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Effect of organic culture on growth and yield of wheat (*Triticum aestivum*) under saline water irrigated condition of semi-arid region

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ABSTRACT

A field experiment was conducted at the research farm of ICAR-CAZRI, Regional Research Station, Pali, Rajasthan during winter (*rabi*) season 2017–18 and 2018–19 to study the effect of organic culture on growth, yield attributes, yield and economics of wheat (*Triticum aestivum* L.) under low saline water irrigated condition. The experiment was laid out in randomized block design consisting of 8 treatments of organic culture with 3 replications. The results revealed that application of organic culture through seed treatments and foliar spray (10%) at different growth stages significantly influenced the growth and yield attributes of wheat in pooled data of 2 years. Application of organic culture (T_4) exhibited significantly the highest grain yield (4391 kg/ha) followed by T_3 (4074 kg/ha) and T_5 treatment (3912 kg/ha) over the control (3044 kg/ha) in both the years (pooled basis). Significantly the higher net return and Benefit cost (B:C) ratio of ₹75446/ha and 2.24, respectively was recorded under the T_4 treatment while the lowest net return of ₹46178/ha and benefit cost ratio 1.40 was obtained under T_1 (control) treatment.Thus, application of organic culture through seed treatment and foliar spray (10%) at 30 and 60 days after sowing (DAS) of wheat was found best for realizing higher growth, yield and benefits.

Keywords: Economics, Growth, Organic culture, Saline water, Wheat, Yield

Wheat (*Triticum aestivum* L.) is the main cereal crop in India with total area and production of 29.8 million hectares and 106.41 million tonnes respectively in 2021–22. Despite vast cultivated area in the country, wheat production is not sufficient to meet annual demand owing to low productivity (3093 kg/ha). However, due to rising soil and water salinity and decreasing soil fertility is a serious threat for the production of crops. In India, total degraded lands are 120.70 Mha, out of which 6.74 Mha land is salt affected in different agro-ecological regions of arid, semi-arid and humid regions, out of which 3.77 Mha areas is affected by sodicity and 2.95 Mha by salinity. Among all the crops, wheat suffered the highest losses in production (4.06 million tonnes) due to salt stress (Sharma *et al.* 2015). Wheat is extremely sensitive to sodicity and salinity at early seedling germination (Ravi Sharma 2015). Salinity stress adversely affect seed germination, plant growth, development of reproductive stage and grain yield by decreasing soil moisture availability (Torun *et al.* 2001, Sabagh *et al.* 2021).

Foliar spray of nutrients is an important practice for management of sustainable and successful crop production in salt affected zones (Waraich *et al.* 2012). Foliar spray of micronutrients helps in rapid translocation when compared with soil application, which is very pertinent in mitigating stress in plants, when plant roots are incapable of absorbing nutrients from soil due to soil moisture stress, soil salinity and loss through leaching (Zhang *et al.* 2010, Rahman *et al.* 2014). Therefore present study was carried out to see the effect of seed treatment and foliar spray of organic culture on improving plant growth, yield attributes and yield of wheat under low saline irrigated conditions.

MATERIALS AND METHODS

A field experiment was conducted at the research farm of ICAR-CAZRI, Regional Research Station, Pali, Rajasthan (25°47'–25°49' N and 73°17'-73°18' E at an altitude of 217-220 m amsl), during winter (*rabi*) season 2017–18 and 2018–19. The region falls in agro-climatic Zone-IIB of Rajasthan, India.The average annual rainfall is 460 mm with a mean maximum annual temperature of 42°C and mean minimum annual temperature of 7°C during growing season. The soil was sandy clay loam having 0.45 m soil

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depth and a dense underlying layer of calcareous murrum layer up to 10–15 m. Organic carbon content in soil was 0.29%, *p*H 7.8 and EC 0.76 dS/m. Available nitrogen, phosphorous and potassium was 187.5,11.1 and 221 kg/ha, respectively. The experiment consisting of 8 treatments of organic culture comprising of control (T_1); seed treatment with organic culture (T_2); seed treatment with one foliar spray of organic culture at 30 DAS (Days after sowing) (T_3); seed treatment with two foliar spray of organic culture at 30 and 60 DAS (T_4); seed treatment with three foliar spray of organic culture at 30, 60 and 90 DAS (T_5); one foliar spray of organic culture at 30 DAS (T_6); two foliar spray of organic culture at 30 and 60 DAS (T_7) and three foliar spray of organic culture at 30, 60 and 90 DAS (T_8) was laid out in randomized block design and replicated thrice. Organic culture was a consortium of micro-organism extracted from cow dung and developed by National Center of Organic Farming (NCOF), Ghaziabad (Uttar Pradesh).This culture was used for promoting growth and development of crop and to protect plants from insect-pest and diseases. Spray solution was prepared in plastic drum with 200 litre of water, mixed with 2 kg jaggery and 30 ml of concentrated organic culture. The 600 litre of organic culture is required for foliar spray in one hectare area. It was sprayed in 10:1 ratio of water and organic culture at 30, 60 and 90 DAS and seed treatment with organic culture was done as per treatment. The wheat variety Raj 4120 was sown at row to row spacing of 22.5 cm, using seed rate of 100 kg/ha. The duration of variety is 125–130 days and potential yield is 55.5 q/ha. Well water having *p*H (7.75), EC (4.65 dS/m), Ca^{2+}+Mg^{2+} (21.6 meq/l), Cl^- (27.58 meq/l), HCO_3^{2-} (5.97 meq/l) and SAR (10.60) was used for providing irrigation to the crop. Total 6 irrigations with saline water as pre sowing and at different growth stages were given which enhanced salinity of the soil having EC up to 0.91 dS/m.

The plant height (cm) of randomly seleted plant from each plot was measured at 30, 60, 90 and 120 DAS and effective tillers, root length, yield attributes, viz. spike length, awn length, 1000-seed weight, number of grains per spike and spikelet/spike at maturity stage were recorded. Dry matter accumulation per meter square from each plot was taken cutting plant at 30, 60, 90 and 120 DAS of crop. Plant samples were oven dried at 65°C and finally weighted. The grain and biological yield was recorded per plot and converted in kg/ha.The harvest index (HI) was calculated as (Donald 1962):

$$\text{Harvest Index (\%)} = \frac{\text{Grain yield (kg/ha)}}{\text{Biological yield (kg/ha)}} \times 100$$

The gross return (GR) was calculated by multiplying the grain yield of crop by the minimum support price (MSP) of ₹1800 and ₹2000 per quintal for the year 2018–19 and 2019–20, respectively, offered by the government of India and straw value was calculated based on local market rates. Net return (NR) was calculated as the difference between GR and total cost of cultivation (TCC) (NR=GR–TCC). Benefit cost ratio was also calculated (BCR= Gross return/ Cost of production).

Statistical analysis was done as per procedure suggested by the Panse and Sukhatme (1985). Procedure was used for comparing treatment means at 5% level of significance. When the data were similar during both the year, pooled analysis was carried out and presented.

RESULTS AND DISCUSSION

Plant growth parameter: Organic culture treatments significantly affected plant height and dry matter accumulation at 30, 60, 90 and 120 DAS and root length in both the years over control. Application of organic culture (T_4) resulted the highest plant height of 34.4 cm, 56.2 cm, 81.9 cm and 89.3 cm as compared to control at 30, 60, 90 and 120 DAS, respetively (Fig 1). However, the other treatments T_5, T_3 and T_8 were statistically at par but higher than control (T_1) in both the years (pooled data). A gradual increase in dry matter accumulation up to harvesting was recorded. Significantly the highest dry matter accumulation was recorded under T_4 treatment of 173.6 g/m^2, 372.9 g/m^2, 1033.2 g/m^2 and 1304.3 g/m^2 at 30, 60 and 90 DAS and at harvesting, respectively over the control (Fig 1). Different organic culture treatments increase soil moisture and nutrient availability to plants and foliar spray enhance photosynthesis efficiency and temperature moderation which results in higher dry matter accumulation leading to better growth of plants. Significant increase in plant height of wheat was observed with foliar spray of different nutrients individually or in combination (Parvez *et al.* 2009). The plant height was significantly increased (70.6 cm), with the soil application of recommended dose of nitrogen with 1% of nitrogen foliar spray as compared to control reported by Nazia *et al.* (2019).

The highest root length was found in T_3 (14.01 cm) followed by T_4 (13.83 cm) which were statistically at par with rest treatments and the lowest root length was recorded under control T_1 (10.84 cm). Seed treatment and foliar spray of organic culture at 30, 60 and 90 DAS (T_3) resulted the highest root length (Fig 2). The root length in treated seeds might be due to increased metabolic activities in the seed.Similar results were reported by Mondal *et al.* (2019).

Yield attributes: Effective tiller, spike length, awn length, number of spikelets per spike and 1000-seed weight were significantly affected by different treatment of organic culture in both the years over control. Data (Table 1) showed maximum number of productive tiller (9.21/plant), spike length (11.22 cm), spikletes (16.94/spike), grains per spike (44.61), higher awn length (7.38 cm), highest test weight (40.83g) in T_4 treatment followed by T_3 and T_5 treatments and minimum numbers were recorded in T_1 (control). These finding corroborate with result reported by Rahman *et al.* (2014) in which foliar spray of 2% urea resulted in maximum number of effective tiller/m^2. Organic culture enhance moisture and nutrient absorption as well as photosynthesis under saline condition resulting in increase in plant height and dry matter accumulation per plant which ultimately promote better development of yield attributes.

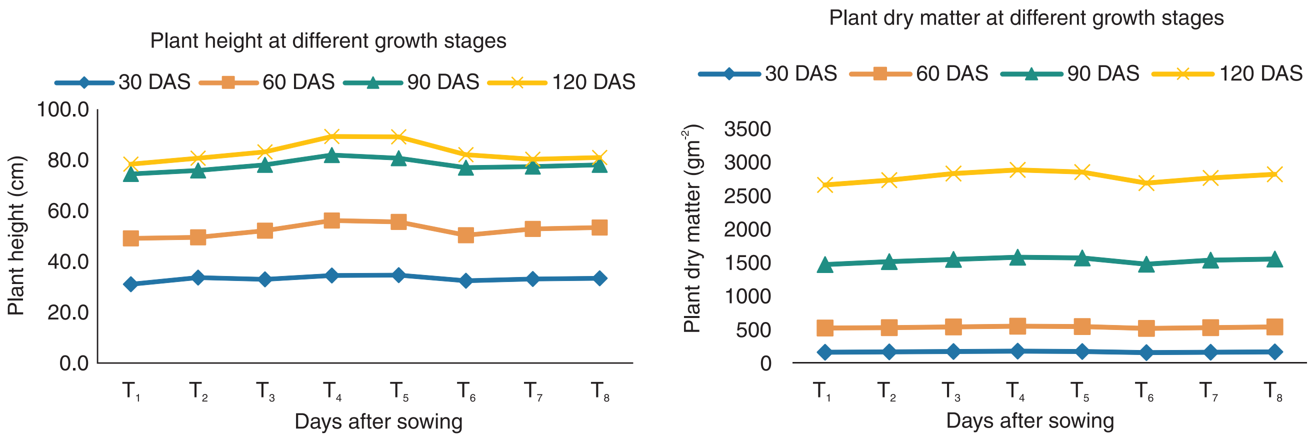

Fig 1 Effect of organic culture on plant height and dry matter accumulation at different growth stages (2 years pooled data). Treatment details are given under Materials and Methods.

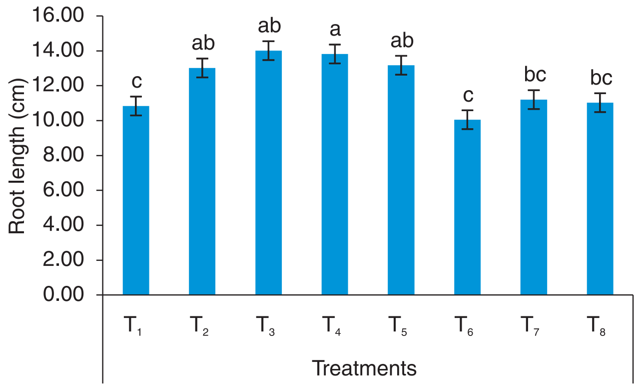

Fig 2 Effect of seed treatments and foliar spray of organic culture on root length of wheat (2 year pooled data).
Treatment details are given under Materials and Methods.

Nazia *et al.* (2019) reported that full recommended dose 168 kg/ha N with 1% of N foliar spray at booting stage significantly increased spike length of wheat crop. Zafar *et al.* (2006) reported that foliar spray with soil application of NPK fertilizer at different concentration rate gave higher value of awn length (9.03 cm) compared to control (4.96 cm) treatment.

Application of different combination of organic culture enhanced growth parameter resulting in improvement in yield and quality parameter as compared to control. Arif *et al.* (2006) reported that foliar spray of nutrients affects all the aspect of wheat crop.The foliar spray of nutrients enables better absorption by leaves which helps assimilation of photosynthates resulting in more production of grains in spike.The reduction in number of grains filling in spikes under salinity condition might be due to irrigation with saline water which affects grain maturity resulting in shrunken kernels and loss of grain yield. Akram *et al.* (2002) showed that salinity reduces yield primarily by a severe reduction in grain number. Application of two and three sprays of organic culture resulted heavier grains as compared to no-spray treatments which may be due to the culture response for enhancing accumulation of assimilate in the grains resulting in heavier grains.These results are similar with the findings of Yassen *et al.* (2010) who reported that foliar spray of 1% urea recorded significantly higher 1000-grain weight of wheat.

Grain yield: Seed treatment and foliar application of organic culture significantly increased wheat grain yield, under low saline irrigated condition in both the years and on

Table 1 Effect of seed treatments and foliar spray of organic culture on yield attributes of wheat (2 years pooled data)

Treatment	Effective tiller/ plant	Spike length (cm)	Awn length (cm)	Spikletes/ spike	Grains/ spike	Test weight (g)
T_1	6.03	8.90	5.87	14.61	37.89	35.30
T_2	6.50	8.82	6.79	14.75	39.33	35.56
T_3	8.27	10.77	7.12	16.25	43.44	39.51
T_4	9.21	11.22	7.38	16.94	44.61	40.83
T_5	8.20	10.30	7.21	16.22	43.94	39.37
T_6	6.07	9.06	6.74	14.22	38.78	37.19
T_7	6.64	9.62	6.84	14.94	42.22	37.02
T_8	8.09	9.76	6.82	15.25	42.83	39.43
S.Em±	0.40	0.32	0.28	0.24	0.42	0.52
CD(0.05)	1.20	0.98	0.86	0.73	1.27	1.56

Treatment details are given under Materials and Methods.

Table 2 Effect of seed treatments and foliar spray of organic culture on yield and harvest index of wheat (Pooled data of 2 year)

Treatment	Grain yield (kg/ha)			Stover yield (kg/ha)			Harvest index (%)		
	2017–18	2018–19	Pooled	2017–18	2018–19	Pooled	2017–18	2018–19	Pooled
T_1	2367	3721	3044	4670	5464	5067	33.7	40.7	37.2
T_2	2586	4270	3428	4740	5882	5311	35.5	42.1	38.8
T_3	3030	5119	4074	5007	6693	5850	37.8	43.4	40.6
T_4	3556	5226	4391	5148	6970	6059	40.9	42.8	41.8
T_5	2917	4907	3912	5676	6779	6227	34.0	42.1	38.1
T_6	2570	3833	3201	4727	5981	5354	35.4	39.2	37.3
T_7	2737	4475	3606	4874	6117	5496	36.0	42.3	39.2
T_8	2876	4688	3782	4902	6434	5668	37.1	42.0	39.5
S.Em±	104	286	160	280	481	290	1.53	3.24	1.91
CD (0.05)	315	867	484	849	1458	879	4.64	9.84	5.79

Treatment details are given under Materials and Methods.

pooled basis. The highest grain yield (3556 and 5226 kg/ha) was recorded in T_4 followed by T_3 (3030 and 5119 kg/ha) and T_5 (2917 and 4907 kg/ha) which was significantly higher than T_1 treatment (2367 and 3721 kg/ha) during 2017–18 and 2018–19, respectively (Table 2). The grain yield of wheat was at par with all other treatments in which organic culture was applied but significantly higher over control. Choudhary *et al.* (2021) reported that grain size of some varieties were good but some varieties seed found shrunk which was due to supply of saline irrigation water and high reduction in grain yield. Application of organic culture as seed treatment and foliar spray resulted higher growth, dry matter accumulation and yield attributes which ultimately culminated in higher yield. Islam *et al.* (2017) and Khaled *et al.* (2021) also found that higher grain yield was observed by the foliar spray than the soil application. The similar results were reported by Saeed *et al.* (2013) that foliar spray of S and N at the rate of 10 to 15% enhanced the grain yield and yield related traits of wheat.

Stover yield: Stover yield of wheat was significantly influenced with application of different treatments of organic culture under low saline irrigated condition. The seed treatment and foliar application (T_5) of organic culture at 30, 60 and 90 DAS exhibited significantly the highest mean stover yield of 6227 kg/ha followed by (T_4) 6059 kg/ha. Application of organic culture treatment T_5 and T_4 significantly increased stover yield of wheat by 21.54%, 24.06% and 10.24%, 27.58% as compared to T_1(control) during 2017–18 and 2018–19 respectively (Table 2). Rests of the organic culture treatment were statistically at par but significantly higher over control during both the years. The higher biomass of wheat with application of organic culture might be due to higher growth, number of leaves, leaf area and plant tiller which directly supported to straw yield. Choudhary *et al.* (2021) reported increase in biological yield with foliar spray of organic culture at different stages of crop as compared to control treatment.

Harvest Index: Harvest Index was significantly influenced with application of different combinations of organic culture. The highest harvest index of 41.8% (Pooled of 2017–18 and 2018–19) was recorded in seed treatment and foliar spray at 30 and 60 DAS followed by treatment

Table 3 Details of treatment's cost and return of wheat crop (Pooled data of 2 years)

Treatment	General cost (₹/ha)	Treatment cost (₹/ha)	Total cost of cultivation (₹/ha)	Gross return (₹/ha)	Net return (₹/ha)	B:C ratio
T_1	32610	-	32610	78788	46178	1.40
T_2	32610	100	32710	87214	54554	1.65
T_3	32610	460	33070	101852	69012	2.07
T_4	32610	880	33490	108496	75446	2.24
T_5	32610	1360	33970	100228	66938	1.96
T_6	32610	360	32970	82876	50086	1.51
T_7	32610	780	33390	91368	58368	1.73
T_8	32610	1260	33870	95434	67494	1.98
S.Em±	-	-	-	2751	2855	0.09
CD (P=0.05)	-	-	-	8344	8658	0.26

Treatment details are given under Materials and Methods.

T_3 (40.6%) and rest of organic culture treatments were statistically at par with T_4 treatment but higher then control (T_1) during both the years (Table 2). The application of organic culture as seed treatment and foliar spray helps in mitigating the adverse effect of salinity, heat and stress resulting in higher harvest index over control. The results corroborate with the findings of Barmeri *et al.* (2012) who reported that foliar spray of micronutrients significantly improved grain, straw yield and harvest index of wheat crop. The results were supported by Vicek *et al.* (2020) who reported that foliar spray of iron, boron and nitrogen increase the harvest index significantly.

Economics: The net return and benefit cost (B:C) ratio was significantly influenced with application of different treatments of organic culture (Table 3). Application of organic culture as seed treatment and foliar spray at 30 and 60 DAS (T_4) resulted significantly the highest net return and B:C ratio of ₹75446/ha and 2.24, respectively, which was statistically at par with the T_3 (₹69012/ha and 2.07) and T_8 (₹67494/ha and 1.98). The lowest net return of ₹46178/ha and benefit cost ratio 1.40 was obtained under T_1 (control). The highest decline in net return and benefit cost ratio under some treatments might be due to salinity impact on grain and growth of plant which ultimately reduced the yield of crop.

Thus, based on two year study it can be concluded that application of organic culture as seed treatment and foliar spray (10%) at 30 and 60 days after sowing is better for realizing higher growth, yield and benefits in wheat production under low saline water irrigated condition.

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