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# Productivity, quality and uptake of nutrients in wheat (*Triticum aestivum*) as influenced by integrated nutrient management

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## ABSTRACT

*A field experiment was conducted at Research farm, S.V.B.P. Univ. of Ag, & Tech. Meerut (U.P.) during rabi season of 2011-12 and 2012-13 to study the effect of integrated nutrient management on wheat productivity, uptake of nutrients and soil fertility on a alluvial soil. The experiment was laid out in randomized block design with 8 treatments and 3 replications. The results revealed that the growth (plant height, number of tillers/meter), yield attributes (grains/spike and test weight) were increased significantly with 100% RD NPK over control. The grain (40.5 q ha$^{-1}$) and straw (62.2q ha$^{-1}$) yields at 100% NPK were 58.8 and 63.6 % higher than that obtained in the control. The growth, yield attributes and yield of grain (41.1q ha$^{-1}$) and straw (64.0q ha$^{-1}$) were maximum with the application of 75% NPK + 2t vermi compost ha$^{-1}$ closely followed by 100% NPK alone. Thus, among the organic manures vermi compost (2.0 t ha$^{-1}$) was found to be more beneficial in terms of growth and yield of wheat crop. The maximum content of protein (12.36%) was recorded with 100% NPK but maximum value of protein yield in grain (506.0 kg ha$^{-1}$) was recorded under 75% NPK + 2t vermi compost ha$^{-1}$ application. The uptake of N.P. and K by wheat grain and straw was the highest at 75% NPK + 2t vermi compost ha$^{-1}$ and the lowest in control. Application of press mud along with the levels of NPK fertilizer proved poorest in respect of yield, quality and uptake of nutrients by wheat crop. The amounts of organic carbon, available N, P and K in post harvest soil were maximum with the application of 75% NPK + 10t FYM ha$^{-1}$ and lowest in control.*

**Keywords:** Productivity, quality, nutrient uptake, yield, wheat, integrated nutrient management

## INTRODUCTION

Wheat is the most important cereal crop because it is the staple food of the people of India. Being the exhaustive crop, wheat requires huge amount of nutrients for producing higher yields. For realizing the inherent yield potential of wheat, action must be taken to the combined application of organic manures and chemical fertilizers. In recent years, there has been increasing recognition of the importance of organics as a source of plant nutrients due to growing ecological concern and deplete inherent soil fertility. Fertilizers played a vital role in agriculture production and productivity in India but continuous and imbalanced use of chemical fertilizers has created problem in the production potential and deterioration of soil health (Sharma *et al.* 2015).Organic supply of nutrients at a peak period of absorption also provide micronutrients and modify soil physical behaviour as well as increase the efficiency of applied nutrients (Kaushik *et al.* 2012). The combined use of organic and inorganic fertilizers has been reported not only to meet the nutrients need of the crop but also has been found to sustain large scale productivity goals. The use of organic manures (FYM, vermi compost and press mud) is the tool to improve physical-chemical and biological properties of the soil. Organic manures, being the source of all essential elements, improve soil organic matter and humus part of soil. These organic manures play an important role in habitation of beneficial bacteria, thus, making the nutrients available to crops. Integrated plant nutrition involves judicious and integrated use of chemical fertilizers along with organic manures. Therefore, the present experiment was undertaken to study the effect of organic manures along with chemical fertilizers on the crop growth, yield, nutrient uptake and soil fertility status in wheat.

## MATERIALS AND METHODS

A field experiment with wheat was conducted at the crop Research Centre, S.V.B.P. University of Agriculture & Technology, Meerut (U.P.) during rabi season of 2011- 12 and 2012-13 using wheat as a test crop.

Geographically it is located at 24° 04/ N latitude and 77$^0$ 42/ E longitude with a mean altitude of 237 meter mean sea level. The climate of the region is subtropical and semi arid characterized with hot summer (max temp. 45° C) and extremely cold winters (min. temp.3$^0$ C). The soil was sandy loam in texture and alkaline in reaction (pH 8.3). The status of organic carbon available N, P and K, was 3.7 g kg$^{-1}$, 150, 11.2 and 170 kg ha$^{-1}$, respectively. The treatments namely: $T_1$ control, $T_2$ 100% RD NPK (150 kg N + 60 kg $P_2O_5$ + 40 kg $K_2O$ ha$^{-1}$), $T_3$ 75% NPK + 10t FYM ha$^{-1}$, $T_4$ 75% NPK + 2 t vermi compost ha$^{-1}$, $T_5$ 50% NPK + 2 t vermi compost + 10t FYM ha$^{-1}$, $T_6$ 75% NPK + 3t press mud ha$^{-1}$, $T_7$ 50% NPK + 3 t press mud + 10t FYM ha$^{-1}$ and $T_8$ 50% NPK + 2 t vermi compost + 3t press mud ha$^{-1}$ were tested in randomized block design having three replications. Half of the N and full amount of P and K as per treatments were applied at the time of sowing and the remaining N was top dressed at two stages in equal amounts. The source of N, $P_2O_5$ and $K_2O$ were urea, single superphosphate and muriate of potash, respectively. FYM (0.61% N, 0.22% P, 0.72% K), vermi compost (1.01% N, 0.78% P, 1.67% K) and press mud (1.5% N, 1.8% P, 2.5% K) were applied before 15 days of sowing. The wheat (var. PBW 373) was sown in the second week of November during both the years using 100 kg seed ha$^{-1}$.The crop was harvested at physiological maturity and grain and straw yields were recorded. Observations on growth and yield attributes were recorded at harvest. Grain and straw samples were digested in di-acid mixture ($HNO_3$ $HClO_4$, 10:1 by volume) and the digest was analysed for P by vanado molybdate yellow colour method and K by flame photometer. Nitrogen in grain and straw was determined by micro-Kjeldahl method and the protein content was calculated from the N content multiplied by 6.25. The protein yield was calculated by multiplying grain yield with protein content in grain. The nutrient content was multiplied with yield data (grain and straw) for calculating nutrient uptake. Soil samples collected after harvest were analysed for pH, organic carbon available N (Subbiah and Asija 1956), available P (Olsen *et al.* 1954), available K (Jackson 1973).

## RESULTS AND DISCUSSION

### *Growth and yield*

Addition of various sources of organic manures along with inorganic fertilizers influenced positively the growth of wheat crop (Table 1). The crop receiving higher amounts of nutrients through organic or inorganic fertilizer sources recorded higher growth of the crop. Among the nutrient management practices, application of 75% NPK + 2 t vermi compost ha$^{-1}$ produced taller plants (81.4 cm), higher tillers/meter (132.8), grains/spike (43.0), and test weight (46.0 g) closely followed by 100% NPK (120 kg N + 60 kg $P_2O_5$ + 40 kg $K_2O$ ha$^{-1}$). The lowest value of growth and yield attributing characters were recorded under control. Adequate and continuous availability of nutrients with recommended NPK or combined use of organic manures with NPK might have improved the growth and yield attributes of wheat (Pathak *et al.* 2005). Singh and Ahmed (2010).Application of 50% NPK along with FYM or vermi compost or press mud improved these growth and yield attributes over control but proved inferior to that of 75% NPK + organic manure treatments. Increase in grain and straw yields of wheat over control (25.5 and 38.0 q ha$^{-1}$) was 40.5 and 63.6% due to 100% NPK application. Higher response to the applied NPK fertilizers was expected on this N, P and K deficient experimental soil (Singh 2016). The grain and straw yield of wheat was significantly influenced by different combinations of organic and inorganic fertilizers. Significantly higher grain (41.1 q ha$^{-1}$) and straw (64.0 q ha$^{-1}$) yields of wheat were recorded in 75% NPK + 2 t vermi compost ha$^{-1}$. All the treatments produced significantly higher yields than absolute control which recorded the lowest grain (25.5 q ha$^{-1}$) and straw (38.0 q ha$^{-1}$) yields. Due to application of organic manures, the activity of beneficial microbes and colonization of microrhizal fungi and enzymes activity increased which play an important role in mobilization of nutrients and thereby leading to better availability of nutrients facilitating in better growth and grain and straw production. Similar increase in yield of wheat with application of organic manure and chemical

fertilizers was also reported by Kaushik *et al.* (2012) and Singh and Singh (2012).Among different organic manures, wheat did not respond favourably to the addition of press mud along with chemical fertilizers.

Table 1: Effect of integrated nutrient management on growth, yield attributes, yield and quality of wheat (mean of 2 years)

| Treatment | Plant height (cm) | Tillers/ $m^2$ | Grain/spike | Test weight (g) | Yield (q $ha^{-1}$) | | Protein (%) | Protein yield (kg $ha^{-1}$) |
|---|---|---|---|---|---|---|---|---|
| | | | | | Grain | Straw | | |
| $T_1$ Control | 66.5 | 99.5 | 33.0 | 35.6 | 25.5 | 38.0 | 10.75 | 274.1 |
| $T_2$ 100% RDNPK | 79.5 | 125.1 | 41.0 | 45.0 | 40.5 | 62.2 | 12.36 | 500.6 |
| $T_3$ 75% NPK + 10t FYM $ha^{-1}$ | 76.7 | 110.6 | 38.0 | 40.5 | 38.0 | 55.3 | 11.94 | 453.7 |
| $T_4$ 75% NPK + 2t VC $ha^{-1}$ | 81.4 | 132.8 | 43.0 | 46.0 | 41.1 | 64.0 | 12.31 | 506.0 |
| $T_5$ 50% NPK + 2t VC + 10t FYM $ha^{-1}$ | 75.9 | 118.6 | 40.0 | 43.7 | 39.1 | 61.2 | 12.00 | 469.2 |
| $T_6$ 75% NPK + 3t PM $ha^{-1}$ | 74.4 | 105.7 | 37.0 | 39.6 | 35.5 | 50.0 | 11.87 | 421.4 |
| $T_7$ 50% NPK + 3t PM + 10t FYM $ha^{-1}$ | 74.0 | 103.5 | 36.3 | 38.8 | 35.5 | 50.7 | 11.69 | 415.0 |
| $T_8$ 50% NPK + 2t VC + 3t PM $ha^{-1}$ | 76.6 | 114.7 | 39.0 | 42.5 | 37.0 | 54.0 | 12.00 | 444.0 |
| CD (P=0.05) | 3.42 | 4.41 | 3.73 | 3.69 | 5.11 | 6.64 | 0.36 | 48.52 |

**Quality**

The lowest protein percentage in wheat grain was recorded in control (Table 1) which may be attributed to low nitrogen status of the soil. The protein content in wheat grain increased from 10.75% at control to 10.36% with 100% NPK application. The protein synthesis is closely associated with the supply of nitrogen as N is a constituent of amino acid and proteins. Increased supply of N, therefore, resulted in greater protein content in wheat grain. The content and yield of protein increased significantly over control when NPK fertilizers were applied with organic manures. The magnitude of increase was higher with 75% NPK + 2t vermi compost $ha^{-1}$ as compared to other treatments. Protein yield increased with application of 50 and 75% NPK along with vermi compost and FYM and press mud over control. These organic manures contain N and upon their decomposition produces more organic acids which in turn make the insoluble N soluble and thus increases N availability. Similar were the results of Singh and Singh (2012) and Singh and Ahmed (2010).

Table 2: Effect of integrated nutrient management on uptake of nutrients (kg $ha^{-1}$) by wheat gram and straw (mean of 2 years)

| Treatment | Nitrogen | | Phosphorus | | Potassium | |
|---|---|---|---|---|---|---|
| | Grain | Straw | Grain | Straw | Grain | Straw |
| $T_1$ | 43.8 | 11.4 | 7.9 | 5.7 | 9.2 | 60.7 |
| $T_2$ | 76.7 | 22.4 | 13.7 | 11.8 | 15.7 | 102.0 |
| $T_3$ | 70..8 | 17.2 | 12.3 | 8.8 | 14.2 | 84.7 |
| $T_4$ | 81.2 | 23.7 | 14.8 | 12.8 | 16.8 | 105.6 |
| $T_5$ | 75.8 | 21.4 | 13.3 | 11.0 | 15.2 | 99.7 |
| $T_6$ | 66.7 | 17.1 | 11.4 | 8.5 | 13.1 | 85.8 |
| $T_7$ | 66.7 | 18.3 | 11.4 | 9.1 | 13.1 | 92.0 |
| $T_8$ | 73.0 | 19.4 | 12.5 | 9.5 | 14.4 | 92.2 |
| CD (P=0.05) | 8.69 | 2.38 | 1.7 | 1.27 | 2.22 | 10.47 |

**Nutrient uptake**

The effect of organic manures and chemical fertilizers was significant on the uptake of N, P and K by the grain and straw of wheat (Table 2). The uptake of N by grain and straw ranged from 43.8 to 81.2 kg $ha^{-1}$ and 11.4 to 23.7 kg $ha^{-1}$. The corresponding ranges for P uptake by grain and straw were from 7.9 to 14.8 and 5.7 to 12.8 kg $ha^{-1}$. The uptake of K ranged from 9.2 to 16.8 kg $ha^{-1}$ in grain and from 60.7 to 105.6 kg $ha^{-1}$ in straw. The maximum uptake of

these nutrients was recorded in the treatment combination of 75% NPK + 2t vermi compost ha$^{-1}$ closely followed by 100% RD NPK. This might be attributed to greater grain and straw production as well as nutrient concentrations with combined use of organic and inorganic fertilizers. Better performance under these treatments might also be due to favourable soil environment which encouraged better root proliferation and ensured higher nutrient uptake. These results corroborate with the findings of Singh *et al.* (2013). The combined application of organic manures along with 50% NPK recorded comparatively lower uptake of N, P and K as compared to integrated use of organic manures and 75% NPK. This might be due to lower supply of available nutrients resulting in lower yield and concentration of NPK in grain and straw of wheat.The lowest uptake of N, P and K by wheat grain and straw were recorded in control which may be attributed to lower grain and straw production in this treatment (Control).

Table 3: Effect of integrated nutrient management on soil fertility (mean of 2 years)

| Treatment | pH | Org. carbon (g kg$^{-1}$) | Avail. N (kg ha$^{-1}$) | Avail. P (kg ha$^{-1}$) | Available K (kg ha$^{-1}$) |
|---|---|---|---|---|---|
| $T_1$ Control | 8.2 | 4.0 | 127.2 | 10.6 | 160.0 |
| $T_2$ 100% RDNPK | 8.1 | 4.1 | 150.1 | 11.5 | 180.0 |
| $T_3$ 75% NPK + 10t FYM ha$^{-1}$ | 7.9 | 4.6 | 161.8 | 13.3 | 190.0 |
| $T_4$ 75% NPK + 2t VC ha$^{-1}$ | 8.0 | 4.3 | 160.5 | 12.7 | 190.0 |
| $T_5$ 50% NPK + 2t VC + 10t FYM ha$^{-1}$ | 7.9 | 4.5 | 160.2 | 12.5 | 189.0 |
| $T_6$ 75% NPK + 3t PM ha$^{-1}$ | 7.8 | 4.3 | 155.7 | 12.0 | 186.0 |
| $T_7$ 50% NPK + 3t PM + 10t FYM ha$^{-1}$ | 7.7 | 4.6 | 159.5 | 12.1 | 188.0 |
| $T_8$ 50% NPK + 2t VC + 3t PM ha$^{-1}$ | 7.8 | 4.3 | 156.5 | 12.7 | 188.0 |
| CD (P=0.05) | NS | 0.11 | 3.75 | 1.30 | 4.30 |

**Soil properties**

The pH value tended to decrease with combined use of organic manures and NPK fertilizer. The lowest value of soil pH (7.7) was recorded under treatment $T_7$ (50% NPK + 3 t press mud + 10 t FYM ha$^{-1}$).The organic carbon, available N, P and K status of post harvest soil improved due to application of organic manures along with NPK fertilizer. In general, maximum values of organic carbon (4.6 g kg$^{-1}$) available N (161.8 kg ha$^{-1}$), available P (13.3 kg ha$^{-1}$) and available K (190.0 kg ha$^{-1}$) were recorded under integrated use of 75% NPK + 10t FYM ha$^{-1}$.Addition of inorganic fertilizers along with organic manures helps in mineralization which resulted in conversion of organically bound forms of nutrients to inorganic forms. However, it was observed that crop receiving same source of organic manures along with different levels of NPK fertilizers (50 and 75% RD NPK) did not vary significantly in respect of organic carbon content of the soil. Such favourable effect of integrated use of organic manures and inorganic fertilizer on available N, P and K content in soil was noticed by Kumar *et al.* (2008) and Singh and Singh (2012).

From the study, it can be concluded that application of 75% NPK + 2 t vermin compost ha-1 was found to be most effective for sustainable wheat production. However, application of 75% NPK + 10 t FYM ha$^{-1}$ proved superior in maintaining the soil fertility.

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