*Forage Res.*, **51**(1) : pp. 91-97 (2025) **http://forageresearch.in**

# CONCENTRATION AND UPTAKE OF MACRO NUTRIENTS IN RICE-WHEAT CROPPING SYSTEM AS INFLUENCED BY ORGANICS WITH FERTILIZERS

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**(Received : 2 May 2025; Accepted : 29 June 2025)**

## SUMMARY

Field experiments were conducted for two years on a sandy loam soil at Agricultural Research Farm, Institute of Agricultural Sciences, Banaras Hindu University, Varanasi, Uttar Pradesh to assess the effects of combined application of organics with chemical fertilizers on concentration and uptake of major nutrients in rice-wheat cropping system on Alluvial soils of Varanasi. The experiment was laid out in randomized block design (RBD) with nine treatments comprised control (no fertilizer), 100% NPK and seven combinations of 70% NPK with different organics *viz.*, FYM, pressmud and vermicompost. The treatments were applied in rice and the residual effect of treatments was evaluated in subsequent wheat crop in the sequence and the cycle repeated twice. The result revealed that the substitution of 30% N by pressmud and FYM equally is significantly improved the yields, concentration of macro nutrients in rice and the residual effect also found significant in wheat. Application of 70% RDF + 30% N through FYM and pressmud recorded maximum yield of grain as 4.90 t/ha in rice and 4.20 t/ha in wheat, highest concentration of N (1.30 & 0.69%), P (0.35 & 0.34%), Cu (7.82 & 16.84 ppm), Mn (15.64 & 53.99 ppm) in grains and straw, respectively of rice crop. Meanwhile, the higher concentration of K and S recorded in other treatment combinations. In wheat crop, the highest uptake of N (63.59 & 51.25 kg/ha), P (17.25 & 25.17 kg/ha), K (17.67 & 104.56 kg/ha) and S (18.17 & 29.10 kg/ha) by grains and straw of rice, respectively was recorded with application of 70% RDF + 30% N by FYM. Similar residual effect in terms of concentration and uptake of nutrients was also reported in subsequent wheat crop during both the years.

**Key words:** Alluvial soil, integration, nutrition, *Oryza sativa, Triticum aestivum* and yield

The rice (*Oryza sativa* L.) - wheat (*Triticum aestivum* L.) cropping system covered around 13.5 mha area in Indo-Gangetic plains (IGP) and the backbone of socio-economic growth of millions of people (Singh *et al.*,2019). The system contributes 23% of total food grain production and remains the main pillar of cereal production (Verma *et al.,* 2016). However, presently the system has begun to shows up sign of exhaustion with yield plateau and soil health decline. It has been realized from long-term fertilizer experiments that neither inorganic fertilizers nor organic manures alone can achieve sustainability in production, whereas integrated use of organics as well as inorganic fertilizers are essential to improve soil health and enhance productivity and input use efficiency which can sustain a highly intensive cropping system. The positive effect of judicious use of organic manure and inorganic fertilizers on productivity of crops and soil fertility has been reported by many workers (Singh *et al.*,2015; Kundu *et al.*,2016). Organic amendments such as recycling of agricultural wastes and application of organic manures have sustained crop production for several years before the introduction of inorganic fertilizers along with the entry of high yielding and fertilizer responsive varieties that have largely replaced the traditional practices (Jat *et al.*,2015; Wanjari and Singh, 2019). The responses of the succeeding crops in a cropping system are influenced greatly by the preceding crops and the inputs applied therein. Therefore, recently greater emphasis is being laid on the cropping system as a whole rather than on the individual crops. In addition, organic manures and biofertilizers have carry-over effect on the succeeding crops (Davari*et al.*, 2012). Jamaval (2006) reported that around 30% of the applied nitrogen as manure may become available to the immediate crop and rest to the subsequent crops.

The intensive cultivation and imbalanced fertilizer application in rice-wheat cropping system resulted multi-nutrient deficiency and also depletion of organic matter from the soil. However, owing to the steadily increasing demands for food grains by the overgrowing populations, a complete shift to an organic farming system is not possible. On another side, nutrient uptake by the rice–wheat cropping system is an important indicator of soil fertility and plant nutrient status. The hypothesis of this investigation was to study the inûuence of integration of chemical fertilizers and organics *i.e.* FYM, pressmud, vermicompost on major nutrients concentration and their uptake by plants in rice-wheat cropping system in alluvial soils of Varanasi.

## MATERIALS AND METHODS

### Experiment site

The present investigation conducted at Agricultural Research Farm, Banaras Hindu University, Varanasi using rice and wheat as test crop. The experimental site was located between 25.14$^0$ to 25.33$^0$ N latitude and 82.56$^0$ to 83.03$^0$ E longitudes and falls in a semi-arid to sub humid climate. The annual average rainfall of this region is about 1100 mm. Generally, the maximum and minimum temperature ranges between 17.9-39.9°C and 9.8-28.3°C in first year and 14.5-38.9°C and 6.2-28.7°C in second crop season, respectively. May and June are the hottest months with maximum temperature ranging from 37 to 40°C. The cold period lies between November and January with minimum temperature varying between 6-12°C. The mean relative humidity is about 71% which rise to 92% during wet season and goes down to 17% during dry season.

### Characteristics of organic inputs

Three organic inputs used under study *viz.*, FYM, pressmud and vermicompost. The FYM had pH 7.42, EC 1.44 dS $m^{-1}$, organic carbon 22.8%, total N, P, K and S contents were 0.78, 0.36, 0.50 and 0.18%, respectively with C:N ratio 29.2:1. Vermicompost having pH 7.42, EC 1.26 dS $m^{-1}$, organic carbon 31.3%, total N, P, K and S contents were 1.41, 0.43, 0.63 and 0.42%, respectively with C:N ratio 22.2:1. Similarly, pressmud had pH 7.56, EC 1.58 dS $m^{-1}$, organic carbon 35.0%, total N, P, K and S contents were 2.0, 1.78, 0.42 and 2.28%, respectively with C:N ratio 17.5:1.

### Fertilisation treatments and management

A randomized block experiment was established with nine different treatments and three replicates. Each field plot was 5.0 m × 4.0 m. The nine treatments were grouped as control (no application), sole mineral fertiliser's treatment and combined mineral and organics nutrient regimes. The RDF were taken as 120:26.20:50 kg N:P:K/ha as tested by regional research station for rice and wheat. The treatments consisted of different organics which applied on nitrogen basis and inorganic fertilizer *viz.*, $T_1$- Control (without fertiliser application), $T_2$- 100% RDF, $T_3$- 70% RDF + 30% N by FYM, $T_4$- 70% RDF + 30% N by vermicompost (VC), $T_5$- 70% RDF + 30% N by pressmud (PM), $T_6$- 70% RDF + 15% N by FYM+15% VC, $T_7$- 70% RDF + 15% N by VC+15% PM, $T_8$- 70% RDF + 15% N by FYM+15% PM, $T_9$- 70% RDF + 10% N by FYM+10%PM+10% VC. Organic manures were applied before 15 days of transplanting of rice. In the two cropping cycles, the total amount of N, P and K applied were uniform across the treatments. The organics were applied in rice crop only and the succeeding wheat crop receives only mineral fertilizers. Urea for N, Di-ammonium phosphate for P, and potassium chloride for K was used throughout the experiments. Urea was applied with three equal splits for the both crops, first as basal fertiliser and second as tillering stage and third at milking. The P and K fertilisers were applied as basal fertilisers before rice transplanting and at sowing of the wheat crop.

### Soils of experimental field :

The soil of the experimental site was moderately alkaline in reaction with pH 8.4, electrical conductivity (0.23 $dSm^{-1}$) medium in organic carbon 0.39%, deficient in available nitrogen (93.50mg/kg) medium in available P (5.83mg/kg) and medium in K (69.93mg/kg), medium in available S (11.45 mg/kg), and DTPA- extractable Fe, Cu, Mn and Zn was 35.53, 2.31, 9.42 and 1.41 mg/kg, respectively.

**Analysis :**

Plant samples of both the crops were collected from five randomly selected plants at harvest stage. The samples were first dried in shade and then in hot air oven at 65°C. The plant samples were ground in willey mill and stored in labeled brown paper bags for analysis. The grain samples were also processed and stored in similar fashion. N content in plant samples was determined by micro Kjeldahl method (Piper, 1966). Di-acid extract was prepared as per the method outlined by Jackson (1973). It was carried out using a 9:4 mixture of $HNO_3$: $HClO_4$. The pre-digestion of sample was done by using 10 ml of $HNO_3$ $g^{-1}$ sample. This di-acid extract was used to determine P, K and S content in the plant and grain samples. Phosphorus was determined spectrophotometrically by vanadomolybdate phosphoric acid yellow colour method and S by tubididymetric method as described by Jackson (1973) from di-acid extract. Potassium was estimated from di-acid extract by using flame photometer (Jackson, 1973). The uptake of nutrients by grain and straw were calculated by content of nutrient multiplied by respective yield.

The two-year data were pooled and subjected to one-way analysis of variance (ANOVA) using SPSS version 16 software. Duncan's multiple range test (DMRT) was performed to test the signiûcance of difference between the treatments.

## RESULTS AND DISCUSSION

**Yields:**

The grain and straw yield of both the crops were significantly influenced by the integrated application of fertilizers with organics (Table 1). In experimentation, maximum yield of grain (4.90 and 4.20 t/ha) and straw (7.44 and 6.62 t/ha) of rice and wheat, respectively were recorded with $T_8$ in which 70% NPK with 15% nitrogen by FYM and another 15% by pressmud was given followed by plot $T_7$ *i.e.* grain (4.81 and 4.13 t/ha) and straw (7.17 and 6.46 t/ ha) in which 70% NPK with 15% nitrogen by vermicompost and another 15% by pressmud. The application of FYM and pressmud alongwith 70% NPK resulted in maximum yield that establishes the fact of synchrony between availability of nitrogen at critical stages of crop as well as other benefits derived from FYM and pressmud, and also treatment $T_8$ adds some additional amount of phosphorus and potassium as compared to $T_7$. The higher nutrient addition by organics improve the yield of crops. Further, application of FYM adds and exploits the fixed nutrients of soil in available form and regulates its supply to the crop through mineralization and prevents them from leaching and other losses (Singh *et al.*, 2015) on other hand pressmud is quick release nutrients as compared to FYM (Sultana *et al.*, 2015) and combination of both with fertilizers provide adequate nutrients to crops during entire growth period and results higher grain yield.

**Macronutrient content in straw and grains:**

The major nutrients concentration (%) in the straw of both crops was significantly increased due to direct and residual effect of INM treatments. The N, P, K and S content in straw (Table 2) varied from 0.40% to 0.69%, 0.13% to 0.34%, 1.03% to 1.41% and 0.19% to 0.44% in rice and 0.36% to 0.77%,

TABLE 1

Effect of integration of nutrient sources yield and yield attributes in rice-wheat cropping system (mean of 3 replicates ± SE)

| Treatments | Grain yield (q $ha^{-1}$) | | Straw yield (q $ha^{-1}$) | | Harvest index (%) | |
|---|---|---|---|---|---|---|
| | Rice | Wheat | Rice | Wheat | Rice | Wheat |
| $T_1$ | 2.59±0.05e | 2.60±0.06e | 5.03±0.14c | 4.31±0.18f | 34.01±1.01c | 37.73±1.34b |
| $T_2$ | 4.01±0.13d | 3.53±0.11d | 6.64±0.09b | 5.34±0.11e | 37.61±0.53b | 39.76±0.27a |
| $T_3$ | 4.10±0.00cd | 3.69±0.03cd | 6.72±0.21b | 5.69±0.13cde | 37.86±0.74ab | 39.32±0.39ab |
| $T_4$ | 4.14±0.13cd | 3.61±0.01d | 6.64±0.10b | 5.50±0.15de | 38.40±1.07ab | 39.68±0.72a |
| $T_5$ | 4.37±0.14bc | 3.91±0.03b | 6.94±0.27ab | 5.92±0.08bc | 38.67±0.35ab | 39.75±0.41a |
| $T_6$ | 4.27±0.08cd | 3.80±0.03bc | 6.85±0.11b | 5.75±0.08cd | 38.42±0.29ab | 39.82±0.15a |
| $T_7$ | 4.81±0.09a | 4.13±0.04a | 7.17±0.22ab | 6.46±0.13a | 40.20±1.11ab | 39.05±0.25ab |
| $T_8$ | 4.90±0.03a | 4.20±0.04a | 7.44±0.15a | 6.62±0.13a | 39.76±0.54a | 38.86±0.33ab |
| $T_9$ | 4.55±0.02b | 3.95±0.04b | 7.03±0.09ab | 6.24±0.10ab | 39.29±0.27ab | 38.75±0.34ab |

Note-Means followed by the same letter in each column are not signiûcantly diûerent using Duncan's multiple range test ($p < 0.05$).

0.13% to 0.34%, 0.96% to 1.43% and 0.17% to 0.38%, respectively in wheat. The 30% replacement of nitrogen significantly improved the macro nutrient content in the straw of both the crops. The highest value of N and P content was observed with the application of 70% RDF + 15% N by FYM+15% N by PM. Meanwhile, the higher K content was recorded with the treatment which received 70% RDF + 30% N by VC and the S content was recorded maximum in the treatment which offered 70% RDF + 30% N by PM. The maximum values of all above nutrients are significantly higher over their respective RDF treatment. Similarly, the integration of nutrients significantly improved the macro nutrient content in the grains of both the crops. The N, P, K and S content in grains (Table 3) ranged from 0.95% to 1.30%, 0.21% to 0.35%, 0.20% to 0.37% and 0.22% to 0.38% in rice and 1.23% to 1.70%, 0.21% to 0.39%, 0.19% to 0.34% and 0.18% to 0.37%, respectively in wheat. The highest value of N and P content was observed with the application of 70% RDF + 15% N by FYM+15% N by PM. Meanwhile, the higher K content was recorded with the treatment which received 70% RDF + 30% N by VC and the S content was recorded maximum in the treatment which offered 70% RDF + 30% N by PM. In the grains, all the higher values are significantly superior over their respective RDF treatment and in terms of percentage, the N, P, K and S content in grains were 10.77%, 28.86%, 21.62% & 28.95% in the rice and 7.65%, 28.21%, 23.52% & 29.73% in wheat, respectively higher over the respective RDF treatment.

The application of farm yard manure, pressmud and vermicompost resulted in an increased N concentration in wheat straw and grain. This might be due to the sufficient and continued availability of N from inorganic and organic sources (Lakshmi *et al.*, 2011). Nitrogen in manure is found in the organic and inorganic forms. The organic form (slow release) slowly mineralizes providing plant-available N, while inorganic forms (fast release) consist primarily of $NH_4$-N and are immediately plant available (Hofman and Van Cleemput, 2004). The higher concentration of nitrogen as observed by several workers in rice (Sultana *et al.*,2015), in pearl millet (Srivatsava *et al.*,2015), in rice-wheat cropping system (Kanaujia, 2016). The higher P content by FYM and pressmud may be due to direct addition of P on decomposition of FYM and release of the fixed P through anion exchange. The production of organic acids and lowering soil pH due to organic acid as the mechanisms by which soil fixed P was made available for plant growth and ultimately increase the concentration (Shahane *et al.*, 2020). Similar finding of increase of P content in plant with addition of organics and fertilizer was also reported by Srivatsava *et al.* (2015) and Kanaujia (2016).

The combination of FYM and vermicompost with 70% RDF was higher in increasing K content in grain and straw of both crops. The vermicompost and FYM also good source of K as compared to pressmud. The increase in K availability as the effect of organics was due to higher microbial activities (Meena *et al.*,2016) and better soil condition which influenced the release of non-exchangeable or fixed-K forms into available forms and then uptake by plant. Fixation of potassium was minimized by the complex formation with organic ligands and increase of $NH_4^+$ ions in the soil (Singh *et al.*,2015). In present investigation, effect of pressmud on S content rice

TABLE 2

Effect of integration of nutrient sources on concentration of nutrients in rice and wheat plant (mean of 3 replicates ±SE)

| Treatments | Nitrogen (%) | | Phosphorus (%) | | Potassium (%) | | Sulphur (%) | |
|---|---|---|---|---|---|---|---|---|
| | Rice | Wheat | Rice | Wheat | Rice | Wheat | Rice | Wheat |
| $T_1$ | 0.40±0.02c | 0.36±0.02c | 0.13±0.01e | 0.13±0.01e | 1.03±0.09c | 0.96±0.09c | 0.19±0.01c | 0.17±0.01d |
| $T_2$ | 0.60±0.01b | 0.62±0.03b | 0.27±0.01cd | 0.23±0.02d | 1.34±0.02ab | 1.04±0.03c | 0.26±0.02b | 0.25±0.02c |
| $T_3$ | 0.61±0.04b | 0.67±0.03ab | 0.28±0.01cd | 0.27±0.01bcd | 1.33±0.03ab | 1.35±0.00ab | 0.27±0.01b | 0.26±0.03c |
| $T_4$ | 0.60±0.02b | 0.63±0.03b | 0.26±0.01d | 0.24±0.01cd | 1.34±0.02ab | 1.31±0.04ab | 0.29±0.02b | 0.29±0.02bc |
| $T_5$ | 0.65±0.01ab | 0.70±0.05ab | 0.32±0.00ab | 0.31±0.00ab | 1.32±0.02b | 1.29±0.02b | 0.41±0.02a | 0.38±0.02a |
| $T_6$ | 0.64±0.02ab | 0.69±0.04ab | 0.30±0.01bc | 0.29±0.02abc | 1.44±0.02a | 1.43±0.03a | 0.30±0.03b | 0.29±0.02bc |
| $T_7$ | 0.67±0.02ab | 0.75±0.04a | 0.33±0.01ab | 0.32±0.02a | 1.38±0.01ab | 1.35±0.02ab | 0.40±0.01a | 0.37±0.02a |
| $T_8$ | 0.69±0.02a | 0.77±0.02a | 0.34±0.01a | 0.34±0.01a | 1.41±0.02ab | 1.40±0.03ab | 0.39±0.02a | 0.36±0.02a |
| $T_9$ | 0.66±0.02ab | 0.71±0.01ab | 0.31±0.01ab | 0.31±0.03ab | 1.39±0.01ab | 1.36±0.01ab | 0.38±0.02a | 0.34±0.00ab |

Note-Means followed by the same letter in each column are not signiûcantly diûerent using Duncan’s multiple range test ($p < 0.05$).

TABLE 3

Effect of integration of nutrient sources on concentration of nutrients in rice and wheat grains (mean of 3 replicates ±SE)

| Treatments | Nitrogen (%) | | Phosphorus (%) | | Potassium (%) | | Sulphur (%) | |
|---|---|---|---|---|---|---|---|---|
| | Rice | Wheat | Rice | Wheat | Rice | Wheat | Rice | Wheat |
| $T_1$ | 0.95±0.05d | 1.23±0.02c | 0.21±0.01e | 0.21±0.01e | 0.20±0.00e | 0.19±0.00e | 0.22±0.01f | 0.18±0.00d |
| $T_2$ | 1.16±0.01bc | 1.57±0.02b | 0.27±0.01d | 0.28±0.02d | 0.29±0.00d | 0.26±0.01d | 0.27±0.01e | 0.26±0.01c |
| $T_3$ | 1.17±0.03bc | 1.65±0.03ab | 0.29±0.00cd | 0.33±0.01bc | 0.31±0.01bcd | 0.28±0.00cd | 0.31±0.01d | 0.30±0.01bc |
| $T_4$ | 1.12±0.03c | 1.62±0.05ab | 0.31±0.00bc | 0.33±0.02c | 0.31±0.01bcd | 0.27±0.00d | 0.33±0.02cd | 0.30±0.01bc |
| $T_5$ | 1.23±0.02ab | 1.67±0.03ab | 0.33±0.02ab | 0.37±0.02abc | 0.31±0.01cd | 0.26±0.01d | 0.38±0.01a | 0.37±0.03a |
| $T_6$ | 1.21±0.06abc | 1.65±0.03ab | 0.32±0.00bc | 0.36±0.02abc | 0.37±0.02a | 0.34±0.00a | 0.34±0.01bcd | 0.30±0.01bc |
| $T_7$ | 1.26±0.01ab | 1.69±0.01ab | 0.34±0.01ab | 0.38±0.01ab | 0.34±0.01ab | 0.30±0.01bc | 0.36±0.02abc | 0.35±0.01a |
| $T_8$ | 1.30±0.01a | 1.70±0.03a | 0.35±0.02a | 0.39±0.01a | 0.36±0.02a | 0.32±0.00ab | 0.37±0.01ab | 0.32±0.01b |
| $T_9$ | 1.24±0.03ab | 1.67±0.07ab | 0.33±0.01abc | 0.37±0.00abc | 0.34±0.01abc | 0.30±0.02b | 0.35±0.01abc | 0.31±0.01b |

Note-Means followed by the same letter in each column are not signiûcantly diûerent using Duncan's multiple range test ($p < 0.05$).

and wheat was higher than FYM and vermicompost because of higher content of S having in pressmud. Higher content of S could be justified as a result of mineralization of organic source that contributed to accumulation of more amount of S in soil and also through microbiological oxidation (Gogoi *et al.*, 2015) and resulted higher concentration in plant. Thus, addition of pressmud, FYM and vermicompost in soil might be the possible reason of enhancement of S content in rice and wheat. Hyder *et al.* (2021) also reported that NPK concentration in wheat straw and grains increased in integrated nutrient management practices. This might be due to (i) increased supply of all essential nutrients directly through organic and inorganic source to crop, (ii) by increasing in the nutrient use efficiency.

**Macronutrient uptake by straw and grains:**

The integration of nutrients significantly improved the macro nutrient content in the straw of both the crops (table 4). The N, P, K and S content in grains ranged from 20.28 to 51.25 kg/ha, 06.68 to 25.17 kg/ha, 52.04 to 104.56 and 9.41 to 29.10 kg/ha in rice and 15.37 to 50.90 kg/ha, 5.47 to 22.14 kg/ha, 41.41 to 92.38 and 741 to 23.66 kg/ha, respectively in wheat. The highest value of N, P, K and S uptake was observed with the application of 70% RDF + 15% N by FYM+15% N by PM. All the higher values of macro nutrients uptake by straw are significantly superior over their respective RDF treatment and in terms of percentage, the N, P, K and S content in straw were 24.29%, 32.50%, 18.04% &41.92% in the rice and 34.60%, 44.08%, 40.15% &43.87% in wheat, respectively higher over their respective RDF treatment. Further, there was a significant increase in the uptake of N, P, K and S by the grains (Table 5) in both crops. The maximum uptake of N (63.59 & 71.50 kg/ha), P (17.25 & 16.45 kg/ha), K (17.67 & 13.24 kg/ha) and S (18.17 & 13.60 kg/ha) by the grains rice and wheat, respectively was recorded in the treatment $T_8$ in which 70% RDF + 15% N by FYM+15% N by PM, whereas the in the plot which received 100% RDF by fertilizers was observed relatively lesser uptake *i.e.* N (43.74 & 55.33 kg/ha), P (9.58 & 9.67 kg/ha), K (10.87 & 9.10 kg/ha) and S (10.49 & 9.29 kg/ha) by the grains rice and wheat, respectively.

The higher macro nutrients uptake by rice and wheat is might be attributed to greater grain and straw production as well as nutrient concentrations with combined use of organics with inorganic fertilizers. Better performance under these treatments might also be due to favourable soil environment which encouraged betterroot proliferation and ensured higher nutrient uptake. These results corroborate with the findings of Singh (2017). Poor availability and higher loss of nutrients under RDF alone resulted lower uptake (Mohana Rao *et al.*,2014). The phosphorus is second most important nutrient after N; while need and significance of potassium nutrition in RWCS was also reported (Shahane *et al.*,2020). The application of 100% NPK alone recorded comparatively lower uptake of N, P and K as compared to integrated use of organic manures and 70% NPK. This might be due to lower supply of available nutrients resulting in lower yield and concentration of NPK in grain and straw of crops. 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). The higher uptake of nitrogen as observed by several workers *i.e.* in rice (Sultana *et al.*,2015), in rice-wheat cropping system (Kanaujia 2016). Increased

TABLE 4
Effect of integration of nutrient sources on nutrient uptake by rice and wheat grains (mean of 3 replicates ±SE)

| Treatments | Nitrogen (kg/ha) | | Phosphorus (kg/ha) | | Potassium (kg/ha) | | Sulphur (kg/ha) | |
|---|---|---|---|---|---|---|---|---|
| | Rice | Wheat | Rice | Wheat | Rice | Wheat | Rice | Wheat |
| $T_1$ | 24.63±1.58e | 32.09±0.52g | 5.32±0.08e | 5.40±0.28g | 5.25±0.05f | 4.93±0.03e | 5.63±0.10f | 4.66±0.15e |
| $T_2$ | 43.74±0.98d | 55.33±1.23f | 9.58±0.17d | 9.67±0.35f | 10.87±0.27e | 9.10±0.09d | 10.49±0.52e | 9.29±0.27d |
| $T_3$ | 50.72±0.66c | 60.70±1.13de | 13.54±0.35bc | 12.30±0.36de | 14.04±0.79cd | 10.20±0.20c | 13.13±0.30d | 11.18±0.42c |
| $T_4$ | 46.32±0.45d | 58.65±1.89ef | 12.98±0.16c | 11.87±0.62e | 12.83±0.35d | 9.70±0.19cd | 13.55±0.82d | 10.73±0.38cd |
| $T_5$ | 53.58±0.55bc | 65.04±1.05bcd | 14.35±0.63bc | 14.60±1.02bc | 13.35±0.26d | 10.29±0.18c | 16.61±0.58ab | 14.26±0.91a |
| $T_6$ | 51.80±2.48c | 62.77±1.40cde | 13.60±0.17bc | 13.69±0.77cd | 15.80±0.81b | 12.74±0.08ab | 14.54±0.39cd | 11.53±0.51c |
| $T_7$ | 60.42±0.64a | 69.72±0.88ab | 16.30±0.46a | 15.64±0.35ab | 16.46±0.31ab | 12.27±0.36b | 17.42±0.91ab | 14.60±0.43a |
| $T_8$ | 63.59±0.55a | 71.50±0.59a | 17.25±0.86a | 16.45±0.10a | 17.67±0.94a | 13.24±0.08a | 18.17±0.35a | 13.60±0.64ab |
| $T_9$ | 56.35±1.36b | 65.98±3.46bc | 14.83±0.57b | 14.54±0.01bc | 15.49±0.20bc | 11.99±0.78b | 15.86±0.37bc | 12.17±0.37bc |

Note-Means followed by the same letter in each column are not signiûcantly diûerent using Duncan's multiple range test ($p < 0.05$).

TABLE 5
Effect of integration of nutrient sources on nutrient uptake by rice and wheat plants (mean of 3 replicates ±SE)

| Treatments | Nitrogen (kg/ha) | | Phosphorus (kg/ha) | | Potassium (kg/ha) | | Sulphur (kg/ha) | |
|---|---|---|---|---|---|---|---|---|
| | Rice | Wheat | Rice | Wheat | Rice | Wheat | Rice | Wheat |
| $T_1$ | 20.28±0.52f | 15.37±0.92f | 6.68±0.93e | 5.47±0.52f | 52.04±5.97e | 41.41±4.99f | 9.41±0.35c | 7.41±0.54d |
| $T_2$ | 38.80±1.00e | 33.29±1.48e | 16.99±0.78d | 12.38±1.01e | 85.70±1.92d | 55.29±0.93e | 16.90±1.66b | 13.28±1.03c |
| $T_3$ | 41.62±2.81cde | 38.16±1.13cde | 19.64±0.64cd | 15.09±0.62de | 92.39±1.45bcd | 76.68±1.68cd | 18.15±0.36b | 14.59±1.36bc |
| $T_4$ | 39.96±2.48de | 34.72±2.62de | 17.41±1.05d | 13.37±0.39e | 88.82±3.09cd | 71.99±0.95d | 19.24±1.11b | 15.84±1.56bc |
| $T_5$ | 45.34±2.19bcde | 41.22±3.21c | 22.32±0.82bc | 18.57±0.16bc | 91.33±3.09bcd | 76.52±0.99cd | 28.26±2.18a | 22.50±0.80a |
| $T_6$ | 44.00±0.85bcd | 39.90±2.90cd | 20.42±0.52c | 16.51±1.24cd | 98.87±1.88ab | 82.03±2.71bc | 20.51±1.84b | 16.80±1.20b |
| $T_7$ | 47.92±1.27ab | 47.98±2.12ab | 23.64±0.63ab | 20.66±1.61ab | 98.97±3.43ab | 86.97±1.10ab | 28.44±0.51a | 23.73±1.04a |
| $T_8$ | 51.25±0.67a | 50.90±0.48a | 25.17±1.31a | 22.14±0.26a | 104.56±1.01a | 92.38±4.03a | 29.10±1.78a | 23.66±1.25a |
| $T_9$ | 46.49±1.54abc | 44.51±1.16bc | 21.89±0.68bc | 18.98±1.38bc | 97.56±1.58abc | 84.55±1.61abc | 26.62±1.21a | 21.41±0.11a |

Note-Means followed by the same letter in each column are not signiûcantly diûerent using Duncan's multiple range test ($p < 0.05$).

P solubility in ûooded rice due to reduction of Fe (III) phosphate compounds because of increased pH in acidic soils, and to increased solubility of Ca-phosphate compounds because of decreased pH in alkaline soils (Saleque *et al.*, (2006), probably would not have increased plant-available P in the soils of this study. Singh *et al*, (2018) observed higher K uptake by the integrated application of nutrients under rice–maize system. Higher uptake of S could be justified as a result of mineralization of organic source (pressmud and FYM) that contributed to accumulation of more amount of S in soil and also through microbiological oxidation and resulted higher uptake by plant. Application of organics in combination with inorganic fertilizers, exhibited better response in nutrient uptake over chemical fertilizer due to steady supply of nutrients throughout the growing period of crops (Gogoi *et al.*, 2015). These results are consonance with the findings of Sultana *et al.* (2015).

## CONCLUSION

From above results and discussion, it is clear that 30% replacement of nitrogen through organics with chemical fertilizer significant influence on the major nutrient concentration in grains as well straw in rice-wheat cropping system. The results further demonstrated that N, P, K and S uptake by grains and straw were also significantly increased with integrated use of fertilizers along with organics. From the present study it was observed that 15% nitrogen through FYM and 15% by pressmud with 70% of the recommended NPK fertilizer gave the best results compared to other combinations. Practically it is difficult for the farmers to apply 10 t FYM $ha^{-1}$ every year (as suggested by other studies), therefore, application of available organic amendments at a lower rate in conjunction with chemical fertilizers can maximize the yield. Chemical fertilizer alone could not enhance the better concentration of nutrients in both crops.

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