Table 1. Composition of leaves of two chickpea crosses sown at NARC, Islamabad, Pakistan, 1987/88.

Chickpea crosses	Crop condition	P (%)	K (%)	Ca (%)	Zn (mg kg^{-1})	Fe (mg kg^{-1})	Mn (mg kg^{-1})
PK 51832 x CM 72	Normal	0.14	0.2	4.0	28	14	310
	Abnormal	0.12	0.3	4.1	27	21	155
PK 51835 x CM 72	Normal	0.13	0.4	6.5	27	21	343
	Abnormal	0.13	1.0	6.0	30	14	129

samples were digested in a HNO_3-$HClO_4$ mixture (2:1) and analyzed for P by colorimetry, K by flame photometry, and Ca, Zn, Fe, and Mn by atomic absorption spectrophotometry. The concentrations of P, Ca, Zn, and Fe were almost equal in the leaves of normal and abnormal plants (Table 1). Potassium concentration was lower in the normal plants than in the abnormal plants. However, the concentration of Mn in the leaves of abnormal plants was 50% (PK 51832 x CM 72), and 62% (PK 51835 x CM 72) less than those of normal plants of the respective crosses.

This investigation indicated that the abnormal growth of the affected plants of these crosses was probably due to Mn deficiency. Further studies are warranted to verify these results.

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A Visual Rating System for Nodulation of Chickpea

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Characterization of chickpea genotypes for nodulation (nodule number and mass) and nitrogen fixation (acetylene-reduction test) is a time consuming and laborious process. It is particularly difficult when many genotypes are involved, such as when screening germplasm lines or advanced breeding lines. Therefore visual rating, generally done for plant diseases, becomes a very handy tool. A visual rating system for nodulation of field-grown chickpea plants is described here. It has been successfully used to evaluate genotypes at two contrasting sites in India: in a Vertisol at ICRISAT

Center (IC), Patancheru, India (18°N), and in an Entisol at Hisar, India (29°N).

The rating system has been developed over several years and is based on field experience. Forty-five-day old, field-grown chickpea plants of different genotypes showing a range of nodulation matching a rating of '1' to '5' were selected in the postrainy season of 1978/79. The lowest nodulation was rated '1' and the highest as '5'. Photographs of these plants (Fig. 1, copies available on request) were used as a reference for nodulation rating in future studies. This rating system was tested in field trials sown at the recommended spacing of 30 cm x 10 cm at Hisar with 18 genotypes (including two controls, K 850 and G 130) in three replications and at IC with 16 genotypes (including two controls) in four replications. The correlation between visual rating and nodule number was 0.79 at both locations, and between visual rating, and nodule mass it was 0.84 at IC, and 0.85 at Hisar (Table 1).

Use of a crowbar was most convenient for digging both types of soils. After loosening the soil around the plant(s), roots and nodules were removed from the soil with a small hand trowel (about 25 cm long blade) such that most of the roots and nodules were recovered. A 20-cm pointed metal rod with a handle was useful in heavy soils to break small clods containing roots and nodules. Ten plants from an inside row of each plot were removed for these observations. Soil adhering to roots and nodules from each plot was washed off before storing at 4°C for observations on nodule number, nodule mass, and visual rating. In Vertisols, it was generally possible to rate the plants without washing. Each plant was rated separately, and loose nodules recovered during digging were allocated equally to all the uprooted plants. Procedures followed to record nodule number and mass, shoot mass, and acetylene-reduction activity have been described by Giller et al. (1988).

To minimize variations across locations and within a genotype it is important that the test genotypes should be grown in a field having abundant effective chickpea rhizobia [at least 10^4 rhizobia (g soil)$^{-1}$], and that optimum soil moisture for nodulation should be present at germination and seedling stages, the test lines should preferably be grown in a field with low available soil-N (preferably less than 25 mg N kg^{-1}

Table 1. Correlation between nodulation, acetylene reduction, plant growth, and visual rating for nodulation of 18 chickpea genotypes at 106 days after sowing, Hisar, India, postrainy season 1978/79. (n = 54)

Character[1]	Nodule dry mass	Shoot mass	Acetylene reduction (μM)		Visual score
			Plant^{-1} h^{-1}	g^{-1} nodule mass[2] h^{-1}	
Nodule number	0.69***	0.64***	0.65***	0.34**	0.79***
Nodule dry mass		0.63***	0.84***	0.39**	0.85***
Shoot mass			0.48***	0.28*	0.63***
μM plant^{-1} h^{-1}				0.73***	0.80***
μM g^{-1} nodule mass h^{-1}					0.47***

1. μM = micro Moles.

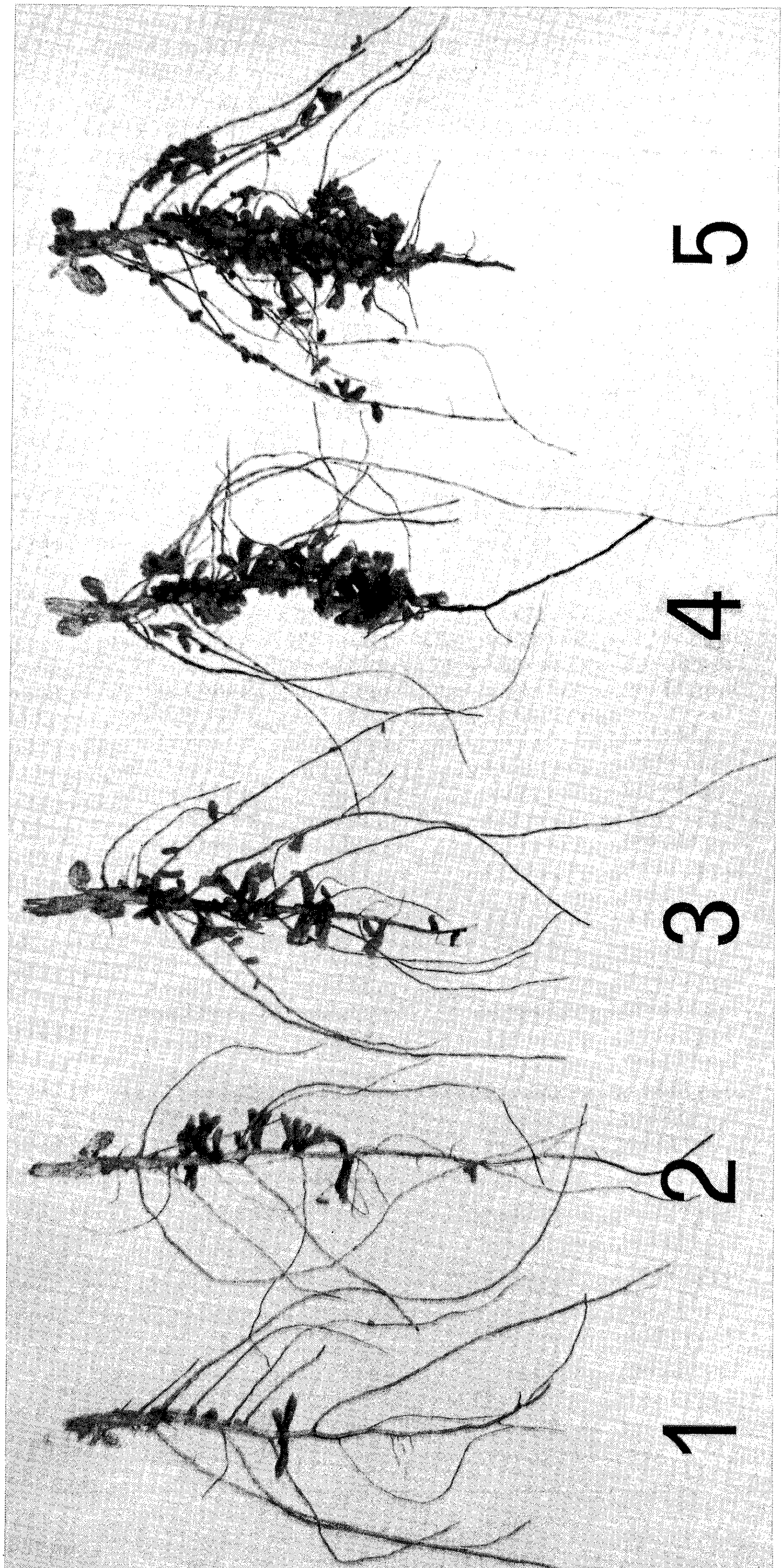

Figure 1. Visual rating scale for nodulation in chickpea.

soil), because mineral-N adversely affects chickpea nodulation (Jessop et al. 1984), and genotypes previously known for their rating should be included as controls. We have used a profusely nodulating line K 850, as a control and in ideal conditions as mentioned above, the rating was '4' or '5'. Its consistency in nodulation has been verified at IC (18°N), ICRISAT's Cooperative Research Station at Gwalior (26°N), and ICRISAT's Cooperative Research Station at Hisar (29°N). Although the reference photographs were taken from 45-day-old plants at IC these were found suitable for evaluation of 40-60-day old plants at IC, 60-80-day old plants at Gwalior, and 70-110-day old plants at Hisar. At Hisar, chickpea plants grow very slowly during the cold period (December - January), after sowing in early November. Thus, it is necessary to select the appropriate time for observation at different locations.

Chickpea nodules are firmly attached to roots, unlike in some other legumes such as pigeonpea, and therefore most of these can be recovered after careful digging. Most of the chickpea nodules in heavy soils such as Vertisols are formed in the top 15 cm and, therefore, excavation of root nodules and evaluation can be done confidently. In light soils such as Entisols, Inceptisols, or Aridisols, nodules can form below 15 cm, and these should be considered in the rating. However, with abundant soil rhizobia in the top 15 cm and optimumal soil moisture at sowing, even in light soils most nodules generally form in the top 15 cm.

The plants uprooted to observe nodulation could also be used to record appearance and growth of plant shoots, particularly when the nodulation ratings are extreme. Such information may be useful in identifying genotypes with high initial growth rates.

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Field Screening of Chickpea for Salinity Resistance

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Naturally saline fields often show great variations in salinity over short distances. This makes screening for salinity resistance in such fields very difficult. A method designed to overcome or even utilize this difficulty of soil variation is described by Saxena (1987) and involves sowing different chickpea varieties radially through saline patches, differences in growth occur along the line of sowing and these can be correlated with soil data for salinity. The method is interesting and useful for several purposes, but nonsuitable for large scale screening of germplasm and segregating populations. For such purposes we want a simple and reliable control as yardstick to compare all test material with.

Considering the difficulty because of variability in salinity over short distance, it was felt that one way to solve the problem perhaps would be by minimizing or removing the distance effect between the test material and the standard control. This can be done by sowing the test entry and the control

Figure 1. Screening for salinity resistance at Hisar, with test entry and control seed sown in the same hole.