chickpea are numerous (Kumar et al. 1990; Saxena 1993, ICRISAT, 1992, Nene and Reed 1994). The major ones are; drought, foliar and root diseases, pod borer and cold. Other causes are damage by late season rains and hailstroms, mostly during flowering and podding stages. These stresses can occur at various times from planting to storage. Here we wish to consider options to alleviate or avoid losses due to stresses.

In formulating the ICRISAT Medium Term Plan (MTP) (ICRISAT, 1992) it was estimated that, if the potential losses during crop growth are avoided, the annual production can be increased by 115 per cent (Table 1). Although there may be differences of opinions in terms of avoidable losses because of various constraints and their ranking, there is no doubt that major production gains could be achieved if some of these losses were reduced.

Biotic Stresses

To quantify crop losses we examined the results of International trials and nurseries. ICRISAT supplied over 1900 trial and nursery sets to cooperators in chickpea growing countries during 1975-1990 and received data from 1239. Of these, 175 (about 14%) trials were complete failures. Much success has been achieved in developing varieties with resistance to Fusarium wilt (Haware, et al. 1990). There has been less success in developing resistances/tolerances to other stresses (Johansen et al. 1994). Damage by foliar diseases and pod borer accounted for over 62 per cent and that by drought for 17 per cent of these failures. Other stresses caused the remaining failures. Informal discussions with chickpea scientists indicated that even the successful trials suffered considerable production losses because of one or more of these stresses. Damage by *Helicoverpa* pod borer is a normal occurrence. Further discussions and an analysis of data suggested that most stresses, and therefore losses, occurred during the later part of the cropping season. We, therefore, examined the late season constraints and observed that foliar diseases, cold and constraints resulting from overgrowth, mainly occur during March in northern India. Thus, it appears that yield gains may be expected if the constraints occurring during this period are avoided

Table 1. Estimated production losses in some important chickpea growing countries/regions and the world, caused by end-of-season biotic and abiotic constraints to chickpea (1988-90 mean)

Country/ Region/Continent	Mean production 1988-90	Estimated Production Loss (000 t)							
		Abiotic		Biotic					Total
		DR/HT	C	S	AB	BGM	V	*Hel.*	
Bangladesh	69	27	0	10	0	17	7	14	75
China	210	126	0	17	-	-	-	42	185
India	4329	2026	269	569	318	161	501	925	4759
Myanmar	110	55	0	11	0	0	0	22	88
Nepal	17	7	3	0	0	5	1	4	20
Pakistan	455	182	68	114	91	46	91	114	706
Middle East	916	532	133	85	218	0	57	145	1170
Africa	267	160	5	40	19	0	22	44	290
Americas	171	72	23	39	0	0	30	43	207
Europe	79	47	4	5	10	0	3	8	77
Australia	83	42	13	8	4	4	8	21	138
World	6700	3276	518	898	660	233	720	1382	7715

ICRISAT Medium Term Plant (MTP) estimates (10).

DR=Drought; HT=Heat; C=Cold; S=Salinity; AB=Ascochyta blight; BGM=Botrytis gray mold; V=Virus; Hel=Helicoverpa pod borer or removed. Other major constraints primarily affect the reproductive growth stage and are estimated to cause the following losses: foliar diseases (eg. ascochyta blight, botrytis gray mold) 13 per cent, pod borer 21 per cent, virus diseases 11 per cent and cold injury 8 per cent. Constraints that mainly affect the early growth stages, e.g. fusarium wilt and root rots, cause losses to the extent of 13 per cent of annual mean production. Salinity also causes a 13 per cent loss.

Abiotic Stresses

Drought, heat and soil salinity are major abiotic constraints. According to the ICRISAT-MTP estimates, drought and heat mainly affecting reproductive growth account for 43 per cent of the production losses (c.f. present production levels). Thus, it appears that chickpea production can be at least doubled if losses caused by end-of-season constraints are alleviated.

It is unlikely that chickpea growing environments will change for the better in the foreseeable future. Little can be done to alleviate ill effects of drought, early in the season. Also options to genetically improve the crop resistance to many of these stresses are limited by the existing narrow genetic variations for enhancement and selection. Moreover pyramiding of many genes for multiple-stress resistance is a long-drawn process. But one way to escape the damage by end-of-season biotic and abiotic stresses is to shorten the crop duration (Nene and Reed 1994). It is not an easy task, because crop duration generally positively correlates with higher yields.

Indeterminate growth habit

Chickpea is an indeterminate plant and continues to grow when soil moisture, temperature and other environmental factors are conducive (Williams and Saxena 1991). Under such conditions, the crop is exposed to a greater risk of end-of-season constraints. The world germplasm collection held at ICRISAT Center has no chickpea genotype which is determinate and which can mature within 4 months in environments characteristic of northern India (Pundir et al. 1988). van Rheenen et al. 1994 reported that they obtained a determinate chickpea plant through mutation breeding. However, the plant failed to produce pods. It may be worthwhile to continue looking for a determinate chickpea which will flower and mature earlier than the presently grown cultivars and change/modify the present breeding strategy of achieving higher productivity, by extending the crop duration.

Genetic control of crop duration

In short-duration environments of the tropics, chickpea productivity has been increased and stabilized by developing extra-short-duration (80-90 days) varieties (Kumar et. al. 1985, Amin et al. 1990). There is likely to be substantial advantage of reducing the crop duration from the present 5-6 months to about 4 months in sub-tropical environments also. This approach might increase the mean productivity and stability of chickpea production in the sub-tropics.

At ICRISAT Center, some segre-gants derived from crosses of extra short-duration lines (ICCV 2 and Harigantas) with medium - and long-duration lines, show signs of genetically enforced early maturity even when moisture is available for continuing vegetative growth. There are indications that major genes for earliness exist in these genotypes which express under relatively warm temperatures (unpublished data). However, these genotypes continue their vegetative growth in cool environments. Thus these genes for earliness appear to be influenced by temperature and to be effective, will require support such as that from the genes for chilling tolerance.

Susceptibility to chilling temperature

One reason for the longer growing period of chickpea in sub-tropical environments can be the occurrence of prolonged chilling temperatures (<5°C) early in the growth season (Saxena and Johansen 1990). In recent years segregants which flower and pod at low temperatures have been identified and chilling tolerant breeding lines were developed at ICRISAT (ICRISAT 1990, 1994). A number of these lines were tested in 1993/94 and 1994/95 at two locations; ICRISAT Asia center (18°N) and Hisar (29°N). These lines flowered earlier than the long-duration control cultivar Pant G 114 at Hisar (Table 2). Two lines matured about 2-3 weeks earlier than Pant G 114. The seed yields of these lines were slightly higher than the control. Thus it appears that some progress has been made, but more work is needed to reduce the crop duration to about 4 months in environments similar to Hisar.

Table 2. Performance of two promising cold terlant entries at Patancheru (18°N) and Hisar (29°N), 1993/94 and 1994/95.

		Days of 50% flowering		Days of maturity		Seed yield (kg/ha)	
Entry Name	Year	Patancheru	Hisar	Patancheru	Hisar	Patancheru	Hisar
ICCX 880355-32 H	1993/94	50	83	113	149	1800	2850
	1994/95	56	67	121	139	1900	3300
ICCX 880354-31 H	1993/94	46	68	103	148	1820	2140
	1994/95	51	59	118	146	2200	3400
CONTROLS							
Annigeri	1993/94	46	84	99	149	1820	690
	1994/95	44	79	118	159	1800	1300
Pant G-114	1993/94	60	85	119	159	1630	1320
	1994/95	65	84	125	159	1700	2000
SE	1993/94	1.3	1.5	1.3	1.4	150	230
	1994/95	1.2	2.1	1.5	1.3	130	270
CV%	1993/94	4.2	3.4	2.1	1.6	1610	2370
	1994/95	5.2	5.3	2.9	1.4	1420	2020

A combination of genes for earliness, chilling resistance and, if available, determinate plant type may, complement and produce genotypes that will mature early in the sub-tropics. If this complementation occurs, the success of extra short-duration varieties already achieved in short-duration, drought-prone environments of the tropics and demonstrated in AP, Maharashtra and Gujarat in India and Myanmar may also be achievable in traditionally long-season environments of the sub-tropics (Amin et al. 1990).

CONCLUSIONS

The development of short-duration varieties which avoid end-of-the-season drought has helped increase chickpea productivity in peninsular India. However, we do not yet have an early and determinate chickpea plant that can flower, pod and mature in about 4 months, in sub-tropic environments typified by northern India. Attempts to develop suitable genotypes continue. Similarly varieties which mature in 100-110 days in central India are needed. Such genotypes may not be as flexible as the conventional indeterminate chickpea, but we anticipate that, due to early maturity, the end-of-season adverse effects of biotic and abiotic stresses will automatically and consistently be reduced to achieve a relatively high mean productivity although yields of 6 t/ha may not be achieved. If stable and high yields are assured, it is anticipated that farmers will expand the area under chickpea and may be more prepared to invest in inputs.

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REFERENCES

Amin, P.W., Jain, K.C., Kumar Rao, J.V.D.K., Pawar, C.S., Kumar, J., van Rheenen, H.A. and Faris, D.G., 1990. On-farm research on chickpea and transfer of technology in India. In : Chickpea in the Nineties : Proceedings of the Second International Workshop on Chickpea Improvement 4-8 December, 1989, ICRISAT (eds. H.A. van Rheenen and M.C. Saxena). ICRISAT Center, Patancheru, A.P. 502 324, India. pp 329-335.

FAO, 1993. Production Year Book: 104.

Haware, M.P., Jimenez-Díaz, R.M., Amin, K.S., Phillips, J.C. and Hililla, H., 1990. Integrated management of wilt and root rots of chickpea. In: Chickpea in the Nineties: Proceedings of the Second International Workshop on Chickpea Improvement 4-8 December, 1989, ICRISAT (eds. H.A. van Rheenen and M.C.

Saxena) ICRISAT Center, Patancheru, A.P. 502 324, India. pp. 129-133.

ICRISAT (International Crops Research Institute for the Semi-Arid Tropics), 1990. Annual Report, 1989. ICRISAT, Patancheru, A.P. 502 324, India: 148.

ICRISAT (International Crops Research Institute for the Semi-Arid Tropics), 1992. Medium Term Plan, 1994-1998: Volume 1 (Main Report), ICRISAT, Patancheru, Andhra Pradesh 502 324, India: 80.

ICRISAT (International Crops Research Institute for the Semi-Arid Tropics), 1994. Cold-tolerant chickpea varieties ICCV 88503, ICCV 88506, ICCV 88510. Plant Material Description No. 53, ICRISAT, Patancheru, A.P. 502 324, India: 4.

Johansen, C., Baldev, B., Brouwer, J.B., Erskine, W., Jermyn, W.A., Li-Juan, L., Malik, B.A., Ahad Miah, A. and Silim, S.N., 1994. Biotic and abiotic stresses constraining productivity of cool season food legumes in Asia, Africa and Oceanea. In: Expanding the production and use of cool season Food Legumes. Proceedings of the Second International Food Legume Research Conference 12-15 April, 1992, Cairo (eds. F.J. Muehlbauer and W.J. Kaiser). Kluwer Academic Publishers, Netherlands: 175-194.

Kelley, T.G. and Parthasarthy Rao, P., 1994. Chickpea competitiveness in India. Economic and Political Weekly, 29(26): I 89-100.

Kumar, J., Gowda, C.L.L., Sethi, S.C., Singh, O. and Singh, M., 1990. Ten years of international trials and their future. In: Chickpea in the Nineties: Proceedings of the Second International Workshop on Chickpea Improvement, 4-8 December, 1989, ICRISAT (eds. H.A. van Rheenen and M.C. Saxena). ICRISAT Center, Patancheru, A.P. 502 324, India: pp. 351-356.

Kumar, J., Haware, M.P. and Smithson, J.B., 1985. Registration of four short duration, fusarium wilt-resistant kabulu (Garbanzo) chickpea germplasms. Crop Science, 25: 576-577.

Nene, Y.L. and Reed, W., 1994. Integrated management system to control biotic and abiotic stresses in cool season food legumes. In: Expanding the production and use of cool season food legumes. Proceedings of the Second International Food Legume Research Conference, 12-15 April, 1992, Cairo (eds. F. Muehlbauer and W.J. Kaiser). Kluwer Academic Publishers, Netherlands: pp. 666-678.

Pundir, R.P.S., Reddy, J.N. and Mengesha, M.H., 1988. ICRISAT Chickpea Germplasm Catalogue Evaluation and Analysis. ICRISAT (International Crops Research Institute for the Semi-Arid Tropics), Patancheru, A.P. 502 324, India: 94.

Saxena, M.C., 1990. Problems and potentials of chickpea production the nineties. In: Chickpea in the Nineties: Proceedings of the Second International Workshop on Chickpea Improvement, 4-8 December, 1989, ICRISAT (eds. H.A. van Rheenen and M.C. Saxena). ICRISAT Center, Patancheru, A.P. 502 324, India: pp. 13-25.

Saxena, M.C., 1993. The challenges of developing biotic and abiotic stress resistance in cool season food legumes. (eds. K.B. Singh and M.C. Saxena) Breeding for stress tolerance in cool-season food legumes. A Wiley-Sayce Publication, New York, U.S.A.: pp 3-14.

Saxena, N.P. and Johansen, C., 1990. Realized yield potential in chickpea and physiological consideration for further genetic improvement. In: Proceedings of the International Congress for Plant Physiology. Vol.I (eds. S.Sinha, P.V. Sane, S.C. Bhargava and P.K.Agrawal). Indian Agricultural Research Institute, New Delhi: Society for Plant Physiology and Biochemistry): 279-288.

Sharma, D. and Jodha, N.S., 1984. Constraints and opportunities of pulses production in semi-arid regions of India. In: Pulse Production Constraints and Opportunities: Proceedings of Symposium on increasing Pulse Production in India - Constraints and Opportunities, October, 1982, New Delhi, (eds. H.C. Srivastava, S. Bhaskaran, K.K.G. Menon, S. Ramanujam and M.V. Rao). Oxform and IBH Publishing Co., New Delhi: pp 241-245.

van Rheenen, H.A., 1991. Chickpea breeding progress and prospects. Plant Breeding Abstract, 61(9): 997-1009.

van Rheenen, H.A., Pundir, R.P.S. and Miranda, J.H., 1994. Induction and inheritance of determinate growth habit in chickpea (*Cicer arietinum* L.) Euphytica, 78: 137-141.

Williams, J.H. and Saxena, N.P., 1991. The use of non-destructive measurements and physiological models of yield determination to investigate factors determining differences in seed yield between genotype of "desi" chick-pea (*Cicer arietinum*). Annals of Applied Biology, 199: 105-112.