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Influence of Sowing Methods on the Productivity of Canola Grown in Saline Field

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Abstract: Field experiment on canola was conducted in saline field at Agricultural Research Institute (ARI) Tarnab during 1997-98. The field was silty clay having 0.69 percent organic matter and was alkaline (pH, 8.84) in reaction. SAR was 2.23 and lime content was 20.25%. Canola was sown using four different sowing techniques included drill, broadcast, furrow and ridge with 4 replication in random arrangement. The results showed that highest grain yield *and* yield components were recorded when seed were grown with ridge sowing. Grain yield in ridge sowing was higher by 45, 31 and 28% than broadcast, drill and furrow sowing method, respectively. The highest grain yield (1119 kg ha^{-1}) may be associated with less saline environment in ridges as irrigation next to the seed row caused movement of salts away from the seeds and into the ridges. This allowed the seed to germinate and establish in less saline conditions thereby increasing yield. The lowest grain yield (618 kg ha^{-1}) of canola produced with broadcast sowing may be associated with higher salt content in soil solution due to evapotranspiration.

Key words: Canola, salinity, sowing methods and ions analysis

Introduction

Introduction of Canola (*Brassies napes*) under the local name ghobi sarsoon is recent and its cultivation is mostly confined to NWFP, Rapeseed first grown in 1942 for use as lubricant was introduced as an edible oil in 1956. The major producing countries are Canada, China, Sweden, Poland and India. The name canola represents a unique type of rapeseed whose seed has certain quality standards. Canola containing 40 to 45 percent oil and 36 to 40 percent protein meal (Hatim and Abbasi, 1994). The oil and meal are now acceptable as alternative to soybean oil and meal. World canola production is about 22 million tones which is about 10 percent of the world production of vegetable oil seed. About 45 million tones of canola enter world trade annually (Quresh *et al.,* 1994).

The increase in domestic production of edible oil is stagnant (3 percent per annum). Increase consumption is due to rapid growth of population (3.3 percent per annum), increasing trend in urbanization and decreasing per capita of animal fat. If the current trend of edible oil consumption continue with increasing demand in international market prices, the edible oil import will double. This makes it necessary to explore means and ways for enhancing yield, bringing new area under cultivation and also utilizing marginal land with certain management practices. In this regard, non-conventional new crops can be grown on marginal land to test their productivity and to find out ways and means for increasing their production on marginal land.

Pakistan being in arid and semi-arid regions, has 5.8×10^6 ha salt affected area of which 2.5 m ha is saline, 3.2 m ha is saline sodic and the remaining is sodic soil. In NWFP, 0.5 m ha soil is salt-affected, which mainly occur in Mardan, Bannu and D.I.Khan area (Chaudhry *et al*., 1978). Approximately, 78.5 percent of the salt affected soil occur in the hot arid zones and the rest are in the sub-humid zones. Excessive salt accumulation has adversely affected the physico-chemical properties of soil, reducing the yield of agricultural crops to varying degrees.

Some rape and mustard cultivars have been reported to be capable of growing on saline soils and drought condition. This can have a great economic potential if its yield can be increased under stress condition and marginal lands with proper management practices (Khan and Agarwal, 1988; Khan, 1989; Chauhan *et al*., 1988; Mohamedali, 1988; Bhagat *et al*., 1989).

The present investigation was therefore, undertaken with a view to find out the salt tolerance of canola and test its growth potential on saline soils. The effort could serve two possible purposes, (i) increasing the edible oil supply in the country from the marginal land and (ii) biological utilization of saline soil where common agriculture is not economically feasible.

Materials and Method

An experiment was conducted in saline field at Agric. Res. Institute (ARI) Tarnab, Peshawar. The soil of the experimental site was silty clay and alkaline in reaction (pH 8.48) and contained 0.69 percent organic matter. The soil varied in salinity, and sodicity. The results of the physico-chemical properties are given in Table 1.

Table 1: Physico-chemical properties of saline field at Agricultural Research Institute (ARI) Tarnab Peshawar

Soil properties	Values	Units
Sand	4.96	%
Silt	54.00	%
Clay	41.04	%
Soil texture	Silty clay	-
Lime content	20.25	%
Organic matter	0.69	%
pH of saturated paste	8.48 (alkaline)	
ECe of saturated extract	4.5	ds m^{-1}
Soluble Na^+	12.65	mmol L^{-1}
Available K^+	0.87	mmol L^{-1}
Soluble Ca^{++} + Mg^{++}	32.10	mmol L^{-1}
Cl^-	13.59	mmol L^{-1}
SAR	2.23	-

Experimental details: The field was thoroughly prepared as required for canola sowing. The field was cleaned off weeds and surveyed for salinity by EM-38 on 5X5 horizontal grid system. The experiment was replicated four times at varying salinity environments of the field, with replication 1 in low saline area (3.47 dS m^{-1}) relative to the filed salinity followed by replication 2 (4.70 dS m^{-1}), 3 (5.71 dS m^{-1}) and replication 4 was grown on high salinity site (6.54 dS Sm^{-1}) of the field. The canola variety Dunkeld was sown in treatment plots, having 5 m length and 4 m width in first week of November 1997-98. Strong partitions were made to separate main plots to avoid the over flow of irrigation water. The crop was grown by a) drill b) broadcast c) furrow and d) ridge method of sowing.

Nitrogen at the rate of 60 kg ha^{-1} and P as P_2O_5 at the rate of 60 kg ha^{-1} was applied as urea and DAP. Full dose of P was added at the time of sowing while the remaining N was supplied through urea during flower initiation.

Field salinity per treatment per replication was determined by taking soil samples at 30 cm depth at the time of harvesting. At boot stage, 5 young and fully expanded leaves per treatment from all replications were collected for Na^+, K^+, Ca^{2+} and Mg^{2+} determination. The following plant characters were observed during the experiment:

Plant height: Plant height was measured with a meter rod from ground level to the tip of the plant. Five plants per treatment were selected for recording plant height and the mean was calculated. Number of plant/m^2: The number of plants per m^2 were counted by using square meter in the field.

Number of pods: The data for number of pods per plant per treatment were recorded by selecting 20 plants for counting the pods.

Number of seeds/pod: Fifty pods per plant and 10 plants from each treatment were taken, threshed and the number of seeds per pod were counted.

1000 grain weight: Thousand grain weight per treatment of the canola crop was recorded by using an electronic balance.

Grain yield: After threshing and cleaning, all grains were weighed to record grain yield per treatment for all the replications.

Biological yield: Harvested crop which included seeds + stem + leaves were weighed after drying in the sun to record biological yield in kilograms per hectare.

Soil analysis: Soil samples collected from the field were air dried and then thoroughly ground with the help of mortar and pestle, passed through < 2 mm sieve and all the standard procedure were used for the salinity measurement as described in Richards (1954). Soil texture, lime and organic matter contents were determined by following Jones (1989).

Plant analysis: Just before initiation of flowers, five fully expanded leaves were collected for ions determination. Before analysis, the plant material was washed twice with distilled water to clean it from dirt and dust. After air drying, the leaf samples were oven dried for 24 hours at 70°C, ground and stored for analysis. The finely ground leaf sample of 250 mg was digested with 1 ml HNO_3 solution over night (Rashid, 1986) and after boiling, the volume was made to 50 ml. Leaf tissue conc. of Na^+, K^+, Ca^+ and Mg^+ in the diluted aliquot were estimated by flame photometer.

Statistical analysis: All the data were analyzed using the randomized complete block design. Means of the data were compared using least significance differences (LSD) test. MSTAT (Microcomputer Statistical Program) was used to analyze the data.

Results and Discussions

Plant height and number of plants/m^2: Sowing methods showed significant (PL˙0.05) effect on plant height of canola grown in saline field (Fig. 1). Tallest plants were produced in the ridge sown plots, while shortest plants were produced with furrow sowing, followed by broadcast and drill sowing methods. The results of furrow and broadcasting methods were statistically non significant. The superiority of ridge sowing method in term of good crop stand under saline condition are reported by Boem *et al.* (1994), Mohamedali (1988) and Chauhan and Singh (1993). Analysis of variance regarding number of plants/m^2 indicate significant ($p \leq 0.05$) effect of sowing methods. Highest counts for number of plants/m^{-1} of canola were noted with ridge sowing, while the lowest counts were recorded with broadcast sowing (Fig. 2). Initially, at the time of germination, there were more seeds germinated but later on due to high salinity in the root zone, fewer plant survived in broadcast sown crop. This result is an agreement with the work of Boem *et al.* (1994).

Number of seeds/pod and number of pods/plant: Analysis of variance regarding number of seeds/pod exhibited that number of seeds/pod was significantly affected by sowing methods (Fig. 3). Similar to number of plants/m^2, higher counts of seeds/pod were recorded in the ridge sown plots, while the lowest counts were noted in broadcast sown plots. Furrow sowing was next to ridge sowing, showing that salt concentration in the root zone is minimum in the ridge and furrow sowing methods. This result of higher number of seeds per pod under low field salinity is supported by Boem *et al.* (1994).
Similar to seeds per pod, number of pods per plant play a major role in yield. Fig. 4 shows the number of pods per plant which were significantly ($p \leq 0.05$) affected by sowing methods. Maximum pods per plant were produced by ridge sown plants. The results for rest of the three methods were statistically non significant. This may be one of the reason of higher grain yield in ridge sown plants. Comparable results were obtained by Singh and Verma (1993), Boem *et al.* (1994) and Sinha (1995).

Biological yield (kg/ha): The result of biological yield as affected by different sowing method is presented in Fig. 5. The results were significant at 5 percent level of probability. Maximum biological yield was observed in ridge sowing method which was at par to drill sowing method. The lowest biological yield was found in furrow and broadcast method. The highest biological yield is due to low salt concentration in root zone of the crop providing the crop essentially less saline environment in the root zone as shown by the post harvest values of ECe. Khan (1989) also reported higher brassica yield when the crop was grown on ridges under saline condition.

1000 grain weight and grain yield: One of the economically most important yield parameter of the crop, the 1000 grain weight and grain yield as affected by sowing method are shown in Fig. 6

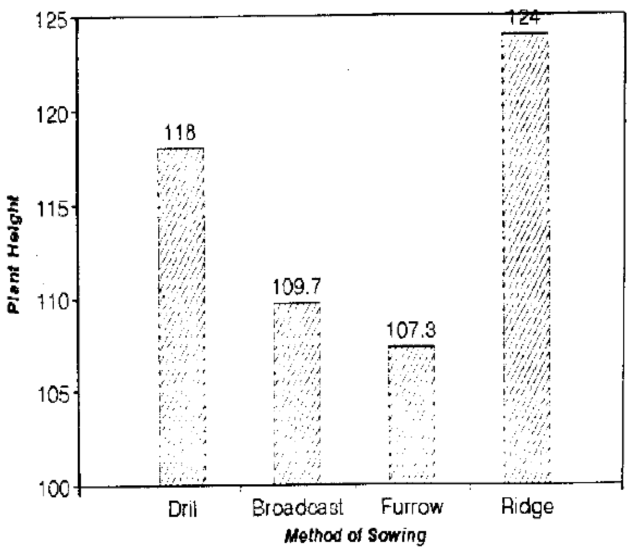

Fig. 1: Plant Height (cm) as Affected by Method of Sowing in saline condition

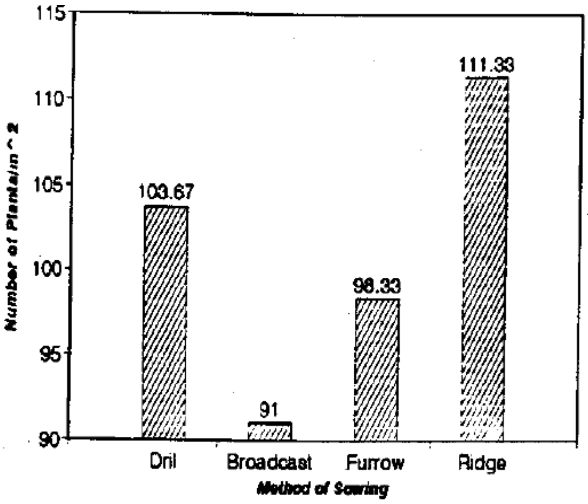

Fig. 2: No. of plants/m^2 as Affected by Method of Sowing in Salline Condition

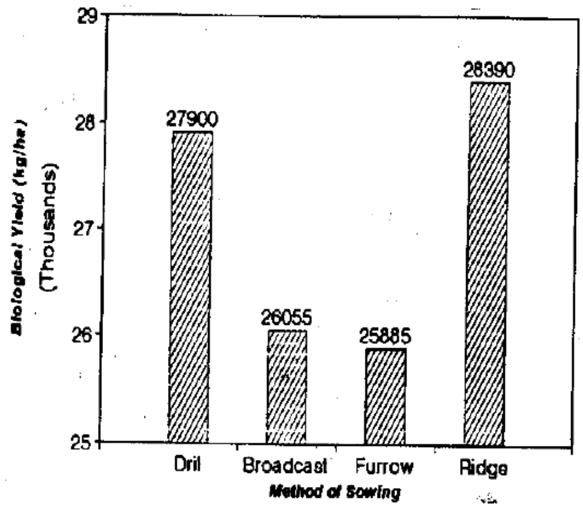

Fig. 5: Biological yield as Affected by Method of Sowing in Saline Condition

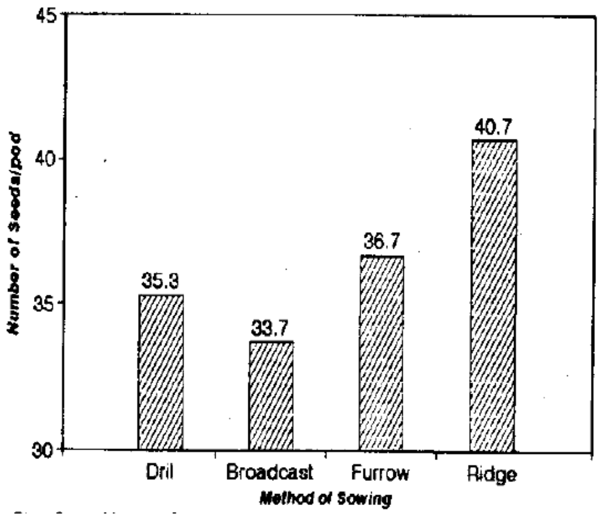

Fig. 3: No. of Seeds pod as Affectcd by Method of Sowing in Salline Condition

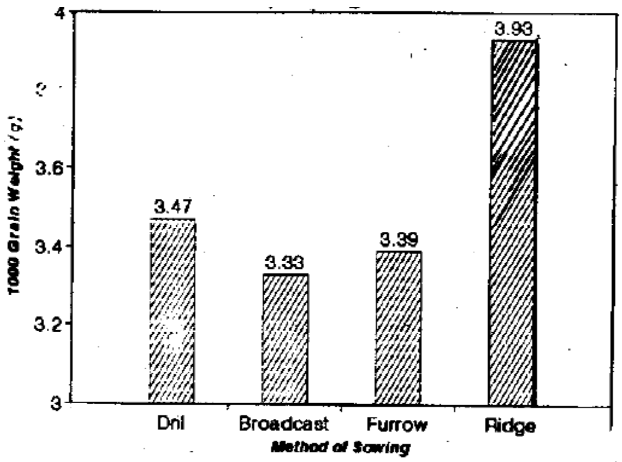

Fig. 6: 1000 Grain weight as Affected by Method of Sowing in Saline Condition

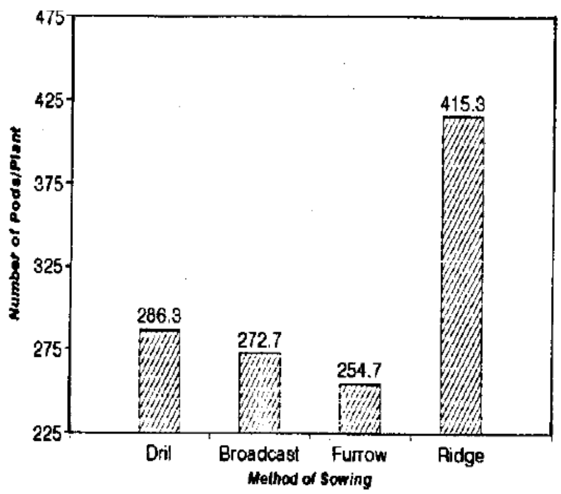

Fig. 4: No. of Podsiplant as Affected by Method of Sowing in Saline Condition

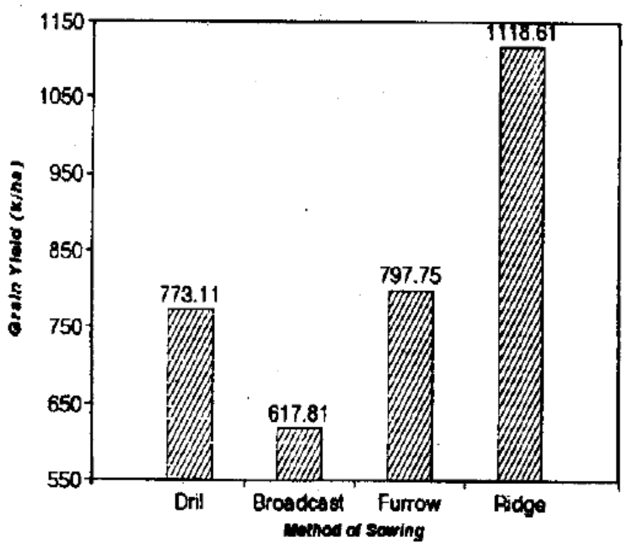

Fig. 7: Grain Yield as Affected by Method of Sowing in Saline Condition

and 7 respectively. Analysis of variance regarding 1000 grain weight was highly significant ($p \leq 0.05$). Crop grown with ridge sowing method showed significantly highest 1000 grain weight as compared to drill sowing and furrow sowing, while broadcast sown crop produced lowest 1000 grain weight. The results of the drill, furrow and broadcast sowing method were at par. Mohamedali (1988) and Hassan and Hassan (1994) found that furrow sowing method was superior to broadcasting.

Similarly, maximum grain yield of 1119 kg ha^{-1} was obtained when crop was grown on ridges which was significantly higher than rest of sowing methods (Fig. 7). There were no significant differences between furrow and drill sowing methods. The lowest yield was obtained when the seed was broadcasted. Bhagwandin and Bhatia (1990) while comparing ridge sowing with furrow or seed sown on flat beds found maximum graind yield on ridge sown crop than flat beds. Similar results were reported by Francois (1994), Khan and Agrawal (1988), Redmann *et al.* (1994), Sinha (1995) and Gaffer and Ali (1990).

Concentration of Na^+, K^+ and K^+/Na^+ ratio in canola leaf: Analysis of variance regarding Na^+ concentrations of canola showed a significant ($p \leq 0.05$) variations with sowing methods. From Table 2, it is evident that the maximum concentration of Na^+ was accumulated by canola grown by broadcast method followed by drill and furrow sowing techniques. The lowest leaf Na^+ was accumulated in ridge sown crop. This may be the possible reason of superiority of ridge sown crop over rest of the methods in saline field and which provide plausible explanation of better yield and other variables under ridge sowing. Results of low yield due to high Na^+ uptake in saline conditions was also noted by Khan (1989) and Huang and Redmann (1995).

Analysis of variance regarding Leaf K^+ concentrations of canola grown in a saline field environments showed a significant ($p \leq 0.05$) variations with sowing methods. From Table 2, it is clear that the maximum K^+ was accumulated by canola sown on ridges. Lowest K' concentrations was accumulated by canola grown by broadcast sowing. Mean values also indicate that drill and furrow sowing methods were not different significantly. One way of tolerance to salinity is maintaining high leaf K^+ and low Na^+ concentrations. The reason of high yield in ridge sowing may be due to high leaf K^+ concentrations This result is supported by the observations reported by Khan (1989) and Huang and Redmann (1995).

Table 2: Concentrations of Na^+, K^+ and K^+/Na^+ ratio of canola leaf as affected by sowing methods under saline field conditions

Sowing methods	Leaf Na^+ (%)	Leaf K^+ (%)	Leaf K^+/Na^+ ratio
T_i Drill	0.89 b	0.84 b	0.94 b
T_2 Broadcast	1.04 a	0.74 c	0.73 c
T3 Furrow	0.87 b	0.86 b	0.99 b
T_4 Ridge	0.66 c	1.00 a	1.52 a
LSD (≤ 0.05) =	0.088	0.050	0.088

Means followed by the same letters are statistically non significant at 5 percent level of probability.

Analysis of variance regarding leaf K^+/Na^+ ratio of canola grown in saline field condition showed a significant ($p \leq 0.05$) variations with sowing methods (Table 2). The highest leaf K^+/Na^+ ratio by canola sown on ridge, while the lowest leaf K^+/Na^+ ratio was noted in canola grown by broadcast method. Plant maintaining high K^+/Na^+ ratio exhibit tolerance to salinity. In present study, it was proved that high yield in ridge sown plot was due to maintenance of high ratio of K^+/Na^+ in leaves. Similar results of maintaining higher K^+/Na^+ ratio were reported by Khan (1989) and Huang and Redmann (1995).

Post harvest electrical conductivity (ECe) of soil saturation extract: Data regarding post harvest ECe of each treatments are given in Table 3. The value of ECe were significantly ($p \leq 0.05$) affected by methods of sowing. Low ECe values were recorded in ridge sown plot while maximum EC was observed in the broadcast sown plot. The reason of high production in ridge sown crop may be associated to the lower ECe values. In ridges, irrigation next to the seed row causes movement of salts away from the seeds to the top of the ridge, leaving the seeds to germinate and establish in essentially a less saline conditions thereby increasing yield. This results is an agreement to the work of Khan and Agrawal *et al.* (1988), Khan (1989) and Francois (1994).

Table 3: Post harvest electrical conductivity (ds/m), of the saline field at Agricultural Research Institute, Tarnab Peshawar

Sowing methods		Electrical conductivity
(ds/m)		
T_1	Drill	5.18 b
T_2	Broadcast	6.56 a
T_3	Furrow	4.87 b
T_4	Ridge	3.35 c
LSD	(≤ 0.05) =	0,78

Means followed by the same letters are statistically non significant at 5 percent level of probability.

Correlation between canola grain yield and leaf Na, K and K/Na ratio: Grain yield correlations were made with ECe, leaf Na^+, K^+ and K^+/Na^+ ratio. It is clear from the relationship studies (Table 4) that ECe and leaf Na^+ were negatively significantly correlated with grain yield while there was positive significant correlation between leaf K^+ concentration and K^+/Na^+ ratio.

A negative significant correlation of leaf Na^+ and positive significant correlation of leaf K^+ and leaf K^+/Na^+ ratio with grain yield suggested that canola plant that accumulate more Na^+, had poor yield and plants which accumulated more K^+, in their leaves had higher grain yield. It is assumed that reduction in yield of the crop at high salinity levels were due to excessive Na^+ uptake of the crop. Khan (1989) and Sharma and Gill (1994) also supported these findings.

Table 4: Relationship between canola grain yield with leaf ions and ECe as affected by sowing methods grown in saline field

Plant characters vs. yield	Carrel -ation	Regression constant (a)	Regression constant (b)	Probability
Leaf Na^+	-0.987**	1.73	-0.012	0.003
Leaf K^+	0.986**	0.25	0.008	0.004
Leaf K^+/Na^+	0.995**	-0.85	0.025	0.001
Soil ECe	-0.984**	13.52	-0.116	0.004

Conclusions and recommendations: Highest grain yield and yield components of canola were recorded when the crop was grown with ridge sowing method suggesting the movement of salt up towards the top of the ridge with evaporating water, thus leaving behind salt free root zone. The increase in grain yield in ridge sown crop was higher by 45, 31 and 28 % than broadcast, drill and furrow sowing methods respectively.

Sodium concentrations in soil and leaves decreased while K/Na ratio and K concentration in soil and leaves increased in ridge sown crop suggesting that maintenance of high K concentration in leaves and low concentration of Na may be the possible reason of higher production of the crop grown on the ridges than other sowing techniques. There was a positive significant correlation between canola grain yield with leaf K^+, $K^+/Na+$ while negative significant correlation with leaf Na^+ and electrical conductivity. Thus for getting good yield of canola under saline condition, crop should be grown on the ridges as the salt will move to the top of the ridge leaving behind less saline environment.

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