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Quality Parameters, Nutrient Content and Uptake as Influenced by INM in Wheat (*Triticum aestivum* L.) under Saline and Non-Saline Irrigation Water

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A B S T R A C T

Quality parameters namely hectolitre weight, sedimentation value, protein content, N/P/K content and uptake were evaluated in WH711 by integrating use of vermicompost, biofertilizers and chemical fertilizers under saline and non-saline irrigation water during *rabi* seasons of 2011-2012 and 2012-2013 at Hisar, Haryana. Hectolitre weight did not differ significantly due to quality of irrigation water, inoculation and vermicompost treatments and ranged from 75.55 to 76.38 kg/hl during first year and 75.49 to 76.33 kg/hl in second year. Protein content (%) was significantly higher under canal water (12.23, 12.13) than saline water (11.11, 10.94) during 2011-12 and 2012-13, respectively while no significant effect was observed on sedimentation value (ml). Protein content and sedimentation value were significantly higher under *Azotobacter* ST3 and *Pseudomonas* P36 + vermicompost @ 5t/ha (31.31, 31.20 ml; 11.85, 11.76 %) than no inoculation (28.33, 28.61ml 11.47, 11.24 %) during both the years, respectively. N, P and K content (%) and uptake (kg/ha) by grain and straw were significantly higher in canal water and inoculation (*Azotobacter* ST3 and *Pseudomonas* P36) + vermicompost @ 5t/ha during both the years. Sedimentation value did not vary significantly with different recommended dose of fertilizers, while protein content was significantly improved under 125% RDF (11.88, 11.82 %) as compared to 75% RDF (11.36, 11.15 %) during 2011-12 and 2012-13, respectively. N and P content and their uptake by grain and straw increased significantly as the RDF increased during both the years. Different recommended dose of fertilizers did not significantly affect K content ingrain and straw during both the years, while K uptake was by grain and straw was significantly higher under 125% RDF over 75% RDF during both the years.

Introduction

Wheat (*Triticum aestivum* L.) is the second most important staple food crop at global scenario after rice. Quality parameters of flour *viz*., colour, appearance etc. are very much important for preparation of final products like bread, chapatti, biscuits etc. In the present investigation various physico-chemical parameters like sedimentation value, protein content and hectoliter weight were determined to study the impact of treatments. Sedimentation value gives an idea of the gluten strength. End use quality of wheat is influenced by quantity and quality of gluten proteins and latter is responsible for selection of wheat varieties for different products (Joppa, 1975). In wheat grains, the sedimentation value normally range from 21 to 47 ml with a mean value of 34 ml (Misra and Gupta, 1995).Protein content is the principal factor determining baking properties of wheat flour. Singh and Paliwal (1986) reported that protein content ranged from 8.82 to 15.85 per cent, in *T. aestivum* while protein in Mexican wheat flour ranged from 9.6 to 11.0 per cent. Hence, it was realized to integrate bio-fertilizers, chemical fertilizers and vermicompost with an aim to investigate the impact on quality parameters and nutrient availability to wheat crop under both saline water and non-saline irrigation water.

Materials and Methods

Integrated nutrient management studies in wheat crop 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, India. The soil was sandy loam in texture, low in organic carbon and available nitrogen, medium in available phosphorus and high in available potassium. WH-711 was used as seedling material, vermicompost was used as organic source and urea, diamonium phosphate and zinc sulphate were used as chemical fertilizers at the recommended dose (RDF) as per the package and practices of CCSHAU. WH-711 seeds were inoculated with *Azotobacter* ST3 and *Pseudomonas* P36 during both the years. The experiment comprised of two levels of quality of irrigation water viz., canal (non-saline) 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. Grain samples were tested for hectolitre weight with the help of hectoliter weight instrument available in the Wheat Quality Laboratory of CCS HAU, Hisar. Sedimentation value was determined by the method of Axford *et al.,* (1979). Protein content in grain was calculated by multiplying the percentage of nitrogen ingrains with 6.25. To determine total nitrogen, phosphorus and potassium in plant samples, 0.2 g of dry material of grains and 0.5 g straw were digested with diacid mixture of H_2SO_4 and $HClO_4$ of9:1 (v/v) ratio. After digestion, the volume was raised to 50 ml with distilled water. This digested material was stored in plastic bottles after filtering through Whatman filter paper no.42 for further analysis. Nitrogen in plant samples was determined from the digested material by using Colorimetric (Nessler's reagent) method (Lindner, 1944). Phosphorus in plant samples was determined from the digested material by using Vanadomolybdo phosphoric yellow color method (Koenig and Johnson, 1942).Potassium in plant samples was determined from the digested material by using flame photometer (directly). The data on quality parameters namely hectolitre weight, sedimentation value, protein content and nutrient content and uptake were analyzed using OP Stat software at 5% level of significance.

Results and Discussion

Quality parameters

Hectolitre weight

The data presented in Table 1 revealed that there were no significant differences among the treatments (quality of irrigation water, levels of fertilizer, inoculation and vermicompost) with respect to hectolitre weight during both the years. Hectolitre weight ranged from 75.55 to 76.38 kg/hl during first year and 75.49 to 76.33 kg/hl in second year. Similar findings were reported by Fana *et al.,* (2012) and Bulut (2013).

Sedimentation value (ml)

Quality of irrigation water and levels of fertilizer did not significantly affect the sedimentation value during both the years. In line with the findings, non-significant effect of salinity (Zheng *et al.,* 2009 and Naserian *et al.,* 2014) and levels of fertilizer (Knapowski *et al.,* 2009) has been reported in previous studies. Although sedimentation values were higher in canal water and 125% RDF, this may be due to decrease in the gluten content at higher salinity and lower fertilizer levels. The findings are in agreement with that of Francois *et al.,* (1986) who observed diminishing sedimentation values due to salinity stress. However, inoculation and vermicompost treatments differed significantly with respect to sedimentation value. Maximum sedimentation value was recorded in *Azotobacter* ST3 and *Pseudomonas* P36 + vermicompost @ 5 t/ha (31.31, 31.20 ml) while minimum was recorded in no inoculation (28.33, 28.61 ml) during 2011-12 and 2012-13, respectively. In line with the findings, Ram *et al.,* (2014) reported maximum sedimentation value in GM + FYM+ Biofertilizers treatment (43.36 ml) and minimum in control (no inoculation, 38.20 ml). Similar results were obtained by Konvalina *et al.,* (2009) and Davari *et al.,* (2012).

Protein content (%)

Protein content of wheat grains differed significantly in all the treatments viz., quality of irrigation water, levels of fertilizer and inoculation and vermicompost during both the years (Table 1). Canal water treatment resulted in higher protein content as compared to saline water during 2011-12 (12.23, 11.11%) as well as 2012-13 (12.13, 10.94%), respectively. Likewise, reduction in protein content due to salinity was reported by Kumar (2000), Tammam *et al.,* (2008) and Datta *et al.,* (2009). Among the inoculation and vermicompost treatments, *Azotobacter* ST3 and *Pseudomonas* P36+ vermicompost @ 5 t/ha (11.85, 11.76%) was found superior with respect to protein content as compared to no inoculation (11.47, 11.24%) during both the years, respectively, while it was at par with vermicompost @ 5t/ha. In line with the findings, Ram *et al.,* (2014) reported maximum protein content in GM + FYM+ Biofertilizer treatment (9.01%) and minimum in control (no inoculation, 7.08%).Application of fertilizer @ 125% RDF resulted in highest protein content (11.88, 11.82%) followed by 100% RDF (11.78, 11.64%) while lowest was recorded in 75% RDF (11.36, 11.15%) during 2011-12 and 2012-13, respectively. Likewise, Kumar (2000) and Sharma *et al.,* (2013) reported significant increase in protein content as the recommended dose of fertilizer increased. The increase of protein content (wheat grain) in different treatments might be due to increased nitrogen uptake as influenced by the use of vermicompost and fertilizers.

Chemical analysis

Nitrogen content (%) and its uptake (kg/ha) by grain and straw

Data presented in Table 2 revealed that N content in grain and straw, N uptake by grain and straw and total N uptake varied significantly among different treatments (quality of irrigation water, inoculation and vermicompost and levels of fertilizer) during both the years. Under quality of irrigation water, canal water treatment resulted insignificantly higher N content in grain (1.954, 1.941%) as compared to saline water (1.777, 1.749%) during 2011-12 and 2012-13, respectively. Similar trend was observed for N content in straw, N uptake by grain and straw and total N uptake during both the years of study. The results of current studies are in conformity with Kumar (2000), Hussain *et al.,* (2014) and Saleh *et al.,* (2015). The decrease in N uptake may be due to accumulation of Na^+ and Cl^- under salinity stress (Alam, 1999). Low content of nitrogen ingrains due to low N uptake was due to limited synthesis of specific N compounds such as proline, glutamine and asparagine (Mansour, 2000 and Ashraf and Harris, 2004).

Under inoculation and vermicompost treatments, *Azotobacter* ST3 and *Pseudomonas* P36 + vermicompost @ 5 t/ha treatment resulted in significantly higher N content ingrain and straw followed by vermicompost @ 5t/ha and minimum was observed in no inoculation during both the years. Similar trend was observed for N uptake by grain, N uptake by straw and total N uptake. Current findings corroborate with those of Devi *et al.,* (2011), Davari *et al.,* (2012), Sharma *et al.,* (2013), Shishehbor *et al.,* (2013), Ram *et al.,* (2014) and Hussain *et al.,* (2016).

The higher nutrient uptake with organic manure and biofertilizers might be attributed to solublization of native nutrients by microorganisms, chelation of complex intermediate organic molecules produced during decomposition of added organic manures, their mobilization and accumulation of different nutrients in different plant parts. The results are in agreement with the findings of Sharma *et al.,* (2013).

Among various fertilizer treatments, 125% RDF treatment recorded maximum N content in grain and straw followed by 100% RDF and minimum was observed in 75% RDF during both the years. Similar trend was observed for N uptake by grain and straw and total N uptake. The increased content and uptake of N and P was due to added supply of nutrients and well developed root system resulting in better absorption of water and nutrients. In line with the findings, Laghari *et al.,* (2010), Chesti *et al.,* (2013) and Sharma *et al.,* (2013) reported increase in N uptake as the levels of fertilizer increased.

Phosphorous content (%) and its uptake (kg/ha) by grain and straw

Phosphorous content in grain and straw, P uptake by grain and straw and total P uptake varied significantly among quality of irrigation water, inoculation and vermicompost and different levels of fertilizer treatments during both the years (Table 3). Under quality of irrigation water, canal water treatment resulted in significantly higher P content in grain (0.266, 0.256%) as compared to saline water (0.230, 0.224%) during 2011-12 and 2012-13, respectively.

Similar trend was observed for P content in straw, P uptake by grain and straw and total P uptake during both the years of investigation. The results of present studies are in conformity with Kumar (2000), Yadav *et al.,* (2015) and Hussain *et al.,* (2014). Soil salinity significantly reduces plant P uptake because phosphate ions precipitate with Ca^+ ions (Bano and Fatima, 2009).

Under inoculation and vermicompost treatments, *Azotobacter* ST3 and *Pseudomonas* P36 + vermicompost @ 5 t/ha treatment resulted in significantly higher P content in grain and straw followed by vermicompost @ 5t/ha and minimum was observed in no inoculation during both the years. Similar trend was observed for P uptake by grain and straw and total P uptake.

Table.1 Effect of saline water and different nutrient management practices on sedimentation value, protein content and hectolitre weight of wheat

Treatments	Sedimentation value (ml)		Protein content (%)		Hectolitre weight (kg/hl)	
	2011-12	**2012-13**	**2011-12**	**2012-13**	**2011-12**	**2012-13**
Quality of irrigation water						
Canal water	30.11	30.40	12.23	12.13	76.37	76.33
Saline water	29.63	29.85	11.11	10.94	75.66	75.56
SEm±	**0.16**	**0.21**	**0.04**	**0.04**	**0.58**	**0.62**
CD at 5%	**NS**	**NS**	**0.11**	**0.11**	**NS**	**NS**
Inoculation and vermicompost						
Inoculation (*Azotobacter* ST3 &*Pseudomonas* P 36) + vermicompost @5t/ha	31.31	31.20	11.85	11.76	76.38	76.33
Inoculation (*Azotobacter* ST3 &*Pseudomonas* P 36)	29.53	29.83	11.60	11.47	75.80	75.73
Vermicompost @5t/ha	30.30	30.85	11.77	11.68	76.34	76.24
No inoculation	28.33	28.61	11.47	11.24	75.55	75.49
SEm±	**0.23**	**0.30**	**0.05**	**0.05**	**0.83**	**0.88**
CD at 5%	**0.69**	**0.90**	**0.16**	**0.15**	**NS**	**NS**
Fertilizers						
75% RDF	29.71	29.99	11.36	11.15	75.85	75.89
100% RDF	29.80	30.11	11.78	11.64	76.07	75.95
125% RDF	30.10	30.28	11.88	11.82	76.13	76.00
SEm±	**0.19**	**0.22**	**0.06**	**0.06**	**0.95**	**0.82**
CD at 5%	**NS**	**NS**	**0.17**	**0.16**	**NS**	**NS**

Table.2 Effect of saline water and different nutrient management practices on nitrogen content and its uptake by wheat crop

Treatments	N content (%) in grain		N content (%) in straw		N uptake (kg/ha) by grain		N uptake (kg/ha) by straw		Total N uptake (kg/ha)	
	2011-12	**2012-13**	**2011-12**	**2012-13**	**2011-12**	**2012-13**	**2011-12**	**2012-13**	**2011-12**	**2012-13**
Quality of irrigation water										
Canal water	1.954	1.941	0.607	0.582	99.90	90.40	46.59	38.61	146.49	129.01
Saline water	1.777	1.749	0.546	0.512	72.74	69.82	34.50	27.34	107.23	97.16
SEm±	**0.005**	**0.006**	**0.004**	**0.003**	**0.91**	**0.76**	**0.44**	**0.37**	**1.14**	**0.94**
CD at 5%	**0.016**	**0.017**	**0.011**	**0.011**	**2.77**	**2.31**	**1.34**	**1.13**	**3.46**	**2.85**
Inoculation and vermicompost										
Inoculation (*Azotobacter* ST3 &*Pseudomonas* P 36) + vermicompost @5t/ha	1.893	1.882	0.626	0.616	91.46	85.33	45.57	38.80	137.03	124.13
Inoculation (*Azotobacter* ST3 &*Pseudomonas* P 36)	1.854	1.834	0.579	0.531	85.59	78.06	40.39	31.22	125.98	109.28
Vermicompost @5t/ha	1.880	1.866	0.584	0.550	88.12	81.83	41.39	33.52	129.51	115.35
No inoculation	1.833	1.798	0.517	0.489	80.11	75.23	34.81	28.36	114.92	103.59
SEm±	**0.008**	**0.008**	**0.005**	**0.005**	**1.29**	**1.08**	**0.63**	**0.53**	**1.61**	**1.33**
CD at 5%	**0.023**	**0.024**	**0.016**	**0.015**	**3.92**	**3.27**	**1.90**	**1.60**	**4.89**	**4.04**
Fertilizers										
75% RDF	1.815	1.784	0.559	0.526	78.12	72.32	37.55	30.55	115.67	102.87
100% RDF	1.883	1.861	0.583	0.546	88.78	82.52	41.54	33.11	130.32	115.63
125% RDF	1.899	1.890	0.588	0.568	92.06	85.49	42.54	35.26	134.59	120.76
SEm±	**0.009**	**0.009**	**0.005**	**0.005**	**0.96**	**0.82**	**0.43**	**0.52**	**1.08**	**0.96**
CD at 5%	**0.027**	**0.026**	**0.013**	**0.013**	**2.78**	**2.36**	**1.24**	**1.50**	**3.10**	**2.76**

Table.3 Effect of saline water and different nutrient management practices on phosphorus content and its uptake by wheat crop

Treatments	P content (%) in grain		P content (%) in straw		P uptake (kg/ha) by grain		P uptake (kg/ha) by straw		Total P uptake (kg/ha)	
	2011-12	**2012-13**	**2011-12**	**2012-13**	**2011-12**	**2012-13**	**2011-12**	**2012-13**	**2011-12**	**2012-13**
Quality of irrigation water										
Canal water	0.266	0.256	0.104	0.098	13.61	11.94	7.94	6.49	21.55	18.43
Saline water	0.230	0.224	0.086	0.082	9.44	8.96	5.41	4.40	14.85	13.36
SEm±	**0.001**	**0.001**	**0.000**	**0.001**	**0.14**	**0.11**	**0.06**	**0.05**	**0.16**	**0.13**
CD at 5%	**0.003**	**0.003**	**0.001**	**0.002**	**0.42**	**0.34**	**0.18**	**0.15**	**0.48**	**0.40**
Inoculation and vermicompost										
Inoculation (*Azotobacter* ST3 &*Pseudomonas* P36)+vermicompost @5t/ha	0.259	0.249	0.102	0.097	12.52	11.29	7.44	6.11	19.96	17.40
Inoculation (*Azotobacter* ST3 &*Pseudomonas* P 36)	0.249	0.243	0.092	0.088	11.51	10.35	6.42	5.16	17.93	15.51
Vermicompost @5t/ha	0.254	0.245	0.096	0.092	11.93	10.75	6.82	5.62	18.75	16.37
No inoculation	0.231	0.225	0.089	0.084	10.13	9.41	6.01	4.88	16.14	14.29
SEm±	**0.001**	**0.001**	**0.001**	**0.001**	**0.19**	**0.16**	**0.08**	**0.07**	**0.22**	**0.18**
CD at 5%	**0.004**	**0.004**	**0.002**	**0.002**	**0.59**	**0.48**	**0.25**	**0.22**	**0.67**	**0.56**
Fertilizers										
75% RDF	0.243	0.233	0.090	0.086	10.51	9.49	6.09	4.98	16.60	14.47
100% RDF	0.249	0.236	0.095	0.091	11.78	10.47	6.80	5.51	18.57	15.98
125% RDF	0.252	0.252	0.098	0.094	12.28	11.40	7.13	5.84	19.42	17.24
SEm±	**0.001**	**0.001**	**0.001**	**0.001**	**0.15**	**0.11**	**0.08**	**0.08**	**0.18**	**0.16**
CD at 5%	**0.004**	**0.004**	**0.002**	**0.003**	**0.43**	**0.32**	**0.23**	**0.27**	**0.53**	**0.47**

Table.4 Effect of saline water and different nutrient management practices on potassium content and its uptake by wheat crop

Treatments	K content (%) in grain		K content (%) in straw		K uptake (kg/ha) by grain		K uptake (kg/ha) by straw		Total K uptake (kg/ha)	
	2011-12	**2012-13**	**2011-12**	**2012-13**	**2011-12**	**2012-13**	**2011-12**	**2012-13**	**2011-12**	**2012-13**
Quality of irrigation water										
Canal water	0.381	0.383	0.921	0.910	19.48	17.86	70.58	60.33	90.06	78.19
Saline water	0.357	0.356	0.875	0.852	14.61	14.24	55.21	45.37	69.81	59.61
SEm±	**0.003**	**0.002**	**0.004**	**0.003**	**0.21**	**0.14**	**0.47**	**0.38**	**0.46**	**0.43**
CD at 5%	**0.008**	**0.006**	**0.013**	**0.008**	**0.63**	**0.42**	**1.44**	**1.15**	**1.39**	**1.31**
Inoculation and vermicompost										
Inoculation (*Azotobacter* ST3 &*Pseudomonas* P 36) + vermicompost @5t/ha	0.389	0.402	0.934	0.923	18.75	18.18	67.75	57.96	86.50	76.14
Inoculation (*Azotobacter* ST3 &*Pseudomonas* P 36)	0.351	0.346	0.866	0.843	16.11	14.68	60.12	49.26	76.24	63.94
Vermicompost @5t/ha	0.382	0.391	0.928	0.914	17.91	17.15	65.56	55.58	83.47	72.73
No inoculation	0.353	0.341	0.865	0.844	15.41	14.20	58.13	48.59	73.54	62.79
SEm±	**0.004**	**0.003**	**0.006**	**0.004**	**0.29**	**0.20**	**0.67**	**0.53**	**0.65**	**0.61**
CD at 5%	**0.011**	**0.010**	**0.019**	**0.012**	**0.89**	**0.60**	**2.04**	**1.62**	**1.97**	**1.85**
Fertilizers										
75% RDF	0.364	0.363	0.895	0.833	15.66	14.71	59.80	50.24	75.46	64.95
100% RDF	0.368	0.370	0.896	0.847	17.32	16.41	63.62	53.32	80.93	69.73
125% RDF	0.375	0.377	0.904	0.852	18.16	17.04	65.26	54.98	83.42	72.02
SEm±	**0.003**	**0.002**	**0.005**	**0.005**	**0.23**	**0.17**	**0.61**	**0.77**	**0.70**	**0.80**
CD at 5%	**NS**	**NS**	**NS**	**NS**	**0.65**	**0.48**	**1.75**	**2.23**	**2.03**	**2.31**

The solubilizing action of organic acids produced during decomposition of vermicompost might have increased the release of native P, stimulated microbial growth in soil and favoured root growth which had finally led to increased P uptake by wheat. The results are in agreement with the findings of Laghari *et al.,* (2010), Devi *et al.*, (2011), Sharma *et al.*, (2013) and Ram *et al.*, (2014).

Among various fertilizer treatments, 125% RDF treatment recorded maximum phosphorous content in grain and straw followed by 100% RDF and minimum was observed in 75% RDF during both the years. Similar trend was observed for P uptake by grain, P uptake by straw and total uptake. The results are in agreement with the findings of Laghari *et al.,* (2010), Chesti *et al.,* (2013) and Sharma *et al.,* (2013).

Potassium content (%) and its uptake (kg/ha) by grain and straw

Potassium content in grain and straw, K uptake by grain and straw and total K uptake also varied significantly among quality of irrigation water, inoculation and vermicompost and different levels of fertilizer treatments during both the years (Table 4).

Under quality of irrigation water, canal water treatment resulted in significantly higher K content ingrain (0.381, 0.383%) as compared to saline water (0.357, 0.356%) during 2011-12 and 2012-13, respectively. Similar trend was observed for K content in straw, K uptake by grain and straw and total K uptake during both the years of study. The results of present studies are in conformity with Hussain *et al.*, (2014) and Yadav *et al.*, (2015). The decrease in K content in grain and straw is due to suppressed K uptake by increased Na^+ concentration in soil solution due to saline water application (Sharma, 2003).

Among the inoculation and vermicompost treatments, *Azotobacter* ST3 &*Pseudomonas* P36 + vermicompost @ 5 t/ha treatment resulted in significantly higher K content in grain and straw, followed by vermicompost @ 5t/ha during both the years. Similar trend was observed for K uptake by grain and straw and total uptake. The increased uptake of K by wheat may be ascribed to the release of K from the K bearing minerals by complexing agents and organic acids produced during decomposition of organic resources. The results are in agreement with the findings of Devi *et al.*, (2011), Sharma *et al.*, (2013) and Ram *et al.,* (2014).

The data also revealed that various fertilizer treatments have no significant effect on potassium content in grain and straw during both the years. In case of grain, straw and total potassium uptake, significantly higher values were recorded with application of125% RDF followed by 100 and 75% RDF treatments during both the years. The results are in agreement with the findings of Laghari *et al.,* (2010). Since, potassium was not added through recommended dose of fertilizer, non-significant effect was observed on K content in grain and straw. Based on two years of investigation, it is concluded that application of vermicompost along with biofertilizers and chemical fertilizers improved the protein content, content and uptake of nutrients by wheat, more pronounced in non-saline water than saline water.

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