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Productivity and quality of wheat spp grown with different fertilization condition*

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Plant breeding and crop management techniques have increased grain yield of wheat and effectively reduced food shortage and malnutrition. The need of the hour is to develop more nutrient-dense staple food crop (Underwood 2000) that could help reduce not only energy but also nutrient malnutrition. Wheat is cultivated in different crop production conditions using different fertilizers. There is increasing demand for organically grown wheat throughout the world. Organic fertilizers influence both yield and plant micronutrient content and thus help sustain crop productivity (Mottaghian *et al*. 2008).

The free-living nitrogen-fixing micro-organism like *Azotobacter* and *Azospirillum* enhance root development, increase water and mineral uptake and produce plant hormones (Rajaee *et al.* 2007). Malik *et al*. 2005 reported increase in grain yield with *Azotobacter* culture, increase in chlorophyll content and delayed flowering.

Keeping in view the merit of organic farming this experiment was conducted to study the uptake of micronutrients in two genetically distinct genotypes having similar physiological maturity and days to heading.

'HD 2733' (Hexaploid) and 'PDW 215' (tetraploid) wheat (*Triticum aestivum* L. emend Fiori & Paol) were selected as the basic genetic material to carry out this study at the research farm of the Institute, New Delhi for the two crop seasons, i e 2004–05 and 2005–06 in same plots. For the two wheat varieties, three types of fertilizer application, i e zero levels, recommended NPK doses and vermicompost were applied in main plots of the experiment. These three main plots were subjected to three levels of bio-fertilizers in subplots. There was a control (A0) and two inoculants of *Azotobacter chroococcum*, i e A 1 (W 5, standard strain for wheat) and A 2 (DA 2, newly identified strain for wheat). In all there were 18 treatments in 1 replication. Split-plot design with three replications was utilized to assess the effect of organic, inorganic farming and biofertilizer on qualitative and quantitative traits of these two genotypes and to study the uptake of micronutrients.

The field soil was sandy loam having *p*H 8.2 with 0.54% organic matter and of medium fertility to P and K availability. During the rainy (*kharif*) season green manuring was applied. Application of various fertilizers to the experiment was manual. The vermicompost @ 7 tonnes/ha as a basal dose and 3 tonnes/ha as top dress was applied with distance 1.5 m in between the fertilizers block as well as the replications. The plot area was 6 m×1.38 m accommodating 6 rows of 6m length and 23 cm apart. Data on yield parameters was generated by random sampling of five plants and for data on effective tillers/m^2 area in each plot was marked. Uptake of Fe, Zn, Cu and Mn by the grain was determined by the method of Lindsay and Norvell (1978). Wheat grain hardness and protein content were determined by standard procedures (AACC 1995). Wheat sedimentation value was measured by the method of Dick and Quick (1983). The date was subjected to statistical analysis using Agres software.

Data on 6 quantitative traits, viz. initial tillers, effective tillers, spike length, grains/spike, peduncle length and 1000-grain weights were collected in the field experiments. The analysis as shown in Table 1 has indicated that there was no difference in the initial tillers and effective tillers produced by these test entries 'HD 2733' and 'PDW 215'. Although spike length was significantly longer in 'HD 2733' as compared to 'PDW 215', the number of grains/spike was statistically similar. The fertilizer applied in the form of vermicompost and NPK had a beneficial effect on yield attributes. Initial tillers, effective tillers and number of grains/spike were significantly enhanced. Only NPK application significantly enhanced peduncle and spike length. Biofertilizer application also positively influenced all of the yield-enhancing parameters. There was significant improvement in number of initial tillers, effective tillers, spike length, grains/spike and peduncle length due to seed

*Short note

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Table 1 Effect of variety, fertilization and *Azotobacter* on growth and yield attributes of wheat (pooled data)

Treatment	Initial tillers/m^2	Effective tillers/m^2	Spike length (cm)	Grains/spike	Peduncle length (cm)	Grain yield (tonnes/ha)
Variety						
'HD 2733'	117.8	99.9	8.82	61.2	13.41	3.20
'PDW 215'	118.5	98.9	7.55	63	17.09	3.31
Fertilization						
Control	113.8	94.3	7.95	58.1	14.19	2.41
Vermicompost	120.4	99.9	8.13	62.5	14.7	3.59
NPK	120.2	99.1	8.49	65.8	16.83	3.76
Biofertilizer						
Azotobacter 0	112.7	94.3	7.70	59.4	14.32	3.02
Azotobacter 1	120.2	102.4	8.49	64.2	15.83	3.29
Azotobacter 2	121.5	101.7	8.37	62.8	15.61	3.46
Variety						
SEm±	1.04	0.60	0.15	0.93	0.27	0.02
LSD (*P*=0.05)	N.S.	N.S.	0.54	N.S.	0.96	0.08
Fertilization						
SEm±	1.92	0.63	0.11	0.77	0.42	0.04
LSD (*P*=0.05)	5.65	1.87	0.33	2.29	1.23	0.12
Biofertilizer						
SEm±	1.53	1.02	0.10	0.46	0.22	0.03
LSD (*P*=0.05)	4.32	2.89	0.29	1.30	0.62	0.08

Table 2 Interactive effect of variety with fertilization and biofertilizer on growth and yield attributes of wheat (pooled data)

Treatment	Initial tillers/m^2	Effective tillers/m^2	Spike length (cm)	Grains/spike	Peduncle length (cm)	Grain yield (tonnes/ha)
Variety×fertilization						
$V_1 \times N_0$	114.17	92.17	8.74	58.56	12.06	2.17
$V_1 \times N_1$	120.17	103.39	9.06	63.67	13.11	3.65
$V_1 \times N_2$	118.94	104.22	8.67	65.00	15.05	3.79
$V_2 \times N_0$	113.50	96.746	7.15	57.67	16.57	2.66
$V_2 \times N_1$	120.61	96.39	7.19	64.83	16.33	3.53
$V_2 \times N_2$	121.44	103.94	8.31	66.61	18.61	3.72
Variety×biofertilizer						
$V_1 \times B_0$	112.39	93.28	8.44	60.11	12.78	2.97
$V_1 \times B_1$	119.33	102.61	9.08	63.50	13.84	3.24
$V_1 \times B_2$	121.56	103.89	8.93	63.61	13.59	3.39
$V_2 \times B_0$	113.00	95.17	6.96	58.61	15.86	3.06
$V_2 \times B_1$	121.11	102.11	7.89	64.83	17.81	3.34
$V_2 \times B_2$	121.44	99.44	7.81	65.67	17.61	3.52
Variety×fertilization						
SEm±	2.44	0.95	0.20	1.29	0.55	0.05
LSD (*P*=0.05)	NS	3.05	0.66	NS	NS	0.16
Variety×biofertilizer						
SEm±	2.05	1.32	0.19	1.07	0.37	0.04
LSD (*P*=0.05)	NS	N.S.	N.S.	3.69	N.S.	N.S.
Variety×fertilization×biofertilizer						
SEm±	3.77	2.17	0.24	1.28	0.65	0.07
LSD (*P*=0.05)	NS	NS	NS	NS	NS	NS

V_1, 'HD 2733'; V_2, 'PDW 215'; N_0 , No fertilizer; N_1, vermicompost; N_2, NPK; B_0, *Azotobacter* 0; B_1, *Azotobacter* 1; B_2, *Azotobacter* 2

application of biofertilizers. The enhancement in plant yield parameters due to inoculation with plant growth promoting micro-organism, like *Azotobacter* and *Azospirillum* are attributed mainly to an improvement in root system development, an increase in water and mineral uptake by roots, plant hormone production and biological nitrogen

Table 3 Effect of variety, fertilization and *Azotobacter* 1000- grain weight and nutrient level

Treatment	1 000-grain weight (gm)	Hardness score	Iron (mg/ kg DM)	Zinc (mg/ kg DM)	Copper (mg/ kgDM)	Manganese (mg/kg DM)	Sedimentation	Protein (%)
Variety								
'HD 2733'	44.4	96.4	27.9	5.10	1.89	1.54	41.7	10.9
'PDW 215'	44.7	99.7	23.0	4.59	1.75	1.15	36.8	9.9
Fertilization								
Control	43.4	98.0	26.1	4.92	1.80	1.42	39.3	9.9
Vermicompost	47.3	99.0	27.5	5.43	2.34	1.42	40.1	11.1
NPK	43.0	97.1	22.7	4.19	1.32	1.20	38.4	10.2
Biofertilizer								
Azotobacter 0	44.5	98.5	24.8	4.81	1.87	1.36	39.0	10.3
Azotobacter 1	44.4	97.1	26.2	4.91	1.78	1.33	39.4	10.4
Azotobacter 2	44.8	98.6	25.4	4.82	1.82	1.35	39.3	10.6
Variety								
SEm±	0.35	0.57	0.18	0.068	0.04	0.1	0.20	0.05
LSD (*P*=0.05)	NS	1.81	1.11	0.41	0.22	NS	0.63	0.28
Fertilization								
SEm±	0.43	0.70	0.34	0.09	0.04	0.1	0.24	0.11
LSD (*P*=0.05)	1.36	NS	1.1	0.28	0.14	NS	0.77	0.36
Biofertilizer								
SEm±	0.56	0.72	0.24	0.09	0.08	0.06	0.36	0.09
LSD (*P*=0.05)	NS	NS	0.7	0.27	0.23	NS	NS	0.25

DM, Dry matter

fixation (Okou and Itzigsohn 1995).

The grain yield, which is sum total effect of a number of components, has shown significant differences among the genotypes, fertilizers and biofertilizers applied in the experiment. The maximum yield was harvested in plots nourished through traditional way of fertilizer application (NPK) and application of *Azotobacter* A 2 inoculants. The yield obtained by both NPK and vermicompost application was statistically higher over the control yield. The yield obtained by application of biofertilizers was also statistically higher than control yield. The results of this experiment are very close to the study carried out by El Sirafy *et al*. (2006). Highest grains and straw yield was obtained with the highest fertilizer ratio with N fertilizer. There was a slight additional increase in grain and straw yield when a biofertilizer was applied along with N fertilizer. The seed grain yield of soybean (*Glycine max* L. Merr.) and wheat had increased significantly with the application of increasing levels of P, farmyard manure and biofertilizer (Dadhich and Somani 2007).

Differential varietal response to fertilizer application was observed for effective tillers, spike length and grain yield (Table 2). Varietal response to biofertilizer application however, differed significantly for only number of grains/ spike. Interactions between variety, fertilizer and biofertilizer were however non-significant for all the traits.

The produce harvested during 2005–06 was subjected to quality analysis, viz.1000-grain weight, hardness score, sedimentation value, protein per cent and concentration of micronutrient, namely Fe, Cu, Zn and Mn. For 1 000- grain weight of these varieties and application of biofertilizers, the interactions were non-significant (Table 3). However, the application of vermicompost significantly improved 1 000-grain weight indicating an increase in the size of the grains. The hardness score differed significantly in these varieties. The application of either of the fertilizer in any form ie vermicompost, NPK and biofertilizer did not alter this trait.

The micro element analysis study had shown that with the exception of Mn all the micronutrients were significantly higher in 'HD 2733' in comparison to 'PDW 215'. The application of NPK did not improve these contents over the control. However, the value of all the micronutrients analyzed with the exception of Mn, in vermicompost nourished plots was significantly higher than those of NPK and control plots. Organic fertilizers are a rich source of micronutrients and their application is known to significantly enhance the uptake of micronutrients (Dadhich and Somani 2007). There was a significant increase in iron content with application of *Azotobacter* A1 but the application of these inoculants showed decreasing trend for the copper and manganese contents as compared to control plots. *Azotobacter* A1 is a known siderophore producing strain (Kumar 1997) and could have significant role to play in improving the Fe content of the grain. Siderophores are iron-chelating low molecular weight compounds which are known to play an important role as iron supplier to crop plants (Crowley 1988).

The sedimentation value at varietal level of 'HD 2733' and 'PDW 215' differed significantly. The value of 'HD 2733'

Table 4 Interactive effect of variety with fertilization and biofertilizer 1000 grain weight and nutrient level

Treatment	1 000-grain weight(g)	Hardness score	Iron (mg/ kg DM)	Zinc (mg/ kg DM)	Copper (mg/ kgDM)	Manganese (mg/kg DM)	Sedimentation	Protein (%)
Variety × fertilization								
$V_1 \times N_0$	43.00	98.29	29.87	5.89	2.30	1.39	42.56	42.78
$V_1 \times N_1$	42.36	98.26	26.68	4.38	1.47	1.47	41.22	41.67
$V_1 \times N_2$	47.91	92.61	27.24	5.04	1.92	1.84	41.44	40.78
$V_2 \times N_0$	43.81	97.83	22.46	4.02	1.31	1.51	36.00	35.33
$V_2 \times N_1$	43.62	99.83	18.67	3.94	1.18	0.93	35.67	37.22
$V_2 \times N_2$	46.76	101.58	27.82	5.81	2.76	1.00	38.78	37.89
Variety × biofertilizer								
$V_1 \times B_0$	44.17	97.21	27.27	27.27	2.02	1.60	42.78	10.69
$V_1 \times B_1$	44.76	95.69	29.08	29.08	2.01	1.43	41.67	11.197
$V_1 \times B_2$	44.34	96.26	27.44	27.44	1.66	1.68	40.78	11.03
$V_2 \times B_0$	44.83	99.76	22.31	22.31	1.71	1.12	35.33	9.88
$V_2 \times B_1$	44.02	98.44	23.33	23.33	1.56	1.23	37.22	9.71
$V_2 \times B_2$	45.33	101.04	23.30	23.30	1.98	1.09	37.89	10.17
Variety × fertilization								
SEm±	0.665	1.066	0.429	0.120	0.062	0.153	0.332	0.136
LSD (*P*=0.05)	NS	NS	1.62	0.502	0.263	0.699	1.247	0.489
Variety × biofertilizer								
SEm±	0.834	1.144	0.333	0.128	0.099	0.125	0.445	0.110
LSD (*P*=0.05)	N.S.	NS	NS	0.488	NS	NS	1.434	0.385
Variety × fertilization × biofertilizer								
SEm±	1.199	1.612	0.619	0.212	0.168	0.165	0.791	0.215
LSD (*P*=0.05)	NS	NS	1.89	0.634	0.493	0.507	2.349	0.653

V_1, 'HD 2733'; V_2, 'PDW 215'; N_0, No fertilizer; N_1, vermicompost; N_2, NPK; B_0, azotobacter 0; B_1, azotobacter 1; B_2, azotobacter 2

was 41.7 while that of 'PBW 215' was 36.8. Application of vermicompost was observed to significantly influence sedimentation value. None of the interactions for biofertilizer treatments were significant.

The protein content which is greatly affected by the crop management practices and the genotypes under test has shown significant interaction. Both these varieties differed significantly in protein contents. Application of vermicompost significantly increased seed protein content. The interaction of *Azotobacter* 2 was significant for this trait.

Differential varietal response to fertilizer application was observed for all the micronutrient analyzed, sedimentation value and protein content (Table 4). Interactions between variety, fertilizer and biofertilizer were also significant for all these traits. Varietal response to biofertilizer application however, differed significantly for only Zn content, sedimentation value and protein content.

SUMMARY

A study was conducted during 2004–06 on effect of different fertilization conditions on qualitative and quantitative traits in different genotypes in wheat using wheat cultivars 'HD 2733' and 'PDW 215' representing *Triticum aestivum* (L.) emend. Fiori & Paol and *T. durum* genotypes. Three types of fertilizers application, ie zero level, recommended NPK and vermicompost were used in main plots and biofertilizers *Azotobacter chroococcum* A 1 and *A. chroococcum* A 2 were applied in subplots. Significant differences were observed at varietal level on spike and peduncle length. Vermicompost and NPK application significantly enhanced effective tillers, peduncle length and grain yield. The biofertilizer application significantly improved grain yield and grain yield parameters over uninoculated plots. Varietal differences were observed for hardness score, sedimentation value and protein per cent. Fertilizer applied in the form of vermicompost and NPK showed significant difference for sedimentation value and protein per cent. Vermicompost application significantly enhanced the concentration of micronutrients (Fe, Zn, Cu and Mn).

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