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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References

Giller, K.E., Sudarshana, M.R., Thompson, J.A., and **Rupela, O.P.** 1988. Evaluation of ^{15}N-isotope dilution for measurement of nitrogen fixation in chickpea (*Cicer arietinum* L.). Biology and Fertility of Soils 6:347-351.

Jessop, R.S., Hetherington, S.J., and **Hault, E.H.** 1984. The effect of soil nitrate on growth, nodulation, and nitrogen fixation of chickpea (*Cicer arietinum*). Plant and Soil 82:205-214.

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.

both in the same plant hole at the same depth. Of course, the test entry and the control need to have distinguishing plant characteristics.

We tried the method in a saline field (mean EC value: 2.15) at Hisar, India, in an experiment during the postrainy season of 1988-89 (Fig. 1).

As test entries we had different progeny bulks from gamma-radiated chickpea cv ICCV 6. We used variety H 208, as a standard control that has reportedly some resistance to salinity (Chandra 1980). In addition we sowed, for comparison, barley, which is a salt-resistant crop. The sowing date was 10 Nov 1988. On 20 Mar 1989 and 5 Apr 1989 the plants were individually scored for salinity symptoms on a 0-5 score scale (0 = no symptoms; 5 = most severely affected). The plants were harvested separately, and the number of seeds and seed yield were determined for each plant.

To compare the test entries with the control, two methods were followed:

A. *Ratio*: The ratio of the data values for test entry and control entry was calculated, whereby, the larger value was the numerator and the smaller value the denominator. The sign of the ratio depended on which entry had the higher or lower value, e.g., for the salinity scoring we used,

$$R_S = \frac{C_S}{T_S} \quad (1a)$$

$$R'_S = -\frac{T_S}{C_S} \quad (1b)$$

C_S = Salinity score control entry
T_S = Salinity score test entry
$R_S : C_S > T_S \quad R'_S : C_S < T_S$

The deviation from unity (Δ) was calculated by subtracting 1 in the case of R and adding 1 in the case of R'.

The mean deviation value for the progeny was calculated as:

$$\Delta_S = \frac{\Sigma (R-1) + \Sigma (R'+1)}{n}$$

n = number of stands.

A high Δ_S meant a good salinity resistance of the test entry compared with the control.

For the seed number and yield we calculated:

$$R_{nr} = \frac{T_{nr}}{C_{nr}} \quad (2a)$$

$$R'_{nr} = -\frac{C_{nr}}{T_{nr}} \quad (2b)$$

T_{nr} = Seed number test entry
C_{nr} = Seed number control entry

$R_{nr} : T_{nr} > C_{nr}$
$R'_{nr} : T_{nr} < C_{nr}$

$$R_y = \frac{T_y}{C_y} \quad (3a)$$

$$R'_y = -\frac{C_y}{T_y} \quad (3b)$$

T_y = Seed yield test entry
C_y = Seed yield control entry

$R : T_y > C_y$
$R' : T_y < C_y$

High Δ_{nr} and Δ_y values mean a comparatively good salinity resistance of the test entry.

B. *Difference*: The difference of the data values for test entry and control entry was calculated as follows:

$$D_S = C_S - T_S \quad (4)$$

$$D_{nr} = T_{nr} - C_{nr} \quad (5)$$

$$D_y = T_y - C_y \quad (6)$$

C_S, T_S, t_y, T_y, C_{nr} and T_{nr} as in previous formula.

The ratio values indicate how much better or worse the test entry is than the control. The difference values estimate the distance between the scores on the 0-5 scale. The ratio and difference values supply different information. For instance, if the test entry has score 0.5 for salinity symptoms and the control entry, 1.0, apparently the control is twice as susceptible as the test entry, but the difference in salinity effect is minor; if the scores are 2.0 for the test entry, and 4.0 for the control entry, again the control is twice as susceptible as the test entry, but now the difference in salinity effect is considerable.

Table 1. Salinity scores, seed numbers, seed yields, and their ratios and differences for progeny bulk M3:5 (ICCV 6, RAD) in one replication of the screening experiment, Hisar, India, postrainy season, 1988/89. (Scoring date: 20 Mar 1989.)

No.of plant stand	Salinity score					Seed number					Seed yield (g)				
	T_S	C_S	R_S/R'_S	$\hat{}S_S$	DS_S	T_{nr}	C_{nr}	R_{nr}/R'_{nr}	$\hat{}_{nr}$	D_{nr}	T_y	C_y	R_y/R'_y	$\hat{}_y$	Dy
1	1.5	1.0	-1.5	-0.5	-0.5	45	12	3.74	2.74	33	5.2	0.8	6.50	5.50	4.4
2	2.5	3.5	1.4	0.4	1.0	16	10	1.60	0.60	6	1.3	1.0	1.30	0.30	0.3
3	2.0	3.5	1.8	0.8	1.5	32	32	1.00	0.00	0	3.9	2.4	1.63	0.63	1.5
4	1.5	2.0	1.3	0.3	0.5	25	28	-1.12	-0.12	-3	3.6	1.8	2.00	1.00	1.8
5	1.0	-	-	-	-	8	-	-	-	-	1.7	-	-	-	-
6	2.0	3.0	1.5	0.5	1.0	28	48	-1.72	-0.72	-20	3.1	3.2	-1.03	-0.03	-0.1
7	1.5	3.0	2.0	1.0	1.5	23	-	-	-	-	2.5	-	-	-	-
8	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
9	2.0	4.0	2.0	1.0	2.0	-	-	-	-	-	-	-	-	-	-
10	3.5	5.0	1.4	0.4	1.5	-	-	-	-	-	-	-	-	-	-
11	2.0	4.5	2.3	1.3	2.5	-	-	-	-	-	-	-	-	-	-
12	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
13	-	4.0	-	-	-	-	-	-	-	-	-	-	-	-	-
14	3.5	5.0	1.4	0.4	1.5	15	-	-	-	-	1.3	-	-	-	-
15	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
16	-	2.5	-	-	-	-	15	-	-	-	-	1.2	-	-	-
17	2.0	4.0	2.0	1.0	2.0	10	13	-1.30	-0.30	-3	1.4	0.9	1.56	0.56	0.5
18	3.0	-	-	-	-	11	-	-	-	-	1.1	-	-	-	-
19	1.5	2.5	1.7	0.7	1.0	25	70	-2.78	-1.78	-45	2.8	4.4	-1.56	-0.56	-1.6
20	1.0	2.0	2.0	1.0	1.0	11	50	-4.55	-3.55	-39	1.5	3.1	-2.08	-1.08	-1.6
n	5	5	13	13	13	12	9	8	8	8	12	9	8	8	8
SE	±0.20	±0.30	±0.26	±0.12	±0.21	±3.2	±7.0	±0.932		±8.9	±0.38	±0.42	±0.97	±0.71	±0.69
Mean	2.03	3.30	1.48	0.64	1.27	20.8	30.9	-0.641	-0.39125	-8.9	2.45	2.09	1.04	0.79	0.65
CV (%)	38.9	35.2	64.2	72.6	59.3	52.9	68.3	411.2		283.6	53.0	60.6	262.6	255.6	301.8

As an example the data for one progeny bulk $M_{3:5}$ (ICCV 6, Rad) are tabulated below for one replication in the Hissar experiment.

The tabulated data show, that the test entry had a significantly lower salinity score than the check ($t = 3.5$); it appears further that $\Delta_S \neq 0$ and $D_S \neq 0$, confirming that the ratio and difference values the data were significantly in favor of the test entry. For seed number such favorable significantly was absent, and also seed-yield ratios and differences were nonsignificant.

The salinity scores for test entry and control in the same plant hole were closely and positively correlated ($r = 0.81$; $n = 13$), which renders support to the usefulness of the screening method. For seed number the correlation was low (–0.06; $n = 8$), and for seed yield too (–0.06; $n = 8$). This may mean that the varietal difference in yield due to salinity is nonsignificant and variable. The correlation between Δ_S and D_S was positive and strong ($r = 0.87$; $n = 13$), and so was the correlation between o_y and D_y ($r = 0.87$; $n = 8$), which may suggest that only one of the two values is required for computations.

References

Saxena, N.P. 1987. Problems and prospects to screen and breed for tolerance to soil salinity: A case study with chickpea. Pages 115-120 *in* Adaptation of chickpea and pigeonpea to abiotic stresses: proceedings of the Consultants' Workshop, 19-21 Dec 1984, ICRISAT Center, India. Patancheru, A.P. 502 324, India: International Crops Research Institute for the Semi-Arid Tropics.

Chandra, S. 1980. Effect of edaphic factors on chickpea. Pages 97-105 *in* Proceedings of the International Workshop on Chickpea Improvement, 28 Feb to 2 Mar 1979, ICRISAT, Hyderabad, India. Patancheru, A.P. 502 324, India: International Crops Research Institute for the Semi-Arid Tropics.