



Effect of integrated nutrient management on wheat (*Triticum aestivum*) yield, nutrient uptake and soil fertility status in alluvial soil

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ABSTRACT

A field experiment was conducted on alluvial soil at SVP University of Agriculture and Technology Meerut (UP) during winter (*rabi*) season of 2013-14 and 2014-15 to study the effect of integrated nutrient management (INM) on yield, nutrient uptake of wheat (*Triticum aestivum* L.) and soil fertility. The experiment was laid-out in a randomized complete block design with 9 treatments and 3 replicates. The results revealed that plant height, tillers/m, spike length, grains/spike test weight, and grain and straw yields increased significantly over control due to fertilizer application. The grain (5 t/ha) and straw (6.88 t/ha) yields at 100% NPK were 79.7 and 78.2% higher than the control. The yield of wheat was improved further with conjoint application of 75% NPK + organic manures (OM). The maximum values of growth, yield attributes and grain (5.39 t/ha) and straw yield (7.33 t/ha) were recorded with 75% NPK + 5 t FYM + 2.5 t VC/ha closely followed by 75% NPK + 2.5 t VC + 3.75 t press mud (PM)/ha. Application of VC and FYM was found to be more beneficial in terms of growth and yield of wheat. The uptake of N, P, K, S, and Zn by wheat crop was highest at 75% NPK + 5 t FYM + 2.5 t VC/ha and lowest in control. The use of organic manures decreased soil pH and their combined use with fertilizers was significantly reflected in the buildup of organic C, available N, P, K, S and DTPA-extractable Zn content of the post-harvest soils. The minimum amount of available nutrients in post-harvest soil was recorded under control.

Key words: Alluvial soil, FYM, Nutrient uptake, Press mud, Soil fertility, Vermicompost, Wheat Yield

Wheat (*Triticum aestivum* L.) is a heavy nutrient feeder and leads to large withdrawal of plant nutrients from soil. The profitable production of wheat crop may be affected by many factors; among these soil fertility to produce grain and straw is of immense practical significance. Indian soils have been exhausted in major and minor elements, thereby hampering the yield of crops. Although the use of various fertilizers has made a tremendous contribution in enhancing food production but the issues such as low nutrient-use efficiency and associated environmental pollution and global warming have raised serious concerns about the existing nutrient management practices (Dass *et al.* 2014). Proper and optimum application of fertilizers not only increases the yield but also favorably affects the quality of the produce. To curb this trend of declining yield, there is a need to adopt the concept of integrated nutrient management (INM). Organic manures are important components of INM and may help restore soil health. Besides, organic manures also supply micronutrients which are not supplied by chemical fertilizers. Use of organic manures (FYM, vermicompost, press mud) also improves physico-chemical and biological properties of the soil. Organic manures being a source of

all essential elements, improve soil organic matter and humus component of soil. These play an important role in habitation of beneficial bacteria, thus, making the nutrients available to crop. Therefore, it is essential to compare various organic manures with chemical fertilizers to find out the most effective combination. Integrated system approach is not only a reliable way of obtaining high productivity with substantial fertilizer economy, but also a concept of ecological soundness leading to sustainable agriculture. The basic concept of INM is maintenance and improvement of soil fertility for sustaining crop productivity on long-term basis. Application of different organic-inorganic sources was effective in realizing high yield, better economy and improved residual fertility of the soil (Dass *et al.* 2008, Dass *et al.* 2013, Singh 2017). In this experiment, effect of different levels of inorganic and organic fertilizers were studied on wheat crop.

MATERIALS AND METHODS

The field experiment was conducted during *rabi* season of 2013-14 and 2014-15 at Crop Research Center, Meerut (U P). The experimental farm is situated at 28° 59' N latitude and 77° 42' E longitude at an altitude of 237 m amsl. The experimental site is characterized by a sub-tropical, semi-arid climate with hot dry summers (45°C) and very low temperature during winter (3°C). The experimental soil

was sandy loam in texture having pH 8.0, organic carbon 5.0 g/kg. Available N, P, K, S were 200, 10.2, 180, and 16.5 kg/ha, respectively, and DTPA-zinc 0.57 mg/kg. The experiment was laid-out in a randomized block design with 3 replications. The experiment included 9 treatments, viz. T₁: Control, T₂: 75% NPK, T₃: 75% NPK + 10 t FYM/ha, T₄: 75% NPK + 5 t vermicompost/ha, T₅: 75% NPK + 3.5 t press mud/ha, T₆: 75% NPK + 5 t FYM + 2.5 t vermicompost/ha, T₇: 75% NPK + 2.5 t vermicompost + 1.75 t press mud/ha, T₈: 75% NPK + 5 t FYM + 1.75 t press mud/ha and T₉: 100% NPK. Nitrogen was given in the form of urea as per treatments. Triple superphosphate and muriate of potash were used as sources for P₂O₅ and K₂O, respectively. Recommended dose of N, P and K for wheat was 150:60:40 kg/ha, respectively. Full quantities of P and K fertilizers were given at the time of sowing. Nitrogen was applied as basal and in 2 splits at first and second irrigation. Well-decomposed FYM (0.52% N, 0.31% P and 0.49% K), vermicompost (1.01% N, 0.75% P and 1.07%K) and press mud (1.50% N, 1.80% P and 2.50% K) were added to the plots as per treatments one week before sowing. The wheat (variety PBW 343) was sown at the rate of 100 kg/ha on November 14 during both the study years. Crop was given 5 irrigations using water from tube well. The crop was allowed to grow up to physiological maturity, and the grain and straw yield were recorded at harvest. The growth and yield attributes were also recorded at harvest following standard procedures as suggested by Rana *et al.* (2014). The grain and straw samples of wheat were first washed with deionized water and rinsed twice with distilled water and then dried in oven at 70°C to a constant weight. The samples were then ground with pestle and mortar, and stored in wide mouth bottles with for chemical analysis. Processed samples were analyzed for their nutrient contents by digesting the samples using di-acid mixture of HNO₃: HClO₄ (10:4) followed by estimation of Zn using an AAS. K and S were determined by vanadomolybdophosphoric yellow colour method, flame photometer (Jackson 1973) and turbidimetric method (Chesnin and Yien 1951), respectively. Nitrogen content was estimated by modified Kjeldahl method

and crude protein content was calculated by multiplying with 6.25. The uptake of nutrients by wheat crop was worked out by multiplying their content values with corresponding yield data. After harvest of the crop, soil samples were collected and analyzed for available N (Subbiah and Asija 1956), P (Olsen *et al.* 1954), K (1 N neutral ammonium acetate extractable), S (0.15% CaCl₂ extractable), Zn (DTPA extractable) as described by Lindsay and Norvell (1978). The trend of results was similar during both study years, hence, two year data were averaged and then subjected to statistical analyses. The statistical analysis was done using procedures described by Gomez and Gomez (1984).

RESULTS AND DISCUSSION

Growth and yield attributes: Addition of various sources of organic manures along with inorganic fertilizers influenced growth characters of wheat crop positively (Table 1). Application of NPK fertilizers (75 and 100%) improved the growth and yield attributes significantly over control, and relatively higher values of these parameters were recorded with 100% RD of NPK fertilizers. This could be due to availability of nutrients in balanced and adequate amounts. The crop receiving higher amounts of nutrients through organic or inorganic fertilizer sources recorded higher plant height and tillers/m row length. Among the nutrient management practices, application of 75% NPK + 5 t FYM + 2.5 t vermicompost/ha produced taller plants (90.6 cm), higher number of tillers/m (87.8), spike length (9.0 cm), grains/spike (38.6) and test weight (45.8 g). The lowest values of these growth and yield attributes were recorded under control. Adequate and continuous availability of nutrients with NPK or combined use of organic manures with NPK might have improved the growth and yield attributes of wheat crop (Singh 2017). Application of 75% NPK along with FYM, or VC or press mud also improved these growth and yield attributes over control but proved inferior to 75% NPK + 5 t FYM + 2.5 t VC/ha (T₆). Among these 3 organic manures, vermicompost was superior to FYM and press-mud with respect to growth and yield attributes of wheat crop (Singh 2017).

Table 1. Effect of integrated nutrient management on growth, yield attributes and yield of wheat (mean of two years)

Treatment	Plant height (cm)	Tillers/m row length	Spike length (cm)	Grains/spike	Test-weight (g)	Yield (t/ha)	
						Grain	Straw
T ₁ Control	74.8	67.2	7.2	28.7	39.0	2.78	3.86
T ₂ 75% RD of NPK	83.5	78.0	8.2	36.0	42.5	4.08	5.60
T ₃ 75% NPK + 10 t FYM/ha	85.8	82.9	8.6	37.1	43.8	4.96	6.79
T ₄ 75% NPK + 5 t VC/ha	88.0	85.5	8.9	37.6	44.2	5.14	7.06
T ₅ 75% NPK + 3.5 t PM/ha	85.0	81.4	8.4	37.0	43.6	4.75	6.48
T ₆ 75% NPK + 5 t FYM + 2.5 t VC/ha	90.6	87.8	9.0	38.6	45.8	5.39	7.33
T ₇ 75% NPK + 2.5 t VC + 1.75 t PM/ha	88.8	86.5	8.8	38.3	45.0	5.28	7.16
T ₈ 75% NPK + 5 t FYM + 1.75 t PM/ha	89.0	86.1	8.6	38.0	44.7	4.98	6.78
T ₉ 100% RD of NPK	88.5	85.7	8.6	38.0	44.1	5.04	6.88
CD (P = 0.05)	2.05	3.15	0.46	0.84	1.07	0.35	0.52

VC, Vermicompost; PM, press mud

Yield: The application of 100% NPK resulted in 79.7% and 78.2% increase in grain and straw yield of wheat, respectively, over control (Table 1). The response of wheat to NPK fertilizers may also be attributed to exhaustive nature of wheat crop, removing more nutrients and thus resulting in response to NPK fertilizers. Application of 10 t FYM/ha + 75% NPK (T₃) increased the grain and straw yield of wheat by 21.4 and 20.8% whereas the application of 5 t vermicompost/ha and 3.5 t press mud/ha increased the yields of grain and straw by 25.8 and 26.1 and 16.2 and 14.2%, respectively. The results also demonstrated the superiority of vermicompost over FYM and press mud which could be attributed to higher nutrient availability with vermicompost (Chaudhary *et al.* 2003, Dass *et al.* 2008). The application of organic manures increased the activity of beneficial microbes and colonization of mycorrhizal fungi and enzymes which play an important role in mobilization of nutrients, facilitating better growth, and grain and straw production. Similar increase in yield of wheat with application of organic manures and chemical fertilizers was reported by Kaushik *et al.* (2012) and Singh (2017). The results, thus, indicate that about 25% NPK fertilizers can be saved by addition of organic manures without any adverse effect on yield. The highest wheat grain yield (5.39 t/ha) and straw yield (7.33 t/ha) of wheat was obtained with 75% NPK + 5 t FYM + 2.5 t VC/ha as compared to other treatments. On an average, this treatment (75% NPK + 5 t FYM + 2.5 t vermicompost/ha) out yielded the 100% recommended dose of NPK fertilizers by an average of 7.7%. Application of 75% NPK + 2.5 t VC + 1.75 t press mud/ha increased the grain yield by 5.5% over 100% NPK treatment. The beneficial effect of these organic manures on wheat yields might be due to additional supply of nutrients as well as improvement in physical and biological properties of soil (Singh and Patra 2017, Ram Bharose *et al.* 2018).

Uptake of nutrients: Nitrogen uptake by wheat crop increased significantly with different treatments over control (Table 2). The mean increase in N uptake was from 51.8 to 100.6 and 18.9 to 38.6 kg/

ha by wheat grain and straw, respectively due to application of NPK over control (Pandey and Singh 2017). The highest N uptake by wheat grain (108.8 kg/ha) and straw (41.1 kg/ha) was recorded with 75% NPK + 5 t FYM + 2.5 t vermicompost/ha. This increase in N uptake might be due to increased grain and straw yield (Singh 2017, Singh and Patra, 2017). Incorporation of 10 t FYM or 5 t vermicompost or 3.5 t press mud/ha along with 75% NPK also improved the utilization of nitrogen by wheat crop (Ram Bharose *et al.* 2018). The P uptake by grain and straw increased from 5.3 kg/ha in control to 12.0 kg/ha and from 3.5 to 10.3 kg/ha with 100% NPK alone. Application of organic manures (FYM, vermicompost and press mud) along with 75% NPK also improved the P uptake by wheat over 75% NPK and control. Among these treatments, relatively higher amount of P was utilized by wheat crop with 75% NPK + 5 t vermicompost treatment, which may be attributed to higher grain and straw production. The maximum values of P uptake by grain (12.9 kg/ha) and straw (11 kg/ha) were recorded with 75% NPK + 5 t FYM + 2.5 t vermicompost/ha treatment. This increase in P uptake may be due to more availability of P from the soil with their application (Paramesh *et al.* 2014, Singh 2017). The K uptake by wheat crop also increased significantly with NPK levels and NPK + organic manures over control. The higher yield of grain and straw under 75% NPK + 5 t FYM + 2.5 t vermicompost/ha absorbed large quantities of K from the soil, thus depleting the soil K (Sharma *et al.* 2016). Application of 75% NPK + 5 t FYM + 1.75 t press mud/ha also improved K uptake by the crop. All the treatments proved beneficial in increasing the uptake of S by wheat crop over control (Table 2). The minimum (4.7 kg/ha) and maximum (12.3 kg/ha) values of S uptake were recorded under control and 75% NPK + 5 t FYM + 2.5 t vermicompost/ha, respectively. The maximum uptake under 75% NPK + 5 t FYM + 2.5 t vermicompost/ha may be due to increased availability of S as a result of addition of organic manures (Ram Bharose *et al.* 2018). Application of press mud was more beneficial in improving the S uptake

Table 2. Effect of integrated nutrient management on uptake of N, P, K, S (kg/ha) and Zn (g/ha) by wheat grain and straw (mean of two years)

Treatment	N		P		K		S		Zn	
	Grain	Straw	Grain	Straw	Grain	Straw	Grain	Straw	Grain	Straw
T ₁	51.8	18.9	5.3	3.5	14.2	49.5	4.7	3.1	66.8	67.5
T ₂	78.0	29.7	9.0	6.1	22.8	75.1	7.3	5.0	100.0	96.6
T ₃	96.2	37.4	9.9	7.5	28.2	91.7	9.4	6.8	129.0	123.5
T ₄	100.2	40.3	11.3	9.1	30.3	96.6	10.7	8.4	136.2	130.6
T ₅	92.6	35.0	9.5	7.1	26.5	88.2	9.9	8.4	123.4	120.0
T ₆	108.8	41.1	12.9	11.0	33.9	103.5	12.3	11.0	150.0	143.0
T ₇	106.6	39.4	12.6	10.7	33.2	101.4	12.1	10.7	147.8	139.6
T ₈	99.6	38.0	11.4	8.1	30.9	95.1	12.4	10.8	134.5	128.7
T ₉	100.6	38.6	12.0	10.3	30.0	95.1	11.0	8.2	124.0	130.8
CD (P= 0.05)	5.81	2.42	0.64	0.62	2.76	3.07	0.86	0.94	17.92	9.11

by wheat grain followed by vermicompost and FYM. The uptake of Zn by wheat grain ranged from 66.8 to 150 g/ha. The corresponding range of Zn uptake by straw was from 67.5 to 143 g/ha, which may be attributed to increased availability of Zn with the addition of organic manures (Singh and Patra, 2017). The highest uptake of Zn was recorded with 75% NPK + 5 t FYM + 2.5 t vermicompost/ha which may be ascribed to higher grain and straw production (Paramesh *et al.* 2014, Pandey 2018). The minimum value of Zn was recorded under control due to low grain and straw production.

Soil fertility: There was a marked difference in soil pH due to various nutrient management practices. The minimum value of soil pH (7.7) was recorded under 75% NPK + 5 t FYM + 2.5 t vermicompost/ha treatment, owing to the formation of organic acids during decomposition of organic manures (Kumara *et al.* 2013). The decrease in pH was more pronounced with the addition of vermicompost compared to FYM and press mud. Use of different nutrient management practices caused a marked change in the soil organic carbon (SOC) content. Application of 100% NPK alone also increased the SOC content in post-harvest soil. Application of 75% NPK along with organic manures significantly increased the SOC content over control. The increase in SOC content was 1.4, 1.3 and 1.4% over control with 75% NPK + FYM (T_3), 75% NPK + vermicompost and 75% NPK + press mud/ha, respectively. The maximum amount of SOC in post-harvest soil (6 g/kg) was recorded with 75% NPK + 5 t FYM + 2.5 t vermicompost/ha. This increase in SOC content may be attributed to addition of organic materials and better root growth (Dass *et al.* 2008 2013, Kashyap *et al.* 2018).

The highest available N content (205.5 kg/ha) was obtained under 75% NPK + 5 t FYM + 2.5 t vermicompost/ha followed by 75% NPK + 2.5 t vermicompost + 1.75 t press mud/ha. The lowest available N content was recorded in control. Application of 75 and 100% NPK significantly increased the available N content over control by 28.2 and 38.7%, respectively. It differed significantly with combined application of inorganic and organic manures. Application of 10 t FYM, 5 t vermicompost and 3.5 t press mud/ha along with 75% NPK fertilizers increased the available N content in post-harvest soil by 32.6, 36.0, and 33.3% over control, respectively. However, treatments having FYM and vermicompost with 75% NPK did not differ significantly among each other. The increase in available N with application of organic manures might be attributed to the direct addition of N through these sources to the available N pool of the soil (Kumara *et al.* 2013). Available P status recorded significant difference due to treatment variations (Table 3). Significantly higher available P content in soil was recorded with application of inorganic and organic manures over control. The treatment comprising of 75% NPK + 5 t FYM + 2.5 t vermicompost/ha maintained the highest amount of available P (13 kg/ha) in post-harvest soil. Application of NPK fertilizers (75 and 100%) significantly increased the available P content over control. Application

of 75% NPK + FYM, 75% NPK + vermicompost and 75% NPK + press mud/ha significantly increased the available P content of soil over control. Combined application of these 3 organic manures with 75% NPK did not differ significantly among themselves in respect of available P content. Use of 75% NPK + 5 t FYM + 2.5 t vermicompost/ha significantly increased the available P content over control and 75% NPK. The increase in available P content with inorganic and organic sources might be attributed to the direct addition of P through these sources as well as solubilization of native P through release of organic acid in the soil (Singh 2017, Pandey 2018).

Available K content in soil differed with 2 levels of NPK fertilizers and higher value of available K was recorded at 100% NPK. The treatment comprising of 75% NPK + 5 t FYM + 2.5 t vermicompost/ha maintained the highest amount of K (202.5 kg/ha) in post-harvest soil. Application of 75% NPK + FYM (T_3), 75% NPK + vermicompost and 75% NPK + press mud/ha also increased the amount of available K over control and 75% NPK alone (Kumara *et al.* 2013, Kashyap *et al.* 2018). These treatments were at par with respect to status of available K. Vermicompost addition had significant effect on available K content than FYM and press mud. Available S content of the soil decreased from 16.5 to 14.5 kg/ha in control. The organic amendments at high rates of application caused drastic increase in soil nutrients particularly N and S. Higher build up of available S was observed with the addition of press mud as compared to vermicompost and FYM. The maximum amount of available S (19 kg/ha) was recorded with 75% NPK + 5 t FYM + 1.75 t press mud/ha and minimum (14.5 kg/ha) was in control. Lowest and highest contents of DTPA-Zn in post-harvest soil were recorded under control and 75% NPK + 5 t FYM + 2.5 t vermicompost/ha, respectively. This increase in available Zn in post-harvest soil may be attributed to increased amount of zinc applied through organic manures to the soil.

It may be concluded from the present investigation that 75% NPK + 5 t FYM + 2.5 t vermicompost/ha recorded

Table 3. Effect of integrated nutrient management on fertility status of postharvest soil (mean of two years)

Treatment	pH	Org.C (g/kg)	N (kg/ ha)	P (kg/ ha)	K (kg/ ha)	S (kg/ ha)	Zn (mg/ kg)
T ₁	8.2	4.4	147.0	8.1	145.0	14.5	0.43
T ₂	8.4	4.7	188.5	11.2	180.6	15.0	0.44
T ₃	7.8	5.8	195.0	11.4	188.5	15.8	0.52
T ₄	7.7	5.7	200.0	12.3	190.0	16.4	0.55
T ₅	7.8	5.8	196.0	11.6	189.2	18.0	0.52
T ₆	7.7	6.0	205.5	13.0	202.5	17.0	0.65
T ₇	7.7	6.0	204.2	12.6	202.0	17.0	0.65
T ₈	7.9	5.9	202.5	12.5	201.5	19.0	0.64
T ₉	8.3	4.9	204.0	12.4	201.0	15.5	0.45
CD (P= 0.05)	0.28	0.27	4.90	1.02	4.11	1.07	0.17

maximum grain and straw yields of wheat as compared to all other treatments in Meerut region of Uttar Pradesh. It may, therefore, be suggested that better yield of wheat may be obtained with application of organic manures along with 75% NPK fertilizers. In addition, IPNS reduces cost of fertilizers and improves soil fertility of post-harvest soil. These results are replicable in the Indo-Gangetic plains of India.

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