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Evaluation of Safflower (Carthamus tinctorius) Genotypes for Salt Tolerance

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Abstract. A field experiment was carried out on a saline Vertisol (2.1-30 dS m^{-1}) of Gangavathi to screen eleven safflower genotypes for salt tolerance. The yield of safflower genotypes was correlated with time weighted mean salinity to compute yield maxima (Ym), threshold salinity (ECt) and slope (S). A-1, Nira and Manjira were found to perform better than other genotypes. The performance of A-1 was found to be superior over Nira and Manjira as salinity increased from 2.0 to 12.0 dS m^{-1}. The genotype Manjira which was promising under marginally saline conditions, suffered at higher salinity (beyond 10 dS m^{-1}).

Key words Vertisol, Salinity, Safflower, Evaluation

Edible oils are an nevitable part of a balanced nutritive diet and have become prohibitively costly. The prevailing crunch in oil supply and increasing demand requires to explore the possibility of bringing more area including salt affected soils under cultivation. Though safflower is reported to be highly salt tolerant (Weiss 1971), genotypic variations have been reported by Francois and Bernstein (1964), Rai (1977), Janardhan *et al.* (1986) and more recently by Gururaja Rao *et al.* (1987) in Vertisols of Karnataka. The data generated on screening of genotypes for salt tolerance on artificially salinized soils do not simulate the natural saline environment and are unrealistic. The present work was carried out to evaluate the genotypic variations of safflower for salt tolerance following Van Genuchten (1983) equation in a soil with natural salinity gradient that exists on a slopy land.

Materials and Methods

Eleven safflower (*carthamus tinctorius*) genotypes (Table 3) were sown during rabi 1990-91 in a Vertisol with natural salinity gradient ranging from 2.6 to 30.0 dS m^{-1}. The land was divided into 10 blocks measuring 5m in length. Each genotype was sown in a line and in all the salinity blocks with a spacing of 45x30cm. 360g urea, 1039g of single super phosphate and 140g of muriate of potash were applied in each plot prior to sowing. All the genotypes received same package of practices.

Soil salinity (0-30cm depth) of each plot was estimated in alternate rows at 0,20,40 and 108 days after sowing to compute the time weighted mean salinity for each salinity block and related to its respective yield using piece-wise linear regression function as proposed by Van Genuchten (1983). Accordingly Ym, ECt and S were calculated for each genotype. Based on these parameters, estimated yield levels of all genotypes at fixed salinity levels were calculated (Table 3) for the purpose of evaluation of genotypes.

The mean monthly maximum temperature ranged from 29.3°C in December 1990 to 37.2°C in March 1991. No rainfall was received during the crop growth period. Plant samples collected at 50 days after sowing were dried at 70-80°C in an oven and finely ground in a Wiley mill. Na and K content in root and shoot samples were determined in wet ashed extract using flame photometer. The yield and other growth parameters (Plant height, number of branches, number of capsules and test weight) were also recorded.

Results and Discussion

Germination : In general, germination percentage declined in all the genotypes with increase in salinity (Table 1). However there was improvement of germination with time except in case of JLSF 113, JLSF-118 and Bhima. The genotype Manjira recorded relatively higher percentage at all salinity levels (up to 10 dS m^{-1}) as compared to other

Table 1 *Effect of salinity on germination of Safflower genotypes*

Varieties	ECe (dS m^{-1})/days after sowing														
	5.0			7.5			10			18			20		
	6	8	21	6	8	21	6	8	21	6	8	21	6	8	21
Manjira	91	91	94	75	88	91	75	75	90	31	37	50	–	–	7
Tara	79	88	94	57	94	94	57	57	57	31	–	7	–	–	–
JLSF-113	88	94	94	69	88	88	57	64	64	–	–	–	–	–	–
JLSF-118	70	78	85	63	88	88	57	69	69	–	–	–	–	–	–
Bhima	67	91	94	63	68	88	54	63	81	–	–	13	–	–	–
S-144	88	91	94	81	81	82	63	64	70	12	12	50	–	7	7
A-300	81	94	95	87	90	90	68	88	88	12	43	50	7	7	7
A-1	63	94	96	63	81	90	60	63	91	7	43	50	–	7	7
Nira	60	94	96	45	80	92	20	50	69	7	18	31	–	–	7

genotypes while, in case of A-1 the germination progressively increased with time and salinity level as well. The highest germination (91%) at 10 dS m^{-1} was recorded by A-1, but at increased level of salinity (18 dS m^{-1}) it recorded only 50 % of germination along with A-300, S-144 and Manjira. Francois et al. (1989) opined similar effects on germination in Rye plants.

Growth and yield parameters : The data on plant height, number of branches and number of capsules per plant were recorded for only a few selected genotypes (Fig.1). The maximum plant height (52.1 cm) in salinity range of less than 4 dS m^{-1} was recorded by genotype A-1 and that of lowest (43.1 cm) was in Tara (Fig 1). When the salinity level was more than 8 dS m^{-1}, Manjira recorded a maximum plant height (38.8 cm) while the lowest (31.2 cm) was in Tara. The plant height was also found to decrease in all genotypes with increase in salinity (Fig.1).

The number of branches and capsules plant^{-1} decreased with increase in salinity in most of the genotypes tested. However, genotype A-1 recorded a higher number of branches and capsules plant^{-1} than Manjira at salinity range of 8 dS m^{-1}.

The test weight (1000 seed weight) was almost same in all the genotypes. It was slightly higher in A-1 and lower in S-144. Manjira also recorded fairly higher test weight (4.6g).

Mineral analysis : The Na/K ratio (Table 2) was higher in root than in shoot at both salinity ranges in all the four genotypes. The Na/K ratio increased in both root and shoot of Manjira with increased salinity whereas a reverse trend was observed in case of others. Increased uptake of Na over K as evidenced by higher Na/K ratio made Manjira susceptible to salinity. In case of A-1, the decrement in the Na/K ratio was higher than other two genotypes Tara and Nira. This explains the possible selective ion-exclusion mechanism that operates in case of A-1, where K is compensated for Na, thus reducing the Na/K ratios. From these results, it was quite evident that A-1 was selectively more tolerant to soil salinity. Sharma (1989) attributed suscep-

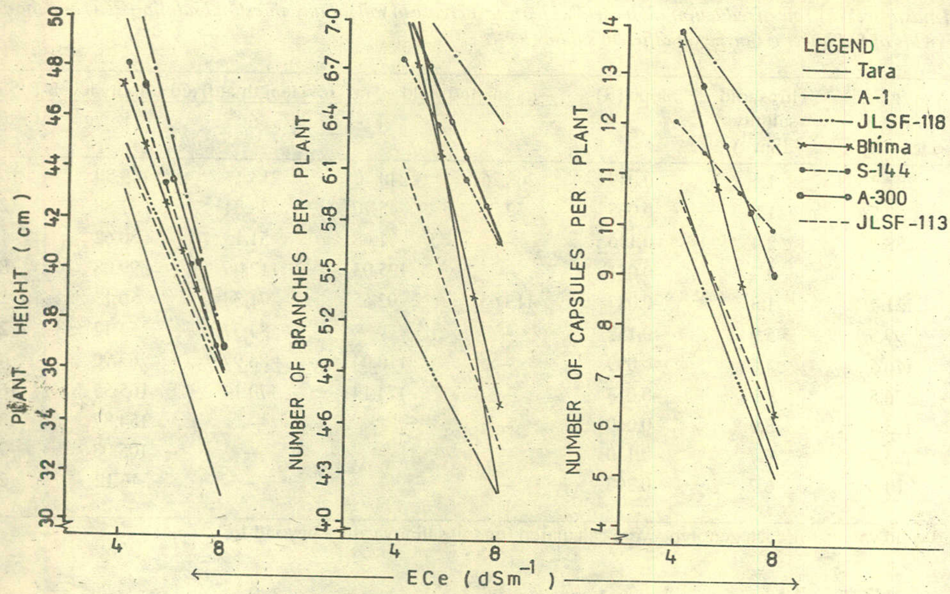

Fig.1 Effect of salinity on growth and yield parameters of safflower

tibility of certain wheat and rice genotypes respectively to the increased Na/K ratios.

Table 2 *Na/K ratio of some safflower genotypes in two salinity ranges*

Variety	plant part	Soil salinity range (ECe dSm^{-1})	
		0 – 6.0	6.0 – 10.0
Manjira	Root	1.57	4.36
	Shoot	0.88	0.96
Nira	Root	6.40	2.30
	Shoot	1.11	0.68
A-1	Root	3.14	1.60
	Shoot	1.30	0.78
Tara	Root	5.60	2.74
	Shoot	1.00	0.73

No definite relation was found between leaf osmotic potential and salt-tolerance of various genotypes under investigation.

Van Genuchten Parameters : Quantitative parameters (Table 3) evolved by Van Genuchten (1983) were computed for all the genotypes to screen them for salt tolerance. An ideal genotype would be one with high yield maxima (Ym), high threshold value (ECt) and lower slope (S). But in nature, it is difficult to find a genotype combined with all these quantitative characters. Out of 11 genotypes tried, A-1, Nira and Manjira performed well in the entire salinity range from 2 to 10 dS m^{-1}. The varieties had relatively higher yield maxima and lower slope as compared to other varieties. However, the genotype A-1 ranked first in its overall performance despite of lower yield maxima than Manjira, because of better performance at higher salinity (beyond 10 dS m^{-1}) and higher threshold value (Table 3). The genotype A-1 also recorded good germination and lower Na/K ratios in the shoot samples contributing to salt tolerance. At lower salinity (< 4.0 dS m^{-1}) the genotype Manjira was found most promising but become susceptible at higher salinity as evidenced by higher Na/K ratios. The varieties JLSF-113, BLY-652 and Tara performed very poorly and were found to be unsuitable for cultivation under saline conditions.

Table 3 *Yield maxima (Ym), rate of reduction (S) in yield with a unit increase in soil salinity, threshold salinity (ECt) and the estimated grain yields of Safflower genotypes at different salinity levels*

Genotypes	Ym (g $5m^{-1}$ row length)	Threshold salinity (dSm^{-1})	Slope (S)	Estimated yield g $5m^{-1}$ row length at fixed salinity levels (dS m^{-1})				
				2	4	6	8	10
Manjira	281.2	1.1	–0.049	268.26	240.70	213.14	185.59	160.28
Tara	53.5	1.8	–0.065	52.75	45.70	38.84	31.88	24.82
JLSF-113	88.5	2.4	–0.116	–	71.68	51.15	30.62	10.62
JLSF-118	127.2	3.7	–0.051	–	125.03	112.06	99.08	86.11
Bhima	121.4	1.3	–0.087	113.63	92.55	71.38	50.13	29.13
S-144	99.5	5.0	–0.152	–	–	84.37	54.12	23.88
A-300	116.5	3.4	–0.099	–	110.04	86.97	63.90	40.77
A-1	176.5	3.2	–0.013	–	174.14	170.14	165.55	160.92
Nira	155.4	8.0	–0.069	–	–	–	154.87	133.48
HUS-309	125.4	6.7	–0.130	–	–	–	105.08	72.73
BLY-652	61.5	6.7	–0.200	–	–	–	46.12	21.03

Note : Estimated yield values for each genotype were calculated for soil salinity values beyond ECt.

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