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RICE YIELD IMPROVEMENT THROUGH VARIOUS DIRECT SEEDING TECHNIQUES ON MODERATELY SALT AFFECTED SOIL

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ABSTRACT

Rice is usually cultivated under flooded conditions by transplanting, an expensive, time consuming and required significant labour pool as compared to the direct seeded rice. Canal water is not satisfying the required demand and ground water at most of the places is unfit for irrigation except some patches. Under prevailing conditions, direct seeded rice is the ultimate strategy for optimum production of rice. Assessment of the different sowing techniques viz. broadcast, ridge and drill sowing and different fertilizer rates on the paddy yield on moderately salt affect soil was executed through field experiments at Research Farm of Soil Salinity Research Institute, Pindi Bhattian, district Hafizabad, Punjab during 2010-2012. Three methods of sowing i.e. ridge, drill and broadcast sowing and five N levels viz. T_1: farmer practices (80-60-0 NPK kg ha^{-1}), T_2: Recommended dose (RD) (110-90-60 NPK kg ha^{-1}), T_3: 75% N of RD, T_4: 125% N of RD and T_5:150% N of RD.Trial was laid out in split plot arrangement with three replications. Results revealed the better growth and development, yield attributes and ultimately the highest paddy yield (4.46 t ha^{-1}) at 150% N of recommended dose fromridge sowing followed by 125% N of recommended dose with 4.35 t ha^{-1} production. Among the sowing techniques, ridge sowing proved the best with all growth, development and yield parameters at the optimum followed by drill sowing. Studies concluded that the effect of various sowing techniques, N rates and their interaction was significant on yield components of direct seeded rice. Nitrogen rate @ 150 % N of RD gave the maximum yield which was statistically at par with the 125% N of RD. Among sowing techniques, ridge sowing proved superior followed than drill and broad cast sowing.Slight decrease in EC_e and SAR was observed with drill sowing at higher rates of N i.e. 125 and 150% of RD.

Keywords: Direct seed rice, nitrogen rates, sowing methods, paddy yield, Salt affected soil, Rice.

INTRODUCTION

Rice, the second major cereal after wheat, the staple feed for almost half of the world population has been cultivated traditionally in flooded conditions (Bouman, 2003a). Rice is very well known due to its high delta of water requirement. The scarcity of water and poor quality ground water results a setback for the crop sector. It is predicted that massive water scarcity reduced sufficient available water for crop growth and severe decline in rice production under flood conditions. In Asia, it is estimated that >20% of irrigated rice would face severe water shortage up to 2025 (Tuong and Bouman, 2003). Resultantly, flooded conditions are impractical and no more right choice for rice cultivation.

The water shortage for rice production can be managed by system of rice intensification (Stoop *et al.,* 2002), alternate wetting and drying (Tabbal *et al.,* 2002; Zhao *et al.*, 2006, Juraimi *et al.*, 2009), saturated soil culture (Juraimi *et al.*, 2010) and aerobic rice cultivation (Bouman, 2003b). Aerobic rice cultivation means growing rice in puddle-less soil without standing water is the ultimate approach to economize water (Anwar *et al.*,2010; Javaid *et al.,* 2012) and soil water is kept at field capacity. Direct seeded rice reduced percolation, evaporation losses and surface runoff (Singh and Chinnusamy, 2006) and saved significant amount water for irrigation (Wang *et al.*, 2002; Zhao *et al.*, 2006).

Rice seedlings are usually transplanted after growing nursery and in puddled soils to avoid more percolation. The puddling of rice fields besides its own benefits also degrades soil physical conditions and creates problems for the subsequent upland crops. There is dire need of research to establish rice without puddling and transplanting. Transplanting is expensive, lengthy and laborious. A rice establishment system is required which is cost effective and produced paddy yield at par to the conventional transplanting (Ehsanullah *et al.,* 2007).

Direct seeding of rice is an outstanding, efficient substitute of transplanting with minimum expenses and other related problems (Mehmood *et al.*, 2002). Direct seeded rice also has the same yield potential as compared to the conventional transplanted rice with efficient agronomic management strategies (Ikeda *et al.*, 2008). Direct seeded rice not only save money, time and labour but also has more seedlings distributed uniformly in the field (Sarwar *et al.*, 2013). Besides, the benefits of direct seeded rice, many areas need to be explored like nutrient uptake especially nitrogen (Zhang and Wang, 2002;

Yadav*et al.,* 2007), weed management and other agronomic issues (Zhao *et al.,* 2006).

Significant high yields of direct seeded rice can be obtained by applying optimum nutrients at proper time. The cultivation of direct seeded rice and transplanted rice was compared and concluded that direct seeded rice required proper management practices at proper time to get high yields and nitrogen use efficiency. Strategies like balanced plant nutrition involved site specific nutrient management, timing and splitting of nitrogen must be opted to ensure better yields (Zhang and Wang, 2002). The fertilizer scheme of transplanted rice needs to be re-visited for direct seeded rice (Yin *et al.,* 2004). Direct seeded rice has shallow root system and ultimately low N-uptake would affect the paddy yield. A proper fertilizer scheme for the direct seeded rice should be followed for the enhanced paddy yield and proper utilization of nitrogen avoiding the losses. Field studies (for three years) was carried out to assess the different sowing techniques viz. broadcast, ridge and drill sowing and different fertilizer rates on the paddy yield on moderately salt affected soil.

MATERIALS AND METHODS

Field experiments were conducted at Soil Salinity Research Institute, Pindi Bhattian, district Hafizabad during 2010-2012. The experimental site is placed on the northwestern border of Rechna Doab (co-ordinates: 73°20′50.2″ E. 31°52′34.2″ N.). The experimental site was prone to salinity / sodicity from year's having textural class sandy loam and situated at an altitude of 212 m above mean sea level with mean precipitation about 500 mm. Rice-wheat rotation is commonly prevails with average rainfall of 500 mm year^{-1} and phreatic surface is at 2m depth. The average maximum / minimum temperature and rainfall during direct seeded rice crop growth period during the entire course of study are presented in Table 1(Ahmad, 2002).

Soil samples were analyzed (0-15 cm and 15-30 cm) to determine the salinity / sodicity level of the field (Table 2). A moderately saline-sodic field was selected, ploughed and leveled. Site of the present study was reclaimed seven years earlier and followed rice-wheat rotation before conductance of experiment. Experiments comprised of three methods of sowing i.e. ridge, drill and broadcast sowing and five nitrogen levels viz. T_1: farmer practices (80-60 NP kg ha^{-1}), T_2: Recommended dose (110-90-60 NPK kg ha^{-1}), T_3: 75% N of RD, T_4: 125% N of RD and T_5:150% N of RD laid out in split plot design with three repeats. Rice cultivar NIAB-IRRI-9 was used as test variety. Seeds were sown at 30 cm apart in case of ridges and drill sowing with seed rate @ 37 kg ha^{-1}. Full dose of phosphorus as SSP and potassium SOP were applied at sowing time (on 24th of June, 2010 and repeated in 20th June 2011 again repeated in 27th June 2012) while nitrogen as urea in two splits, half at sowing and half after 30 days after sowing. Agronomic practices and plant protection measures were kept uniform. Soil samples were collected before sowing and after harvesting of the crop from depth of 0-15 cm and 15-30cm for analysis of soil (Table-2). Total numbers of ten irrigations were applied to direct seeded rice and monitored regularly each year and flooded condition was avoided. One spray of weedicide i.e. Isoproturon 50WP @ 500 mL acre^{-1} was applied on moist soil after 30-35 days of planting each crop. To control the leaf folders, insecticide Confidor 200 SL (Imidacloprid) @ 300 mL acre^{-1} and Karate 2.5 EC (lambda-cyhalothrin) @ 300 mL acre^{-1} was applied to each rice crop. Data regarding yield and yield components were recorded at harvesting (harvesting dates for three consecutive years i.e. 28-10-2010, 31-10-2011 and 29-10-2012, respectively). Data of each parameter recorded different in each year were pooled and subjected to statistical analysis. The pooled data were analyzed by analysis of variance (ANOVA) (Steel *et al.,* 1997) and differences among the means were compared by applying the Duncan's multiple range tests (Duncan, 1955).

RESULTS AND DISCUSSION

Results revealed that yield components like plant height, number of tillersm^{-2}, number of grains panicle^{-1}, panicle length and paddy yield increased significantly with increasing nitrogen rates (Table 3, 4 and Figure 1). While among the sowing techniques, ridge and drill sowing were found superior than broadcast sowing.

The highest level of nitrogen i.e. 150% N of recommended dose produced significantly taller plants, number of tillers m^{-2}, panicle length, number of grains panicle^{-1} and resultantly paddy yield than the rest of nitrogen levels. Nitrogen fertilizer (150% N of RD) produced maximum plant height (129.8cm), number of tillers (265.0) plant^{-1}, number of grains panicle^{-1} (120), panicle length (29.3cm) and paddy yield (4.46 t ha^{-1}) with ridge sowing technique and at par with 125% N of RD.

Ridge sowing exhibited the maximum plant height (Table 3) i.e. 113.6 cm followed by drill sowing i.e. 108.6 cm. Nitrogen levels 150 % RD and 125 % RD were statistically at par and improvement in plant height than recommended dose was 12.6 and 3.29%, respectively. Ridge sowing showed maximum number of tillers m^{-2} (Table 3) i.e. 247.9 followed by drill sowing i.e. 236.4 than broadcast i.e. 224. Percent increase in number of tillers than RD with 150 % RD and 125 % RD was 7.17 and 11.44%, respectively. Insufficient supply of nitrogen demonstrated poor plant height due to less vegetative growth and inefficiency of chloroplasts (Blumenthal *et al.,* 2008; Narits, 2010). Among the sowing strategies, the ridge sowing showed more plant height than other methods because ridge sowing provided better soil conditions and reduced lodging while minimum plant height was observed with broadcast method (Bakht *et al.,* 2011). The reduced tillering was observed with drill sowing might be due to high population density, ultimately competition for nutrients and inefficient utilization of nutrients as compared to bed sowing that had higher tillering capacity resultantly paddy yield (Baloch *et al.,* 2007; Ullah *et al.,* 2007; Ikeda *et al.,* 2008).

The maximum number of grains panicle^{-1} (Table 4) was produced with ridge sowing i.e. 109 followed by drill sowing i.e. 105 that was at par with broadcast i.e. 98. Percent increase in number of tillers was observed than RD with 150% and 125% RD was 10.57 and 6.73%, respectively. The maximum panicle length (Table 4) was recorded in ridge sowing i.e. 25.58 cm followed by drill sowing i.e. 23.96 cm and followed by broadcast sowing i.e. 20.0 cm. The maximum panicle length was observed with 150% and 125% N of RD i.e. 26.8 cm and 24.40 cm, respectively. Our results corroborated with many researchers that increasing trend of nitrogen enhanced the yield components regardless of sowing method used. Application of nitrogen at high rates results in higher yield components like number of grains panicle^{-1}and panicle length than lower rates might be due to reduced competition for nitrogen than other ordinary rates (Jamil and Hussain, 2000). Awan *et al*. (2005) reported that panicle grain weight was reduced in direct seeded rice on flat soil than rest of sowing techniques. Results showed that all the parameters gradually decreased as the nitrogen levels decreased.

The paddy yield increased with the increasing rates of N (Figure 1). Highest paddy yield was observed with 150% N and 125% of RD i.e. 4.18 and 4.05 t ha^{-1}, respectively. The ridge sowing proved better than drill and broadcast sowing. Ridge sowing exhibited 4.04 t ha^{-1} paddy yield followed by 3.73 t ha^{-1} with drill sowing. Interaction effects between sowing techniques and nitrogen levels were found to be significant. The maximum paddy yield @ 150% N of RD was due to more number of grains, more number of tillers and panicle length resulted in more paddy yield than the remaining levels (Manzoor *et al.,* 2006). The yield components viz. plant height, number of tillers m^{-2}, number of grains panicle^{-1}, panicle length and paddy yield were registered correlation with the nitrogen levels and sowing techniques also the yield improvement by increasing N levels with ridge sowing was reported by numerous researchers (Awan *et al*., 2005; Ullah *et al.,* 2007; Juraimi *et al.*, 2010; Bakht *et al.*, 2011).

As regard of sowing methods the yield parameters showed that maximum plant height (113.4cm), number of tillers (247.93m^{-2}) number of grains panicle^{-1} (109), panicle length (25.6cm) and paddy yield (4.04 t ha^{-1}) produced by the ridge sowing method as compared to drill and broadcast sowing method in saline sodic conditions. Ridge sowing proved to be superior than other methods because ridges provide better soil conditions for nutrient acquisition (Baloch *et al.,* 2007; Ullah *et al.,* 2007; Bakht *et al.,* 2011). Results revealed that direct seeded rice has been produced with ten irrigations and flooding was avoided. Usually flooded rice has been produced with 16-17 irrigations so in direct seeded rice 6-7 irrigations have been saved. Literature revealed that about 25% of saving of water was observed (Tuong and Bouman, 2003;Bluemling*et al.,* 2007**;** Bouman *et al.,* 2007; Khan *et al.,* 2009)

The post-harvest soil analysis was presented in (Figure 2, 3 and 4). Results regarding soil pH_s after harvest clearly demonstrated that interaction of sowing technique and nitrogen levels had not affected the soil pH which might be due the buffering capacity of soil. Although slight variation was observed in soil pH_s. Soil EC_e and SAR were reduced under all sowing methods as compared to the soil initial status. Results demonstrated that rice crop stand remained under moist / submerged condition resultantly the soluble salts might have been dissolved / leached down to free the root zone from salts. The leaching of soluble salts reduced the EC_e and SAR and affected the yield components positively. Ridge sowing improved the yield components and reduced soil chemical properties i.e. EC_e and SAR. The supremacy of ridge sowing over drill and flat sowing was also reported (Shafiq *et al.,* 2001; Khan *et al*., 2004; Khan *et al.,* 2010).

Field studies concluded that the effect of various sowing techniques, nitrogen rates and their interaction was significant on yield components of direct seeded rice. Nitrogen rate @ 150 % N of RD gave the maximum yield which was at par with the 125% N of RD. Among sowing techniques, ridge sowing proved superior followed than drill and broad cast sowing. Further studies should be carried out to confer this technology.

Table 1.Meteorological data during the three years (2010-2012) of experiment at Soil Salinity Research Institute, Pindi Bhattian

Year	Month	Average Low Temperature (ºC)	Average High Temperature (ºC)	Average Precipitation (mm)
2010-2012	June	23	39	24
	July	23	34	84
	August	22	33	81
	September	21	33	27
	October	16	31	03

Table 2 Pre-sowing soil analysis of the experimental site

S. No.	Parameters	Unit	Depth of soil	
			0-15 cm	**15-30 cm**
1.	pH_s	-	8.74-8.81	8.61- 8.67
2.	EC_e	$dS\ m^{-1}$	4.21- 4.32	4.10- 4.25
3.	SAR	$(mmol\ L^{-1})^{1/2}$	34.5 – 35.1	32.4 - 34.1

Table 3. Plant height and number of tillers m^{-2} of direct seeded rice as affected by various sowing techniques in salt affected soils

Nitrogen levels (kg NPK ha^{-1})	Plant height (cm)				Number of Tillers m^{-2}			
	Ridge	**Drill**	**Broadcast**	**Mean**	**Ridge**	**Drill**	**Broadcast**	**Mean**
T_1: Farmer practice (80-60-0)	100.3^{fghi}	97.7^{ghi}	91.6^{ij*}	96.5^{C}	227^{de}	220^{ef}	215^{g}	220^{D}
T_2: Recommended dose (RD) 110- 90-60	115.7^{c}	110.5^{cde}	105.4^{defg}	110.5^{B}	249^{c}	234^{d}	220^{ef}	234^{C}
T_3: 75 % N of RD	102.6^{efgh}	94.3^{hi}	89.1^{j}	95.1^{C}	221^{ef}	211^{fg}	205^{g}	212^{E}
T_4: 125 % N of RD	119.4^{bc}	113.6^{cd}	109.8^{cdef}	114.1^{A}	273^{a}	262^{b}	249^{c}	261^{A}
T_5:150 % N of RD	129.8^{a}	126.9^{ab}	116.7^{c}	124.5^{A}	265^{ab}	255^{bc}	233^{d}	251^{AB}
Mean	113.6^{A}	108.6^{B}	102.5^{B}		247.9^{A}	236.4^{B}	224^{C}	
LSD	LSD (Fertilizer) = 4.6584; LSD (Methods) = 7.1728; LSD (Interaction) = 8.0686				LSD (Fertilizer) =6.4087; LSD (Methods) = 3.5249; LSD (Interaction) = 11.10			

**Means sharing the same letter(s) in a column do not differ significantly at p<0.05 according to Duncan's Multiple Range Test*

Table 4.Number of grains $Panicle^{-1}$ and Panicle length of direct seeded rice as affected by various sowing techniques in salt affected soils

Nitrogen levels (kg NPK ha^{-1})	Number of grains $Panicle^{-1}$				Panicle length (cm)			
	Ridge	**Drill**	**Broadcast**	**Mean**	**Ridge**	**Drill**	**Broadcast**	**Mean**
T_1: Farmer practice (80-60-0)	103^{defg*}	100^{efgh}	89^{i}	97 D	23.5^{bcde}	20.7^{defg}	17.7^{fg}	20.6^{C}
T_2: Recommended dose (RD) 110- 90-60	110^{bcd}	106^{def}	97^{gh}	104^{C}	24.6^{bcde}	22.3^{cdef}	20.7^{defg}	22.5^{BC}
T_3: 75 % N of RD	98^{fgh}	93^{hi}	86^{c}	92^{E}	22.7^{cdef}	20.0^{efg}	16.6^{g}	19.8^{C}
T_4: 125 % N of RD	115^{abc}	111^{bcd}	107^{cde}	111^{B}	27.8^{ab}	25.1^{bcd}	22.3^{cdef}	24.4^{AB}
T_5:150 % N of RD	120^{a}	117^{ab}	110^{bcd}	115^{A}	29.3^{a}	26.7^{abc}	24.4^{bcde}	26.8^{A}
Mean	109^{A}	105^{A}	98^{B}		25.58^{A}	23.96^{B}	20.0^{C}	
LSD	LSD (Fertilizer) = 4.1201; LSD (Methods) = 5.5714; LSD (Interaction) = 7.1363				LSD (Fertilizer) =2.8047; LSD (Methods) = 1.8679; LSD (Interaction) = 4.8578			

**Means sharing the same letter(s) in a column do not differ significantly at p<0.05 according to Duncan's Multiple Range Test*

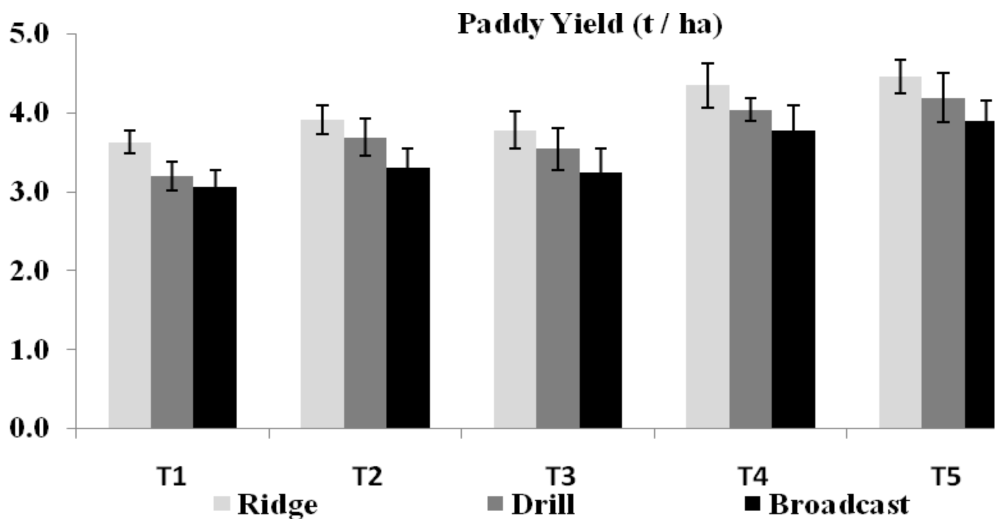

Figure 1. Effect of various sowing techniques and N levels on Paddy Yield (t / ha)

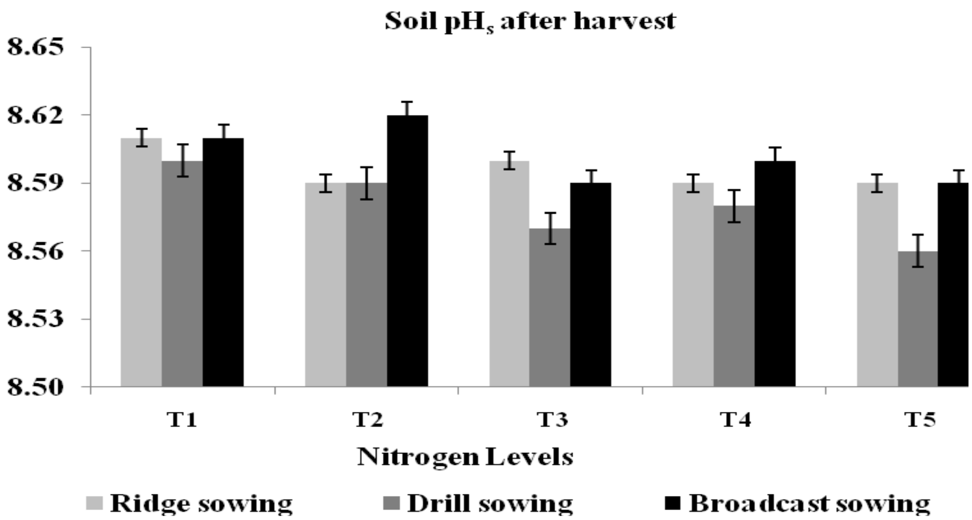

Figure 2. Effect of various sowing techniques on soil pH_s in salt affected soils

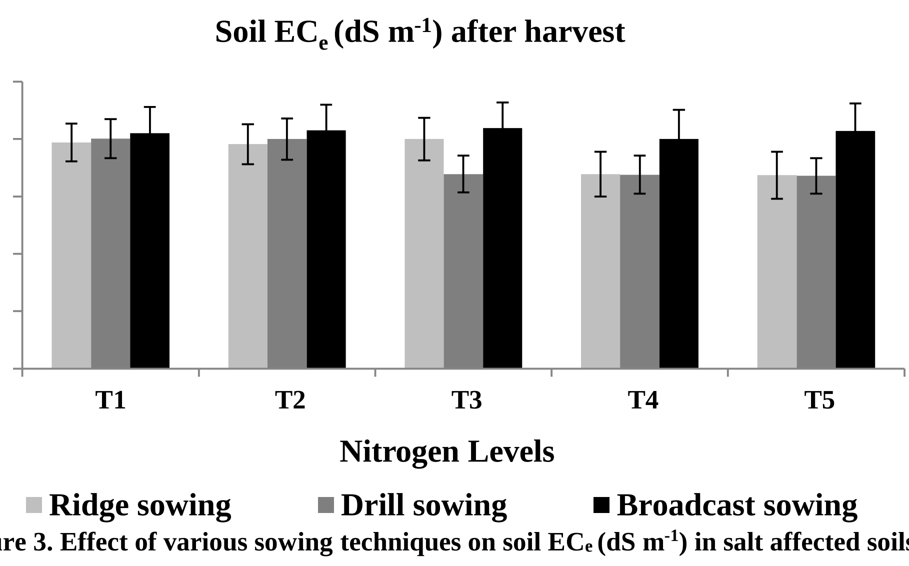

Figure 3. Effect of various sowing techniques on soil EC_e (dS m^{-1}) in salt affected soils

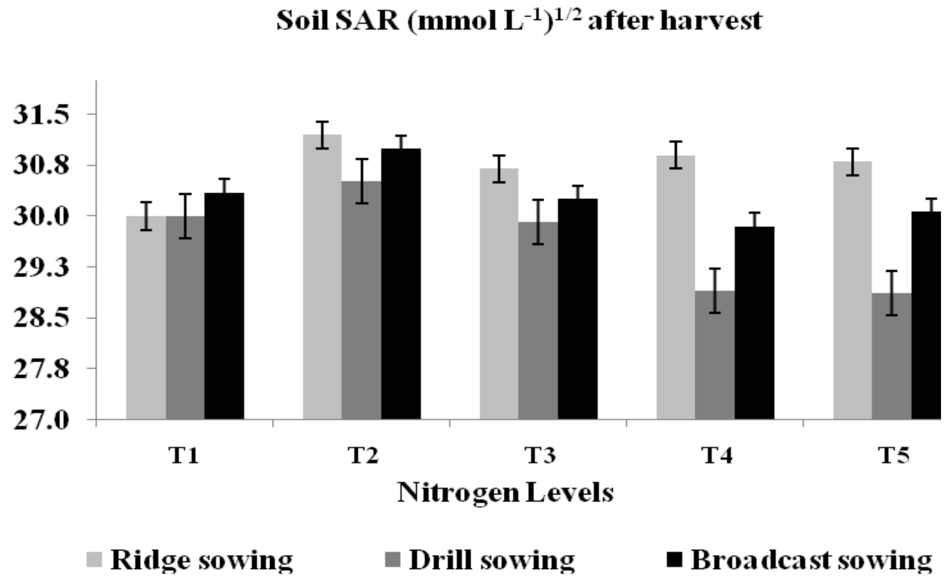

Figure 4. Effect of sowing techniques on soil SAR (mmol L^{-1})$^{1/2}$ in salt affected soils

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