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IMPACT OF SOWING TECHNIQUES AND NITROGEN FERTILIZATION ON CASTOR BEAN YIELD IN SALT AFFECTED SOILS

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ABSTRACT

Irrigation induced soil salinity or secondary salinization has become severe threat to food security through deterioration of soil and reduction of crop yields. An integrated management approach is direly needed to combat the salinity stress by reclamation of soil through amendments, agronomic / engineering approaches, scheduling of irrigation schemes, proper drainage and farming practices. Another approach is the introduction of minor crops on marginal lands by different management practices. Castor bean (*Ricinus communis* L.) belongs to the family Euphorbiaceae grown as non-edible oil seed crop with enormous significance. Experiments were conducted to assess the best dose of fertilizer and different sowing methods to popularize the non-traditional crop among the farming community under salt affected soils during 2010-13. Treatments included in the study were i.e. N levels (90 and 60 kg N ha^{-1}) and sowing methods (ridge, drill and broadcast sowing) laid out in split plot arrangement with three replications. Results exhibited that the maximum plant height (316.7 cm), number of branches $plant^{-1}$ (13.00), number of nodes $plant^{-1}$(25.03), 100 seed weight (29.07 g) and seed yield (2.072 t ha^{-1}) obtained from ridge sowing method with 90 kg N ha^{-1} compared to the rest of treatments. Moreover, ridge sowing method with 90 kg N ha^{-1} proved to be the effective technique for successful production of castor bean on salt affected soil. The ridge and drill sowing showed least value of EC_e and SAR at both levels of N as compared to broadcast sowing.

Keywords: Sowing methods, fertilizer, Ricinus, yield and yield components.

INTRODUCTION

Castor bean is successfully grown in arid and semi arid regions of the world. Castor bean oil is used as lubricant in high speed engines, manufacturing of soaps, transparent paper, printing-inks, varnishes, plasticizers and also for medicinal, nylon and electrical insulations. Sulphonated castor oil is used for dyeing and preservation of leather, production of Ricinoleic acid (polyamide resin) and in biodiesel studies (Anonymous, 2009; Ombrello, 2009).

Pakistan an agro-based economy has been severely affected by salinity / sodicity. Some 6.68 mha of land is salt affected comprised of ~ 26 % of irrigated land and the major share among salt affected soils is saline sodic i.e. 3.2 mha. Salinity / sodicity are important constraints affecting irrigated agriculture of Pakistan. It is estimated that 3.16 mha salt affected area lies within the canal commanded area and 2.64 mha outside the canal commanded area while 2.93 mha are cultivated and half of salt affected is waste land (Qureshi, 1993; Khan *et al.*, 1998).

Salt affected soils are characterized by poor infiltration rate, water permeability, hydraulic conductivity and porosity of saline sodic soils. Saline sodic soils are deteriorated due to dispersion, translocation of clay particles and choking the macro / micro pores due to which roots of the plant face resistance for proliferation, aeration, water absorption and nutrient uptake resultantly reduced the yield (Eker *et al.*, 2006).

Different strategies including ploughing, leaching, chemical amendments, suitable sowing techniques, fertilization help plant growth on salt affected soils. Despite being an important cash crop, castor bean has never been realized as commercial crop in Pakistan and is grown on marginal land without giving much care and attention. Castor bean requires a loamy soil of medium texture and sub soil is permeable and good drainage (Cheema *et al.,* 2013). Castor bean can withstand to salinity and drought and have gained prominent position in dry land agriculture due to extensive, deep root system and fast growth pattern. Castor bean has been considered as oil seed bioenergy crop responsible for biodiesel production (Chatzakis *et al.,* 2011; Dias *et al.,* 2013).

Nitrogen is the most limiting nutrient in the soil. Adequate supply of nitrogen to crops is fundamental to optimize crop yields, mismanagement of nitrogen, such as excessive N application results in contamination of ground water (Ju *et al.,* 2006; Kalimantan, 2011). Farahani and Aref (2008) conducted an experiment in which castor bean was treated with four nitrogen levels (0, 40, 80 and 120 kg ha^{-1}) and showed that highest seed yield, biological yield and oil yield were achieved under application of 80 kg N ha^{-1}, highest 1000 seed weight was received with 120 kg N ha^{-1}. Several researchers studied that effect of varied levels of nitrogen on seed yield of castor bean and found significant increase in yield with an increase in nitrogen level and the highest yield was recorded with 120 kg N ha^{-1} (Taylor *et al.,* 2005; Sawan *et al*., 2007). It was investigated that growth and yield parameters of castor bean were increased with increasing levels of nitrogen fertilizers and maximum was at 120 kg N ha^{-1} (Diniz Neto *et al.,* 2012). Pohlmeier (2007) reported that 50 kg N ha^{-1} was suitable under Belgium conditions. The proposed study was conducted to assess castor bean sowing using different fertilizer levels under various sowing methods among farming community of salt affected area.

MATERIALS AND METHODS

The experiment was conducted at Research Farm, Soil Salinity Research Institute (SSRI), Pindi Bhattian, Hafizabad for three consecutive years (2010-2013). The site of SSRI, Pini Bhattian was placed on western border of Rachna Doab with coordinates: 73º 20' 50.2" eastern longitude 31º 52' 34.2" northern latitude with an altitude of 212m above sea level. Rice-wheat rotation is commonly prevails with average rainfall of 500 mm $year^{-1}$ and phreatic surface is at 2m depth. The average maximum temperature, minimum temperature and rainfall during castor bean crop growth period during the entire course of study are presented in Table 1.

Soil samples were analyzed (0-15 cm and 15-30 cm) to determine the salinity / sodicity level of the field. A moderately saline-sodic field was selected, ploughed and leveled. Site of the present study was reclaimed eight years earlier and under rice-wheat rotation before conductance of experiment. Soil was medium textured (0-15 cm) having pH_s: 8.82, EC_e: 4.10 dSm^{-1}, SAR: 28.23 $(mmol\ L^{-1})^{1/2}$ and from (15-30 cm) soil pHs: 8.79, EC_e: 3.91 dSm^{-1}, SAR: 26.92 $(mmol\ L^{-1})^{1/2}$. Treatments included: Sowing Methods (ridge, drill and broadcast sowing) and N level (60 and 90 kg N ha^{-1}). Uniform dose of P i.e. 60 kg ha^{-1} and half nitrogen was applied at the time of sowing (on 9th November, 2010 and repeated in 10th November 2011 again repeated in 14th November 2012) while remaining half nitrogen was applied at flowering. The experiment was laid out in split plot design having four replications keeping plot size 5m x 10m. Fertilizer level was placed in main plots while sowing methods in subplots. The test cultivar of castor bean was DS-30. The crop was maintained for one growth cycle throughout the year. Irrigation was applied at 15 days of interval and one weeding operation was carried out. Castor bean was considered as insecticidal for the pests so no pesticide was applied. Data regarding yield and yield components were recorded at harvesting (harvesting dates for three consecutive years i.e. 04-04-2011, 03-04-2012 and 08-04-2013, respectively). Data of each parameter recorded different years 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 regarding plant height, number of branches $plant^{-1}$, number of capsules $cluster^{-1}$, 100-seed weight and seed yield of castor bean are presented in Table 2.

Plant height was significantly affected by sowing methods and nitrogen rates. Maximum plant height (306.3 cm) was recorded with ridge sowing method which differed significantly from all others sowing methods. In case of nitrogen levels the treatment 90-60 NP kg^{-1} gave highest plant height (288.5 cm) but differed significantly from 60-60 NP kg^{-1} (277.0 cm). In case of interaction the treatment of 90-60 NP $kgha^{-1}$ and ridge sowing method gave the maximum plant height (316.7 cm) which was differed significantly from all other treatments. However the minimum plant height (258 cm) was obtained with the broadcast sowing plus 60-60 NP kg ha^{-1} fertilizer application. Similar results are also confirmed by the work of Glass (2003) who reviewed that higher N rates improved the plant physical parameters. Application of N at higher rate i.e. 90 kg ha^{-1} improved more vegetative growth and root development thus more nutrient uptake resultantly increased plant height than lower N rate i.e. 60 kg N ha^{-1}. Plants with inadequate supply of nitrogen bears stunted growth due to nonfunctioning of chloroplasts (Blumenthal *et al.,* 2008). The ridge sowing demonstrated more plant height than other methods and minimum in broadcast because ridge sowing provided better soil conditions and reduced lodging (Bakht *et al.,* 2011).

The maximum number of branches $plant^{-1}$ (12.2) was counted from ridge sowing. In case of fertilizer level 90-60 NP kg ha^{-1} produced more number of branches $plant^{-1}$ (11.6) than 60-60 NP kg ha^{-1} treatment (9.4). As regard the interaction fertilizer application @ 90-60 NP kg ha^{-1} with the ridge sowing method produced highest number of branches $plant^{-1}$ (13.0) which was at par with drill sowing (12.0) and at same fertilizer level. However it was also at par with the treatment when sown with drill and fertilizer was applied @ 60-60 NP kg ha^{-1} (11.3). Minimum number of branches were recorded where 60-60 NP kg ha^{-1} and crop with broadcast (7.6). Similarly, ridge sowing coupled with higher N rates enhanced the number of branches $plant^{-1}$ due to more vegetative growth and sprouting (Srinivas *et al.,* 2005; Vanaja *et al.,* 2008; Bakht *et al.,* 2011).

Results clearly depicted that number of capsules cluster^{-1} were significantly affected by fertilizer application and sowing methods. Maximum number of capsules cluster^{-1} (102.3) was observed with ridge sowing and fertilizer was applied @ 90-60 NP kg ha^{-1}. As regard the sowing methods the highest number of capsules cluster^{-1} (97.7) was obtained where crop was sown through ridge sowing. In case of fertilizer application, nitrogen dose was significantly affected the number of capsules cluster^{-1}, data showed that maximum number of capsules cluster^{-1} (102.3) was recorded where maximum N was used. Planting of ridge sowing with higher N rates improved the vegetative growth and consistent nutrient supply on ridges resulted in more yield (Khan *et al.*, 2010; Chatzakis *et al.*, 2011).

Results revealed that maximum 100-seed weight (29.1 g) was recorded where fertilizer was applied 90-60 NP kg ha^{-1} and sowing was done on ridges. In case of fertilizer application 90-60 NP kg ha^{-1} (27.0 g) produced more yield than 60-60 NP kg ha^{-1} (24.9 g). As regard the sowing methods, ridge sowing (27.9 g) proved better than drill sowing and broadcast sowing, (25.9 g) and (23.9 g) respectively. The increased photosynthetic activity that increased accumulation of metabolites and resultantly direct impact on seed weight (Farahani and Aref, 2008; Chatzakis *et al.* (2011).

Results showed significant interaction between fertilizer application and sowing methods for seed yield and varied between 1.534-2.072 t ha^{-1} (Table 2). The highest seed yield (2.072 t ha^{-1}) was observed with ridge sowing and N @ 90 kg ha^{-1} was applied. In case of sowing methods, the maximum seed yield (1.949 t ha^{-1}) was received with the ridge sowing techniques as compared to drill sowing (1.602 t ha^{-1}) and broadcast sowing (1.388 t ha^{-1}). Fertilizer application was also significantly affected the seed yield. More seed yield (1.758 t ha^{-1}) where high dose of fertilizer was applied (90-60 NP kg ha^{-1}). The increase in growth parameters and yield component received with the increase in nitrogen level might be due to healthy plant vegetative growth and root development ultimately stimulated more yield (Farahani and Aref, 2008; Olanite *et al.*, 2010). The results are also in line with the previously reported by many workers (Dufour *et al.*, 2003; Pohalmeier, 2007; Farahani and Aref, 2008; Kalimantan, 2011).

Data presented in Figure 1, 2 and 3 showed that with the drill and broadcast method, the pH, EC_e and SAR were slightly decreased and planting crop on ridges, the pH, EC_e and SAR were decreased significantly up to safe limit. It was also noticed that pH, EC_e and SAR more decreased on the shoulder than bottom of the ridge. It might be decreased due to upward movement of the salts and base and shoulder of the ridge become free from the injurious salts. The use of chemical amendments with agronomic practices such as ploughing followed by leaching with and incorporation of suitable sowing techniques promotes the plant growth on marginal lands (Khan *et al.*, 2010). The soil analysis of different parts of ridges indicated that the maximum reduction in the pH, EC and SAR was observed at the shoulder region owed to the reason that accumulation of salts was highest at crown / top part or bottom of ridge (Chen and Feng, 2013).

Study clearly demonstrated that the highest seed yield was obtained with the fertilizer application of 90-60 NP kg ha^{-1} when crop was planted on ridges in salt affected soils. It is also concluded that ridge sowing is the best method of sowing for the cultivation of castor bean in salt affected areas.

Table 1. Meteorological data during the three years (2010-2013) of experiment at Soil Salinity Research Institute, Pindi Bhattian.

Year	Month	Average Low Temperature (ºC)	Average High Temperature (ºC)	Average Precipitation (mm)
2010-2013	November	11	25	06
	December	07	20	15
	January	05	19	06
	February	07	21	30
	March	12	24	33
	April	17	31	33

Table 2. Plant Height (cm), number of branches plant^{-1} and number of capsules cluster^{-1} of castor bean influenced by sowing methods and N levels.

Methods of Sowing	Plant Height (cm)			Number of branches plant^{-1}			Number of capsules cluster^{-1}			100-seed weight (g)			Seed Yield (t ha^{-1})		
	Nitrogen Levels (kg N ha^{-1})														
	90	**60**	**Mean**	**90**	**60**	**Mean**	**90**	**60**	**Mean**	**90**	**60**	**Mean**	**90**	**60**	**Mean**
Ridge	316.7* a	295.9 b	306.3 A	13.0 a	11.3 ab	12.2 A	102.3 a	93.0 bc	97.7 A	29.1 a	26.9 b	27.9 A	2.072 a	1.826 ab	1.949 A
Drill	278.6 c	277.1 c	277.8 B	12.0 a	9.3 c	10.7 B	95.7 b	89.3 cd	92.5 B	27.2 b	24.7 c	25.9 B	1.748 b	1.456 c	1.602 B
Broadcast	270.1 cd	258.0 d	264.0 C	9.6 bc	7.6 d	8.7 C	91.7 bc	85.7 d	88.7 B	24.8 c	23.1 d	23.9 C	1.456 c	1.321 d	1.388 C
Mean	288.5 A	277.0 B		11.6 A	9.4 B		96.6 A	89.3 B		27.0 A	24.9 B		1.758 A	1.534 B	
LSD	LSD (Fertilizer) =9.978; LSD (Methods) =12.498; LSD (Interaction) =17.675			LSD (Fertilizer) =1.2649; LSD (Methods) =1.0408; LSD (Interaction) =1.4719			LSD (Fertilizer) =3.285; LSD (Methods) =4.381; LSD (Interaction) =5.690			LSD (Fertilizer) = 0.669; LSD (Methods) = 0.6427; LSD (Interaction) = 0.909			LSD (Fertilizer) =0.219; LSD (Methods) =0.203; LSD (Interaction) =0.128		

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

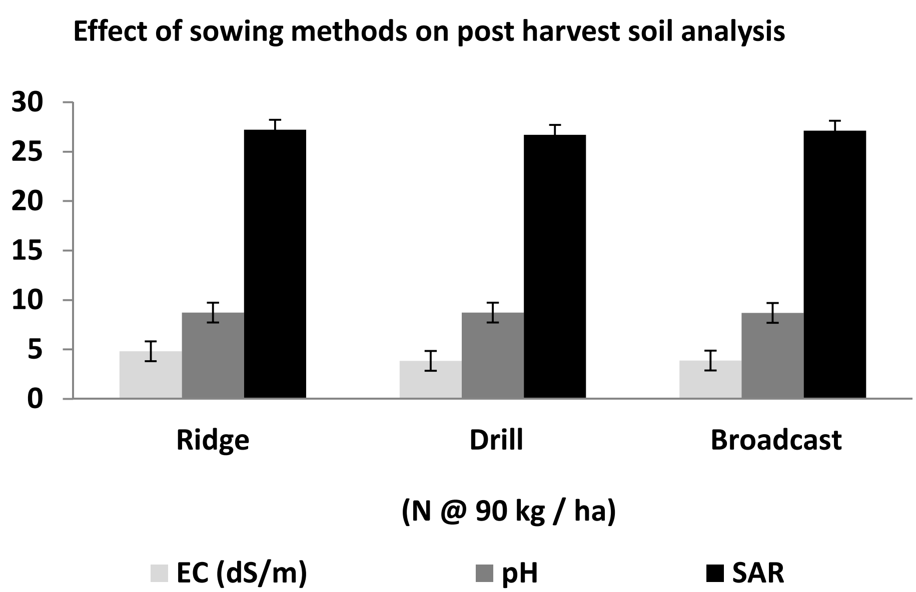

Figure 1. Effect of sowing methods on post harvest soil analysis (N @ 90 kg ha^{-1})

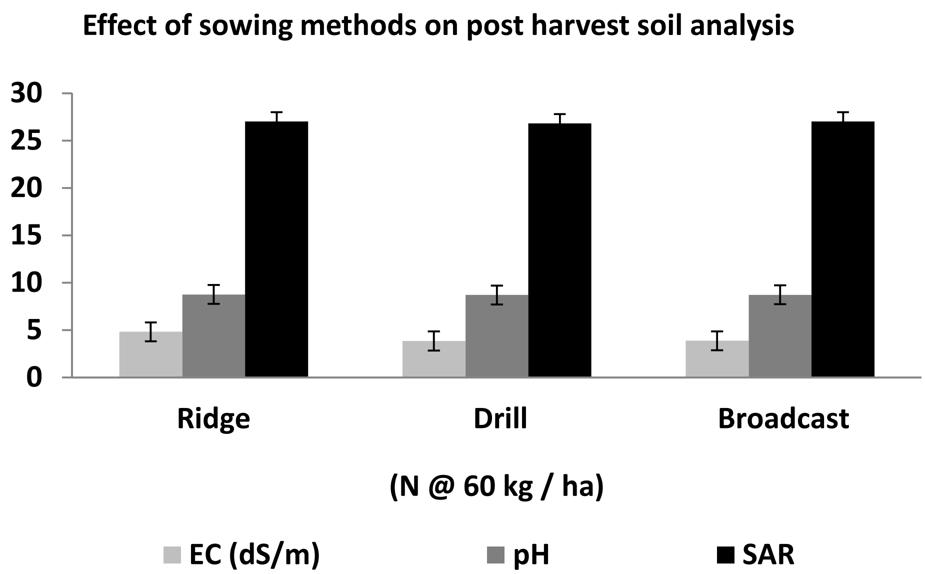

Figure 2. Effect of sowing methods on post harvest soil analysis (N @ 60 kg ha^{-1})

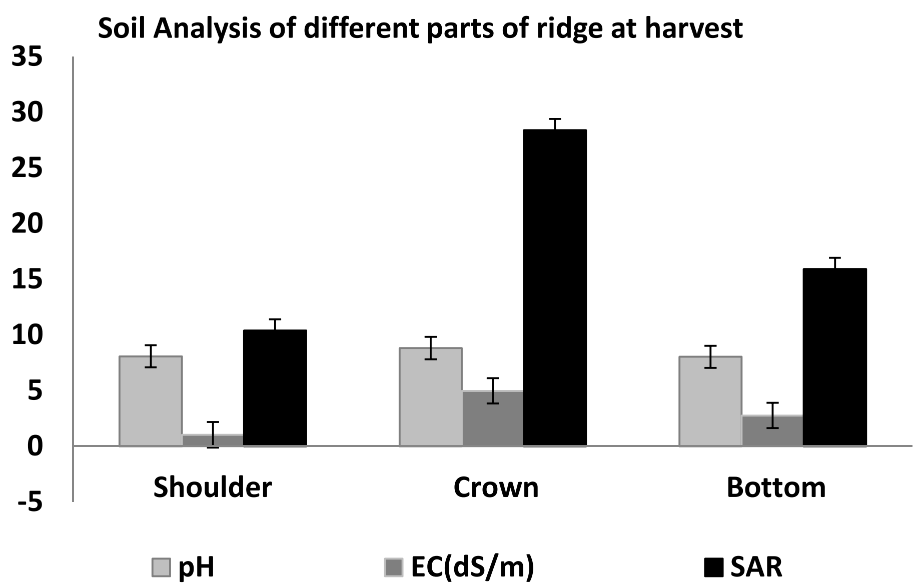

Figure 3. Soil analysis of different parts (shoulder, crown and bottom) of ridge at harvest.

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