results were recorded for wheat, tef, and lentil (Abebe et al. In press).

There was no significant response of chickpea to increasing rates of phosphorus fertilizer (Fig. 1a and b). Similar results were also obtained for other crops (DZARC 1991). This was despite the fact that Vertisols in the highlands have low (<8 mg kg^{-1} P as determined by the Olsen method) available phosphorus levels (Mamo et al. 1988). It is thought that chickpea and other legumes and cereals may benefit from their extensive root systems, which allow them to explore a large volume of soil, thereby enabling them to satisfy their P requirements (Saxena 1980). However, this statement cannot be generalized.

In the central highlands of Ethiopia, chickpea yield in farmers' fields is seldom more than 1 t ha^{-1}. However, in this experiment, improved drainage resulted in a grain yield of more than 1.5 t ha^{-1}.

It may be concluded that the sowing date could be advanced by about 20 days from the conventional sowing date (i.e. from mid-August to early September) if farmers adopt a broadbed-and-furrow system. Secondly, chickpea yields can be increased through improved drainage, and finally, phosphorus is not yield-limiting but applications could be considered when soil tests and the crop P level indicate a need.

References

Abebe, M., Mamo, T., Duffera, M., and **Kidanu, S.Y.,** (In press.). Crop response to improved drainage of Vertisols in the Ethiopian highlands. Journal of Agronomy and Crop Science.

DZARC (Debre Zeit Agricultural Research Center). 1991. Annual research report for 1990/91. Debre Zeit, Ethiopia: DZARC. 184 pp.

Geletu Bejiga, and **Abebe Tullu** 1982. The influence of planting dates on the yield of three chickpea (*Cicer arietinum*) varieties. Ethiopian Journal of Agricultural Science 4:61–66.

Jutzi, S.C. 1986. Deep black clay soils (Vertisols)–Management options for the Ethiopian highlands. Presented at the African Mountains Workshop, 18-27 Oct 1986, Addis Ababa, Ethiopia. 7 pp.

Mamo, T., Haque, I., and **Kamara, C.S.** 1988. Phosphorus status of some Ethiopian highland Vertisols. Pages 232–252 *in* Management of Vertisols in sub-Saharan Africa: proceedings of a Conference, 31 Aug-4 Sep 1987, International Livestock Centre for Africa, Addis Ababa, Ethiopia (Jutzi, S.C., ed.). Addis Ababa, Ethiopia: ILCA.

Saxena, M.C. 1980. Recent advances in chickpea agronomy. Pages 88–96 *in* Proceedings of the International Workshop on Chickpea Improvement, 28 Feb–2 Mar 1979, ICRISAT, Hyderabad, India. Patancheru, A.P. 502 324, India: International Crops Research Institute for the Semi-Arid Tropics.

Pathology

Multilocational Testing of Chickpea for Field Resistance to Ascochyta Blight

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Ascochyta blight caused by *Ascochyta rabiei* (Pass.) Lab. is the most important disease of chickpea (*Cicer arietinum* L.) in West Asia, North Africa, the southern and eastern regions of Europe, and the northwestern regions of India and Pakistan. Chickpea crops can be completely devastated by ascochyta blight in epiphytotic years. Several fungicides that are effective as seed dressings or for foliar application have been identified, but their application is impractical or noneconomical (Reddy and Singh 1990). Most of the fungicides used to control ascochyta blight are of the contact type, and are not effective as foliar applications when it rains.

Intensive work on resistance breeding in kabuli chickpea has been done at the International Center for Agricultural Research in the Dry Areas (ICARDA) in Syria. From the material generated at ICARDA, 29 ascochyta blight resistant kabuli cultivars have been released in 14 Mediterranean countries (Singh 1993). However, these lines are not adapted to the Indian subcontinent.

In India, research on ascochyta blight of chickpea was intensified after the epiphytotics of 1981 and 1982, and a systematic search for stable sources of resistance in germplasm and breeding material began at Ludhiana, Hisar, and Sriganganagar in the 1985/86 season. Chick-

pea lines identified as resistant or moderately resistant in field screening at Hisar by ICRISAT in cooperation with CCSHAU, were tested in blight-endemic areas in India and at Islamabad, Pakistan. The results of this multilocational testing are reported here.

Nursery. Entries for the Chickpea Ascochyta Blight Nursery (CABN) were selected from germplasm and breeding lines screened in a disease nursery at Hisar. The CABN was composed of 20 entries every year, and each entry was tested for at least 2 years during the postrainy seasons of 1989/90–1992/93 at each location. About 80 seeds of each entry were sown in 4-m long single rows in two replications in a randomized complete block design in a field where the disease naturally occurs every year. Single rows of the susceptible control cultivar Pb 7 were sown after every two test rows to serve as spreader infector rows.

Test locations. Selection of test locations was done on the basis of natural disease occurrence. Ascochyta blight occurs every year at these locations and artificial epiphytotics can be created by inoculating plants and ensuring humid conditions. The locations were Berthin (Himachal Pradesh), Hisar (Haryana), Ludhiana and Gurdaspur (Punjab), Sriganganagar (Rajasthan), RS Pura (Jammu and Kashmir), and New Delhi in India, and Islamabad in Pakistan.

Inoculation procedure. Debris from infected plants was spread in the field and plants were sprayed with a spore suspension to obtain uniform disease incidence. The spore suspension was made by soaking 10 to 15-day-old ascochyta-infected kabuli chickpea seeds in water (Narayana Rao and Haware 1991) for 30 min, stirring with a clean glass rod and passing the suspension through double-layered muslin cloth. The suspension was adjusted to the required spore concentration using a hemocytometer. The spore suspension (200×10^4 spores mL^{-1}) was applied with a knapsack sprayer twice in the season in the evening at around 1700 on cloudy days at 80-85 and 87-92 days after sowing. Perfo-irrigation was given twice a day at 1300 and 1900 from the day after inoculation.

Disease scoring. Disease severity was scored on a 1–9 point scale where 1 = no visible lesions on any plant (highly resistant), 3 = lesions visible on less than 10% of the plants, no stem girdling (resistant), 5 = lesions visible on up to 25% of the plants, stem girdling on less than 10% of the plants but little damage (moderately resistant); 7 = lesions on most of the plants, stem girdling on less than 50% of the plants, resulting in death of a few plants (susceptible); 9 = lesions profuse on all the plants, stem girdling on more than 50% of the plants, and death of most of the plants (highly susceptible). In all the locations, the susceptible control cultivar Pb 7 showed disease ratings of 8 to 9 in all the years of testing.

Three lines in Ludhiana and two in Berthin were found resistant in both the years of testing. Sixteen lines in Ludhiana, 12 each in Gurdaspur and Sriganganagar, 11 lines in Hisar, 7 in New Delhi, 6 in Berthin, and 3 lines in R.S. Pura were found to be moderately resistant in both the years of testing (Table 1). No line was found resistant/moderately resistant at Islamabad in Pakistan. At this location the environment, mainly temperature and humidity, was more congenial for disease development.

The lines found resistant in field screening were also tested in a plant growth room at ICRISAT Asia Center where they were found to be moderately resistant to susceptible. The higher disease scores in the plant growth room were due to its uniform temperatures and humidity that favored disease development. Therefore lines identified as resistant in field screening are useful components of a resistance-breeding program.

Multilocational testing of chickpea lines identified in field screening at Hisar has helped to identify a few lines with stable resistance in India. The differential reaction of these lines in Pakistan could indicate the presence of an aggressive pathotype of *A. rabiei* in that country.

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References

Narayana Rao. J., and **Haware, M.P.** 1991. An improved growth medium for the multiplication of *Ascochyta rabiei* in the laboratory. International Chickpea Newsletter 25:24–25.

Table 1. Chickpea lines resistant to ascochyta blight at different locations, postrainy season 1989/90–1992/93.

Location	Resistant entries and disease incidence[1]	
	≤3	3.1 to 5
India		
Berthin	2 (ICC 13816, ICCX 810800-3H-BH-1H-1H-BH	6 (ICCs 16331, 16332, 16343, ICCX 800839-BPN-BPN-BPN-BPN-1H, 810737-BPN-BPN-BPN-3PN-BH, 810974-BH-BW-56H-1H-1H-1HWR-BH)
Gurdaspur	0	12 (ICCs 607, 1400, 13416, 13816, 86447, (ICCX 790151-2P-1H-1H-2H-1H-1HWR-BH, 800859-BPN-BPN-BPN-3PN-1HWR-BH, 810737-BPN-BPN-BPN-3PN-BH, 810800-3H-BW-BH-1H-1H-BH, 810974-BH-BW-56H-1H-1H-1HWR-BH, 830677-10H-BH-BH,830697-10H-BH-BH)
Hisar	0	11 (ICCs 1400, 13816, 16331, ICCL 86447, ICCL 89445, ICCX 790151-2P-1H-1H-2H-1H-1HWR-BH, 800859-BPN-BPN-BPN-3BPN-1HWR-BH, 810737-BPN-BPN-BPN-3PN-BH, 810800-3H-BW-BH-1H-1H-BH, 810974-BH-BW-56H-1H-1H-1HWR-BH, 830697-10H-BH-BH)
Ludhiana	3 (ICCX 790151-2P-1H-1H-2H-1H-1HWR-BH, 800839-BPN-BPN-BPN-BPN-1H, 810800-3H-BW-	16 (ICCs 607, 1400, 1472, 13816,16331, 16332, 16343, ICCL 86447, ICCL 89445, ICCX 800859-BPN-BPN-BPN-3BPN-1HWR-BH, 810457-3H-1H-1H-1HWR-BH, 810737-BPN-BPN-BPN-3PN-BH, 810974-BH-1H-1H-BH)BH-BW-56H-1H-1H-1HWR-BH, 830677-10H-BH-BH, 830697-10H-BH-BH, 860047-BP-20H-BP)
New Delhi	0	7 (ICCs 607, 1400, 13416, ICCL 86447, ICCX 800839-BPN-BPN-BPN-BPN-1H, 800859-BPN-BPN-BPN-1HWR-BH, 830677-10H-BH-BH)
RS Pura	0	3 (ICCX 810800-3H-BW-BH-1H-1H-BH, 810974-BH-BW-56H-1H-1H-1HWR-BH, 860047-BP-20H-BP)
Sriganganagar	0	12 (ICC 13816, ICC 16344, ICCL 86447, ICCX 790151-2P-1H-1H-2H-1H-1HWR-BH, 800859-BPN-BPN-BPN-3BPN-1HWR-BH, 810457-3H-1H-1H-1HWR-BH, 810737-BPN-BPN-BPN-3PN-BH, 810800-3H-BW-BH-1H-1H-BH, 810974-BH-BW-56H-1H-1H-1HWR-BH, 830677-10H-BH-BH,830697-10H-BH-BH, (C 44 x ICC 1772)-BS-11P-1H-1H-BH

1. Average of 2 replications scored on 1–9 scale for 2 years, where 1 = highly resistant, 5 = moderately resistant, and 9 = highly susceptible.

Nene, Y.L. 1982. A review of ascochyta blight of chickpea. Tropical Pest Management 28(1):61–70.

Reddy, M.V., and **Singh, K.B.** 1990. Management of ascochyta blight of chickpea through integration of host plant tolerance and foliar spray of chlorothalonil. Indian Journal of Plant Protection 18:65–69.

Singh, K.B. 1993. Problems and prospects of stress resistance breeding in chickpea. Pages 17–35 *in* Breeding for stress tolerance in cool season food legumes (Singh, K.B., and Saxena, M.C., eds.). Chichester, UK: John Wiley & Sons; Aleppo, Syria: International Center for Agricultural Research in the Dry Areas.