Available online at www.ijpab.com

DOI: http://dx.doi.org/10.18782/2320-7051.6113

ISSN: 2320 – 7051

Int. J. Pure App. Biosci. **5 (6):** 744-751 (2017)

International Journal of Pure & Applied Bioscience

Research Article

OPEN ACCESS

Effect of Integrated Nutrient Management on Growth and Development of Wheat (*Triticum aestivum* L.) under Saline and Canal Water Irrigation

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Received: 5.11.2017 | Revised: 7.12.2017 | Accepted: 10.12.2017

ABSTRACT

Vermicompost, biofertilizers and chemical fertilizers were integrated to evaluate the performance of WH-711 at different growth stages under saline and non saline irrigation water during rabi seasons of 2011-2012 and 2012-2013 at Hisar, Haryana. Studies revealed that plant stand, plant height, dry matter accumulation, plant tillers per meter row length and Leaf area index were significantly higher in canal water as compared to saline water irrigation during both the years. Vermicompost @ 5 t/ha + Azotobacter ST3 + Pseudomonas P36 treatment resulted in significantly higher plant height, dry matter accumulation, plant tillers per meter row length and Leaf area index as compared to no inoculation during both the years. Maximum LAI, dry matter accumulation and plant tillers per meter row length were obtained under 125% RDF which was statistically at par with 100% RDF and significantly higher than 75% RDF treatment at all the stages of crop growth during both the years. Vermicompost + inoculation and levels of fertilizers, however, had no significant effect on plant stand per meter row length at 15 DAS.

Key words: *Vermicompost, Azotobacter, Biofertilizers, Irrigation*

INTRODUCTION

Wheat (*T. aestivum* L.) is the second most important staple food crop of the world after rice. It is cultivated in almost all countries; the major wheat producing countries are China, India, USA, Russia, France and Australia. In India, wheat is cultivated in an area of 30 mha with total production of 88.94 mt and productivity of 2872 kg/ha during 2014-15. In Haryana, it was grown over an area of 2.52 mha with production of 11.63 mt and highest productivity of 4624 kg/ha during 2014-15[2]. In Haryana, on an average, 55% of ground water is of poor quality. Amongst the poor quality waters, the proportion of sodic, saline and saline-sodic waters are 18, 11 and 26%, respectively[19]. In modern agriculture, keeping in mind status of the soil health, it is well recognized that neither organic manures nor chemical fertilizers individually can supplement the balanced amount of nutrients required by the plant to sustain production. Crop responses to organics and bioinoculants do not bring an immediate change as chemical fertilizers, but lead to increased use efficiency of fertilizers and enhanced physico-chemical properties of soil on long term basis. Moreover, quality of irrigation water has deteriorated over the years due to excessive use of chemical fertilizers.

Cite this article: Kumar, S. and Satyavan, Effect of Integrated Nutrient Management on Growth and Development of Wheat (*Triticum aestivum* L.) under Saline and Canal Water Irrigation, *Int. J. Pure App. Biosci.* **5(6):** 744-751 (2017). doi: http://dx.doi.org/10.18782/2320-7051.6113

Salinity is a major hindrance threatening wheat productivity in semi-arid regions by inducing physiological drought stress, ion toxicity and mineral deficiencies. Wheat crop is sensitive to salinity during seedling and vegetative growth stages. Hence, it was realized to integrate biofertilizers, chemical fertilizers and vermicompost to investigate the effects on growth and development of wheat under both saline water and canal water irrigation.

MATERIALS AND METHODS

The present studies on integrated nutrient management in wheat under saline and non saline irrigation water were conducted during *rabi* seasons of 2011-2012 and 2012-2013 at Research Farm, Department of Soil Science, of Chaudhary Charan Singh, Haryana Agricultural University, Hisar. Hisar is situated in the sub-tropics at 29º 10´N latitude and 75º 46´E longitudes at an elevation of 215.2 meter above mean sea level in Haryana state of India. The soil of the experimental field was sandy loam in texture, low in organic carbon and available nitrogen, medium in available phosphorus and high in available potassium. Wheat variety WH-711 was used as seedling material, vermicompost was used as organic source. Urea, diamonium phoshphate and $ZnSo_4$ were used as chemical fertilizers at the recommended dose (RDF) as per the package and practices of CCSHAU, Hisar. Seeds of WH-711 were inoculated with *Azotobacter* ST3 & *Pseudomonas* P36 during both the years. The experiment consisted of two levels of quality of irrigation water *viz.*, canal water and saline water (8-10 dS/m) and four inoculation and vermicompost treatments *viz.*, no inoculation (control), vermicompost @ 5 t/ha, *Azotobacter* ST3 + *Pseudomonas* P36 and *Azotobacter* ST3 + *Pseudomonas* P36 + vermicompost @ 5 t/ha in main plots and three levels of fertilizer *viz.*, 75, 100 and 125% RDF in sub-plots. The 24 treatment combinations were tested in split plot design replicated thrice.

RESULTS AND DISCUSSION

Plant population

In the present studies, plant stand/mrl was significantly higher under application of canal water during both the years (40.36 and 39.35, respectively) than under saline water (38.41 and 37.36, respectively) at 15 DAS (Table 1). In line with the findings, Kumar[16] and Kumar *et al*.[17] also reported that salinity reduced plant population in wheat crop. Under saline water, moisture intake in seed may be reduced due to increased salt concentration of soil solution, which might have affected the germination adversely[15]. Inoculation + vermicompost and fertilizer treatments had no significant effect on plant stand at 15 DAS during both the years. Non significant affects of vermicompost and RDF on plant stand were also reported by Ranwa in wheat crop.

Plant height

Plant height increased up to maturity in all the treatments. Significantly taller plants at 30, 60, 90, 120 DAS and at harvest were recorded under application of canal water than saline water during both the years (Table 2). Similar reduction in plant height under salinity conditions in wheat crop was reported by Kumar *et al*.[17] and Mojid *et al*.[20] which might be due to immobilization of food reserves thereby suspending cell enlargement and division[14], Kalhoro *et al*.[13] also reported larger decrease in plant height at high salinity (EC = 10 dS/m) levels in wheat. Under different inoculation and vermicompost treatments, maximum plant height was recorded with application of *Azotobacter* ST3 & *Pseudomonas* P36 + vermicompost @ 5 t/ha which was significantly higher than no inoculation at all the stages of crop growth during 2011-12 and at 60, 90, 120 DAS and at harvest during 2012-13 followed by vermicompost @ 5 t/ha. Similar results have also been reported by other workers[9,17] in wheat crop. Vermicompost and bioinoculants increased the availability of nutrients in adequate amount at different growth stages of wheat crop resulting in taller plants[23]. The fertilizer levels influenced plant height significantly at all the stages of crop growth. Maximum plant height was recorded when the crop was fertilized with 125% RDF followed by 100% RDF and lowest plant height was recorded with application of 75% RDF at all the growth stages for both the years. Laghari *et al*.[118] and Yousaf *et al*.[25] also reported decrease in plant height as the RDF decreased in wheat crop. Higher dose of fertilizer might have resulted in maximum N uptake, leading to increased protein synthesis, cell division and cell enlargement which in turn are elaborated into protoplast and thereby protein is left available for cell wall formation materials, which is expressed morphologically in terms of increased plant height.

Dry matter accumulation

During both the years of experimentation, application of canal water recorded significantly higher dry matter accumulation than saline water at all the stages of crop growth *i.e*. 30, 60, 90, 120 DAS and at harvest (Table 3). Drastic reduction in dry matter accumulation was recorded at 90 and 120 DAS with saline water application in the present studies. In line with the findings, other workers[4,11] also reported significant and inverse relationship of dry matter with salinity levels. Likewise, dry matter reduction has been reported at higher salinity levels (EC = 10-13 dS/m) by Mojid *et al*.[20] and to the tune of 28 and 29% at 75 and 90 DAS (EC = 09-12 dS/m) by Kumar *et al*.[17]. The reduction in dry matter accumulation is attributed to decreased plant height, number of tillers and leaf area index. During both the years, inoculation with *Azotobacter* ST3 & *Pseudomonas* P36 + vermicompost @ 5 t/ha produced significantly higher dry matter than no inoculation at all the stages of crop growth. Similarly, significant and positive effect of vermicompost along with PSB on dry matter accumulation in wheat was reported over vermicompost and absolute control[1,10]. The higher dry matter accumulation in vermicompost + inoculation treatment may be due to the fact that vermicompost increases the population of other beneficial microorganisms such as N-fixers, P-solublizers and activity of nitrogenase and urease enzyme[6]. In addition, beneficial effects of *Azotobacter* could be attributed to its multiple actions for synthesis of growth promoting substances, antifungal and antibiotics which might have been utilized by the plants in synthesis of proteins, carbohydrates, starch and other assimilates, thereby improving growth of plant. Inoculation with *Pseudomonas* enhances availability of P through solubilization of insoluble phosphorous carriers such as calcium and magnesium phosphate from soil[8]. Dry matter accumulation increased significantly with successive increase in recommended dose of fertilizers from 75 to 125% RDF. However, dry matter accumulated under 125% RDF was at par with 100% RDF at all the stages of crop growth during both the years. Probably increased fertilizer rates enhanced more leaf area resulting in higher assimilation of photosynthates and thereby resulting in more dry matter accumulation. Overall improvement in growth of plants under application of fertilizers could be ascribed to vital role of nitrogen (enhances growth processes being an integral part of chlorophyll, proteins and nucleic acid) and phosphorous (improves metabolic and physiological processes, improving both vegetative and reproductive growth) which subsequently led to build up of all the components of plant biomass[5,24] . The results are in close conformity with the findings of several researchers[4,8,22].

Plant tillers per meter row length

Results indicated that maximum plant tillers/mrl was recorded at 60 DAS during both the years and thereafter decreasing trend was observed in all the treatments (Table 4). Higher number of plant tillers/mrl was obtained under canal water than saline water at all the stages of crop growth during both the years. In line with the findings, other workers also reported significant decrease in plant tillers/mrl in salinity treatments as compared to canal water[4,11,16,17]. Inoculation and vermicompost treatments also significantly influenced the plant tillers/mrl at all the stages during 2011-12 and 2012-13. Maximum plant tillers/mrl were recorded under *Azotobacter* ST3 & *Pseudomonas* P36 + vermicompost @ 5 t/ha followed by vermicompost @ 5t/ha and *Azotobacter* ST3 & *Pseudomonas* P36, while minimum was obtained under no inoculation. The findings of Devi *et al*.[10] and Choudhary *et al*.[9] are corroborated with the present studies. It was also observed that different fertilizer levels significantly influenced the plant tillers/mrl at all the stages during both the years. Maximum plant tillers/mrl were obtained by application of 125% RDF which was statistically at par with 100% RDF treatment and minimum was observed with 75% RDF application. Probably this increase in plant tillers/mrl is due to the better supply of photosynthates from leaves to tillers[12]. Significant effect of fertilizer was also reported by Chaturvedi *et al*.[7], Laghari *et al*.[18] and Qazizadah[21]. This was mainly due to more number of plants per unit area.

Leaf area index (LAI)

Initially, the increase in LAI was at the slower rate but 30 DAS, there was a rapid increase in the LAI up to 90 DAS and declined thereafter at 120 DAS. Alam also reported similar trend of increase in LAI with the advanced of age of the plant. Significantly higher LAI was recorded with the application of canal water as compared to saline water at all the stages of crop growth *i.e*. 30, 60, 90 and 120 DAS during both the years. Highest LAI was recorded at 90 DAS with canal water application during 2011-12 (3.85) and 2012-13 (3.34) (Table 5). Likewise, maximum LAI at 90 DAS was recorded by Mojid *et al*.[20] and Azizian and Sepaskhah (2014) in canal water as compared to saline water treatment. Significantly higher LAI was obtained with the application of *Azotobacter* ST3 & *Pseudomonas* P36 + vermicompost @ 5 t/ha as compared to no inoculation treatment at all the stages of crop growth during both the years. Highest LAI was recorded at 90 DAS with the application of *Azotobacter* ST3 & *Pseudomonas* P36 + vermicompost @ 5 t/ha during 2011-12 (3.74) as well as 2012-13 (3.21). Maximum LAI was obtained under 125% RDF which was statistically at par with 100% RDF and significantly higher than 75% RDF treatment at all the stages of crop growth during both the years. Maximum LAI was recorded at 125% RDF (3.71, 3.12) during 2011-12 and 2012-13, respectively at 90 DAS. Co-findings of Alam also supported the present outcome of increase in LAI with increasing dose of fertilizer could be ascribed to the fact that better supply of fertilizer might have led to increase in leaves per unit area resulting in more leaf area. Similar findings were also reported by Jat[12] and Choudhary *et al*. [9].

Table1. Effect of saline water and different nutrient management practices on plant stand per meter row length at 15 DAS of wheat crop

Treatments	2011-12	2012-13
Quality of irrigation water		
Canal water	40.36	39.35
Saline water	38.41	37.36
SEm±	0.60	0.57
CD at 5%	1.83	1.74
Inoculation and vermicompost		
Inoculation (*Azotobacter* ST3 & *Pseudomonas* P 36) + vermicompost @5t/ha	40.76	39.59
Inoculation (*Azotobacter* ST3 & *Pseudomonas* P 36)	39.54	38.18
Vermicompost @5t/ha	40.05	38.41
No inoculation	37.20	37.24
SEm±	0.85	0.81
CD at 5%	NS	NS
Fertilizers		
75% RDF	38.72	37.44
100% RDF	39.22	38.35
125% RDF	40.22	39.28
SEm±	0.71	0.68
CD at 5%	NS	NS

Table 2. Effect of saline water and different nutrient management practices on plant height (cm) of wheat crop

Treatments	**2011-12**					**2012-13**				
	Days after sowing					**Days after sowing**				
	30	**60**	**90**	**120**	**At harvest**	**30**	**60**	**90**	**120**	**At harvest**
Quality of irrigation water										
Canal water	17.21	45.66	75.10	87.35	88.06	16.11	41.78	66.59	80.26	80.93
Saline water	15.31	40.24	66.34	76.64	77.56	14.45	35.68	57.11	70.73	71.59
SEm±	0.17	0.40	0.46	0.36	0.38	0.32	0.38	0.38	0.44	0.45
CD at 5%	0.53	1.21	1.41	1.09	1.16	0.98	1.15	1.15	1.35	1.38
Inoculation and vermicompost										
Inoculation (*Azotobacter* ST3 & *Pseudomonas* P 36) + vermicompost @ 5t/ha	16.99	44.51	73.21	84.83	85.44	15.71	40.66	65.44	78.02	78.27
Inoculation (*Azotobacter* ST3 & *Pseudomonas* P 36)	16.33	42.34	70.13	81.00	82.00	15.12	38.35	60.97	75.10	75.78
Vermicompost @ 5t/ha	16.47	43.49	71.15	82.25	83.11	15.51	38.89	61.64	75.50	76.58
No inoculation	15.24	41.44	68.39	79.90	80.67	14.78	37.01	59.36	73.35	74.39
SEm±	0.25	0.56	0.61	0.51	0.52	0.45	0.54	0.54	0.63	0.62
CD at 5%	0.75	1.71	1.86	1.54	1.57	NS	1.63	1.63	1.91	1.89
Fertilizers										
75% RDF	13.04	41.34	68.92	80.58	81.17	12.04	37.58	60.05	73.86	74.55
100% RDF	17.46	43.29	70.96	82.07	83.08	16.48	39.02	62.37	75.79	76.81
125% RDF	18.27	44.21	72.28	83.34	84.17	17.31	39.59	63.14	76.84	77.40
SEm±	0.30	0.52	0.53	0.49	0.49	0.31	0.38	0.40	0.41	0.45
CD at 5%	0.87	1.51	1.54	1.41	1.40	0.87	1.11	1.15	1.19	1.31

Table 3. Effect of saline water and different nutrient management practices on dry matter accumulation per meter row length of wheat crop

Treatments	**2011-12**					**2012-13**				
	Days after sowing					**Days after sowing**				
	30	**60**	**90**	**120**	**At**	**30**	**60**	**90**	**120**	**At**
Quality of irrigation										
Canal water	7.53	37.77	172.17	244.75	252.88	7.39	36.30	158.05	221.70	225.14
Saline water	6.83	37.29	137.46	196.84	203.84	6.45	31.46	129.57	181.74	183.13
SEm±	0.03	0.35	1.10	1.90	1.79	0.06	0.24	0.93	1.11	1.32
CD at 5%	0.09	1.08	3.35	5.77	5.42	0.18	0.72	2.81	3.36	4.01
Inoculation and										
Inoculation (*Azotobacter* ST3 &	7.61	36.77	162.35	229.77	238.12	7.17	36.08	151.10	211.96	215.28
Inoculation (*Azotobacter* ST3 &	7.16	34.79	153.81	218.12	225.81	6.98	33.50	141.63	198.59	201.02
Vermicompost @5t/ha	7.27	35.63	157.82	225.33	232.36	7.03	34.39	145.07	202.42	206.03
No inoculation	6.70	32.92	145.28	209.94	216.22	6.52	31.55	136.44	193.91	198.21
SEm±	0.04	0.50	1.56	2.69	2.53	0.08	0.34	1.31	1.48	1.87
CD at 5%	0.13	1.53	4.73	8.16	7.66	0.25	1.02	3.97	4.50	5.67
Fertilizers										
75% RDF	6.80	33.49	147.79	210.38	217.74	6.44	32.03	136.32	190.95	194.98
100% RDF	7.33	35.38	156.36	223.20	230.70	7.05	34.50	145.91	204.91	208.12
125% RDF	7.43	36.22	160.30	228.78	236.16	7.28	35.10	149.20	209.30	212.30
SEm±	0.06	0.30	1.53	2.23	1.92	0.05	0.32	1.27	1.58	1.61
CD at 5%	0.16	0.87	4.42	6.41	5.54	0.15	0.92	3.67	4.55	4.64

Table 4. Effect of saline water and different nutrient management practices on plant tillers per meter row length of wheat crop

Treatments	2011-12				2012-13			
	Days after sowing				Days after sowing			
	60	90	120	At harvest	60	90	120	At harvest
Quality of irrigation water								
Canal water	109.86	105.22	102.76	99.89	105.82	102.17	98.54	94.58
Saline water	91.70	87.97	84.00	82.39	89.63	85.45	82.08	78.58
SEm±	0.35	0.70	0.49	0.51	0.37	0.45	0.43	0.40
CD at 5%	1.07	2.11	1.48	1.56	1.13	1.38	1.29	1.21
Inoculation and vermicompost								
Inoculation (*Azotobacter* ST3 & *Pseudomonas* P 36) + vermicompost@5t/ha	104.80	102.37	97.19	94.06	99.52	95.88	92.53	88.90
Inoculation (*Azotobacter* ST3 &	100.03	95.16	92.45	90.76	97.04	93.27	89.80	85.70
Vermicompost @5t/ha	101.53	96.79	94.29	91.81	99.40	94.92	91.17	87.15
No inoculation	96.73	92.07	89.58	87.94	94.95	91.16	87.74	83.56
SEm±	0.50	0.98	0.69	0.87	0.52	0.64	0.60	0.57
CD at 5%	1.52	2.98	2.09	2.64	1.59	1.95	1.82	1.72
Fertilizers								
75% RDF	98.85	94.84	91.30	88.63	94.57	90.41	86.71	83.29
100% RDF	100.96	97.18	93.82	91.55	98.74	94.66	91.39	87.37
125% RDF	102.51	97.76	95.02	93.25	99.87	96.36	92.73	89.08
SEm±	0.54	0.69	0.46	0.63	0.60	0.63	0.48	0.63
CD at 5%	1.56	1.99	1.34	1.83	1.74	1.82	1.38	1.83

Table 5. Effect of saline water and different nutrient management practices on leaf area index (LAI) of wheat crop

Treatments	2011-12				2012-13			
	Days after sowing				Days after sowing			
	30	60	90	120	30	60	90	120
Quality of irrigation water								
Canal water	0.60	1.94	3.85	2.32	0.59	1.90	3.34	2.17
Saline water	0.49	1.81	3.37	2.01	0.48	1.79	2.68	1.83
SEm±	0.004	0.003	0.03	0.01	0.005	0.004	0.02	0.01
CD at 5%	0.01	0.01	0.08	0.04	0.01	0.01	0.06	0.03
Inoculation and vermicompost								
Inoculation (*Azotobacter* ST3 & *Pseudomonas* P 36) + vermicompost @5t/ha	0.58	1.92	3.74	2.25	0.57	1.90	3.21	2.12
Inoculation (*Azotobacter* ST3 & *Pseudomonas* P 36)	0.54	1.87	3.57	2.15	0.54	1.83	2.96	1.96
Vermicompost @5t/ha	0.54	1.88	3.63	2.19	0.54	1.85	2.98	2.00
No inoculation	0.51	1.82	3.48	2.08	0.49	1.78	2.89	1.90
SEm±	0.005	0.004	0.04	0.02	0.005	0.007	0.03	0.01
CD at 5%	0.02	0.01	0.11	0.06	0.02	0.02	0.09	0.04
Fertilizers								
75% RDF	0.52	1.84	3.49	2.08	0.50	1.80	2.86	1.90
100% RDF	0.55	1.88	3.63	2.19	0.54	1.86	3.06	2.04
125% RDF	0.56	1.90	3.71	2.23	0.56	1.87	3.12	2.06
SEm±	0.003	0.006	0.03	0.01	0.007	0.008	0.02	0.01
CD at 5%	0.01	0.02	0.09	0.04	0.02	0.02	0.07	0.04

ACKNOWLEDGEMENT

The authors are thankful to, Dr. Jagdev Singh, Prof. & Head, Dept. of Agronomy, CCS HAU, Hisar, for providing me all the necessary facilities and cordial help whenever needed. The assistance got from Mandeep Rathee, a Ph.D. student of Department of Entomology, CCSHAU is also acknowledged.

CONCLUSION

Based on two years of investigation, it is concluded from the present studies that application of canal water along with vermicompost @ 5t/ha + Azotobacter + *Pseudomonas* improved growth parameters and development of wheat.

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