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# Effect of integrated nutrient management on yield, quality and uptake of nutrients in oat (*Avena sativa)* in alluvial soil

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## ABSTRACT

*A field experiment was conducted during rabi season (2012-13 and 2013-14) at Research Farm, R.B.S. College, Bichpuri, Agra (U.P.) to study the effect of integrated nutrient management on yield, quality, and uptake of nutrients in oat (Avena sativa). The experiment was laid out in randomized block design with nine treatments and three replications. The results revealed that the plant height, green foliage and dry matter yields of oat crop increased significantly up to 100% NPK over control. The green foliage (400.37q $ha^{-1}$) and dry matter (59.75q $ha^{-1}$) yields at 100 % NPK were 37.8 and 40.1% higher than that obtained in the control. The maximum values of growth, yield attributes and green foliage yield (428.75q $ha^{-1}$) and dry matter yield (63.96q $ha^{-1}$) were recorded with 75% NPK+5 t FYM +20 kg S $ha^{-1}$ closely followed by 75% NPK+5t FYM +10 kg Mn $ha^{-1}$. Farmyard manure alone was also found to be more beneficial in terms of growth and yield of oat crop. The maximum content of protein (14.06 %) were recorded with 100 % NPK but maximum value of protein yield (889.0 kg $ha^{-1}$) was recorded with 75% NPK+5 t FYM +20 kg S $ha^{-1}$. The uptake of N, P, K, S, Fe, Cu and Zn by oat crop was highest at 75% NPK+5 t FYM +20 kg S $ha^{-1}$ and lowest in control. The amounts of available N, P and K in post harvest soil were maximum with the application of 100 % NPK but organic carbon, sulphur and iron, were maximum with the 75% NPK+5 t FYM +20 kg S $ha^{-1}$ and Cu and Zn with 75% NPK+5t FYM +10 kg Mn $ha^{-1}$. The minimum amounts of available nutrients in post harvest soil were recorded under control treatment.*

**Key words:** - Oat, INM, quality, uptake of nutrients, soil fertility, yield

## INTRODUCTION

Oat (*Avena* sativa) is an important cereal mainly for fodder during rabi season. Oat provides a very nutritious fodder (protein 13-15%) especially suited to milch animals. The ever-rising demand for fodder and feed for sustaining livestock production can be met through increasing productivity of fodder. The profitable production of oat crop may be affected by many factors, among these soil fertility to produce good fodder and seed, is of practical significance. The poor yield of oat crop in our country is mainly ascribed to low fertility of soil, inadequate manuring and cultural practices. Our soils have exhausted in respect of major and minor elements hampering the yield of crops. The new varieties of the crop require higher amounts of nutrients for realizing their inherent yield potential. Proper and optimum application of fertilizers not only increases the yield but also favourably affects the quality of the produce. To curb this trend of declining yield, there is need to adopt the concept of integrated nutrient management. Organic manure is important components of an integrated nutrient management and may help to recover soil health. Besides, organic manures also supply the traces of micronutrients, which are not supplied by chemical fertilizers. Therefore, it is needed 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 integrated plant nutrient system is maintenance and improvement of soil fertility for sustaining crop productivity on long-term basis. Application of different organic-inorganic sources was found very effective in realizing high yield, better economy (Singh, 2017) and improved residual fertility of the soil. The present experiment comprising different levels of inorganic and organic fertilizers was undertaken to study their effects on oat crop.

## MATERIALS AND METHODS

A field experiment was conducted during rabi season of 2012-13 and 2013-14 at Research Farm, R.B.S. College, Bichpuri, Agra (U.P.).The farm is situated at 27$^{o}$ 2’ N latitude and 77$^{o}$ 9’ E longitude at an altitude of 168 meter above the mean sea level. The experimental site is characterized by semi-arid climate with hot dry summers (46 to 48° C) and very low temperature during winter (as low as 2° C). The probability of onset of monsoon is first week of July and it ends by third week of September. The average rainfall is about 650 mm, which a major portion of 546 mm (84 per cent) receiving from July to September and only 104 mm (16 per cent) is received in the remaining part of the year. The experimental soil was sandy loam in texture having pH 8.0, organic carbon 3.7 g kg$^{-1}$, available N 165 g kg$^{-1}$, available P 10.2 g kg$^{-1}$, available K 130 g kg$^{-1}$ and available S 16.5 g kg$^{-1}$, DTPA –iron 4.6 mg kg$^{-1}$,manganese 2.2 mg kg$^{-1}$,cupper 0.23 mg kg$^{-1}$ and zinc 0.57 mg kg$^{-1}$. The experiment was laid out in randomized block design with three replications. The experiment included nine treatments, viz. $T_1$Control, $T_2$ 5 t FYM ha$^{-1}$,$T_3$ 75% NPK,$T_4$ 75% NPK + 5 t FYM ha$^{-1}$,$T_5$ 75% NPK + 10 kg Mn ha$^{-1}$,$T_6$ 75% NPK + 20 kg S ha$^{-1}$,$T_7$ 75% NPK + 5 t FYM + 10 kg Mn ha$^{-1}$,$T_8$ 75% NPK + 5 t FYM + 20 kg S ha$^{-1}$ and $T_9$ 100% NPK. Nitrogen was given in the form of urea as per treatments. Triple superphosphate and muriate of potash were used as sources for $P_2O_5$ and $K_2O$, respectively. Recommended dose of N, P and K for oat was 100:60:40 kg ha$^{-1}$, respectively. Full quantities of P and K fertilizers were given at the time of sowing. Nitrogen was applied as basal and two splits at first and second irrigation. Sulphur and Mn were applied at sowing as elemental sulphur and manganese chloride, respectively. Well-decomposed FYM (0.52% N, 0.31% P and 0.49% K) was added to the plots as per treatment one week before sowing. The oat (variety Kant) was sown at the rate of 80 kg ha$^{-1}$ on November 4, 2011 both the year. The oat crop was irrigated at the proper time as judged by the appearance of soil and the crop. In all three irrigation were given to the oat crop. The source of irrigation water was canal. The crop was allowed to grow up to 65 days after sowing. The green foliage yield was recorded at harvest. The dry matter samples of oat were first washed with demonized water and rinsed twice with distilled water and then dried in oven at 70$^{0}$ C to a constant weight to calculate the dry matter yield. The samples were then ground with pastel and mortar and stored in wide mouth bottles with proper labeling for chemical analysis. Processed samples were analyzed for their nutrient contents by digesting the samples using di-acid mixture of $HNO_3$: $HClO_4$ (10:4) followed by estimation of Fe, Mn, Cu and Zn using an AAS. Phosphorus, K and S were determined by vanadomolybdo phosphoric yellow colour method, flame photometer (Jackson 1973), turbidimetric method (Chesnin and Yien, 1951), respectively. Nitrogen content was estimated by modified Kjeldahl method and crude protein content was calculated by multiplying with a factor of 6.25.The uptake of nutrients by oat 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% $CaCl_2$ extractable), Fe, Mn, Cu and Zn (DTPA extractable) as described by Page *et al.* (1982).The trend of results was similar during both the years hence; data were subjected to pooled analysis for results and discussion.

## RESULTS AND DISCUSSION

### Yield

The plant height of oat crop ranged from 94.1 to 107.6 cm. Mean height of oat crop was highest (107.6 cm) under 75% NPK + 5t FYM + 20 kg S ha$^{-1}$ followed by 100% NPK (107.2 cm). The minimum height of plants was recorded under control (Table 1). The highest green foliage yield of oat was obtained by 75% NPK + 5t FYM + 20 kg S ha$^{-1}$ as compared to other treatments. On an average, balanced use of nutrients, (NPK + FYM + S outyielded the state recommended dose of NPK fertilizers by an average of 7.1%. The corresponding increase in green foliage yield with 75% NPK + 5t FYM + 20 kg S ha$^{-1}$ was 47.6% over control. Similar studies conducted by Singh (2017) and Pandey and Singh (2017) in Agra region on wheat revealed that application of nutrients in balanced amounts resulted in significantly higher grain yields over state recommended dose of NPK and control treatments. Application of 75% NPK + 5t FYM $ha^{-1}$ to oat increased the forage and dry matter yields significantly over 75% NPK alone. The beneficial effect of FYM on yields might be due to additional supply of nutrients as well as improvement in physical and biological properties of soil. Singh and Patra (2017) reported similar results. Application of 10 kg Mn $ha^{-1}$ along with 75% NPK increased the green foliage and dry matter yields by 28.0 and 27.1% over control, respectively. But this treatment failed to improve the yields of oat over 75% NPK alone (Singh and Patra 2017). Application 20 kg S $ha^{-1}$ along with 75% NPK ($T_6$) to oat increased the yields significantly over S R (100% NPK) and control treatment. Pandey and Chauhan (2016) reported similar results. The results clearly indicate that the highest yield was obtained with balanced use of fertilizers. Hussain *et al.* (2013), Pandey (2017), support these findings and Singh (2017) Thus, the balanced use of fertilizers in combination with FYM + S and FYM + Mn is necessary for sustaining productivity. The extent of response was higher with 75% NPK + 5t FYM + 20 kg S $ha^{-1}$ as compared to 75% NPK + 5t FYM + 10 kg Mn $ha^{-1}$.

Table 1: Effect of integrated nutrient management on plant height, yields, protein content, protein yield and crude fiber in oat plants (mean of two years)

| Treatments | Plant Height (cm) | Green foliage yield (q $ha^{-1}$) | % response | Dry matter yield (q $ha^{-1}$) | Protein content (%) | Protein yield ( kg $ha^{-1}$) | Crude fiber (%) |
|---|---|---|---|---|---|---|---|
| $T_1$ Control | 94.10 | 290.40 | - | 42.64 | 12.93 | 550.0 | 33.10 |
| $T_2$ 5 t FYM $ha^{-1}$ | 97.40 | 330.25 | 13.7 | 48.21 | 13.18 | 631.5 | 33.05 |
| $T_3$ 75% NPK | 99.50 | 355.80 | 22.5 | 52.71 | 13.50 | 711.5 | 33.00 |
| $T_4$ 75% NPK + 5 t FYM $ha^{-1}$ | 103.65 | 406.00 | 39.8 | 59.18 | 13.75 | 810.7 | 32.84 |
| $T_5$ 75% NPK + 10 kg Mn $ha^{-1}$ | 100.95 | 371.75 | 28.0 | 54.19 | 13.62 | 736.9 | 32.90 |
| $T_6$ 75% NPK + 20 kg S $ha^{-1}$ | 102.65 | 385.00 | 32.6 | 56.04 | 13.75 | 767.7 | 32.78 |
| $T_7$ 75% NPK + 5 t FYM + 10 kg Mn$ha^{-1}$ | 105.10 | 410.10 | 41.2 | 61.20 | 13.87 | 844.5 | 32.57 |
| $T_8$ 75% NPK + 5 t FYM + 20 kg S $ha^{-1}$ | 107.60 | 428.75 | 47.6 | 63.96 | 13.93 | 889.0 | 32.48 |
| $T_9$ 100% NPK | 107.25 | 400.37 | 37.8 | 59.75 | 14.06 | 836.5 | 32.39 |
| CD (P= 0.05) | 2.00 | 17.0 | | 2.56 | 0.56 | 43.5 | NS |

**Quality**

Protein and crude fiber content of a fodder crop are important parameters, which govern the quality of fodder crop. There was significantly higher per- centage of protein in plants under all the treatments as compared to control. The protein content in oat plants ranged from 12.93 to 14.06 per cent, the minimum being in control. Application of 75% NPK + 5t FYM + 20 kg S $ha^{-1}$ being at par with 100% NPK and 75% NPK + 5t FYM + 10 kg $M_n$ $ha^{-1}$ proved significantly superior to other treatments in respect of protein content. This may be due to accumulation of more nitrogen with these treatments and ultimately showing more protein content (Pandey and Kumar, 2017 and Pandey and Chauhan, 2016). Application of FYM alone (5t $ha^{-1}$) also improved the protein content in oat plants over control (Singh and Patra, 2017). Application of 75% NPK + 5t FYM $ha^{-1}$, 75% NPK + 20kg S $ha^{-1}$ and 75% NPK + 10 kg Mn $ha^{-1}$ also improved the protein content over control, Among these treatments, application of 75% NPK + 10 kg Mn $ha^{-1}$ proved inferior in improving the protein content. The protein yield in oat plants ranged from 550 kg $ha^{-1}$ at control to 889 kg $ha^{-1}$ with 75% NPK + 5t FYM + 20 kg S $ha^{-1}$. The minimum protein yield was noted under control, which may be attributed to lower protein content and dry matter yield of oat crop. Protein production significantly increased with increasing levels of NPK and higher value of protein yield was recorded with 100% NPK fertilizers. Addition of 75% NPK + 5t FYM $ha^{-1}$ enhanced the protein production over 75% NPK alone. Application of S and Mn coupled with 75% NPK and 5t FYM $ha^{-1}$ also improved the protein yield and maximum value of protein yield (889.0 kg $ha^{-1}$) was recorded with 75% NPK + 5t FYM + 20 kg S $ha^{-1}$ showing the beneficial effect of combined application of chemical fertilizers and FYM (Pandey and Singh, 2017). Crude fiber content in oat plants was not affected significantly by various treatments. However, the minimum and maximum values of crude fiber were recorded with 100% NPK and control, respectively. Addition of FYM, S and Mn with 75% NPK did not affect the crude fiber content significantly over control.

Table 2: Effect of integrated nutrient management on uptake of nutrients by oat crop (mean of two years)

| Treatments | Nitrogen (kg ha$^{-1}$) | P (kg ha$^{-1}$) | K (kg ha$^{-1}$) | Sulphur (kg ha$^{-1}$) | Iron (g ha$^{-1}$) | Mn (g ha$^{-1}$) | Copper (g ha$^{-1}$) | Zinc (g ha$^{-1}$) |
|---|---|---|---|---|---|---|---|---|
| $T_1$ Control | 88.2 | 8.1 | 81 | 7.24 | 341 | 134 | 17.0 | 117 |
| $T_2$ 5 t FYM ha$^{-1}$ | 101.7 | 10.1 | 93 | 9.1 | 397 | 162 | 21.2 | 147 |
| $T_3$ 75% NPK | 113.8 | 12.1 | 102 | 10.5 | 435 | 170 | 21.6 | 146 |
| $T_4$ 75% NPK + 5 t FYM ha$^{-1}$ | 130.1 | 14.7 | 117 | 13.0 | 495 | 201 | 27.2 | 182 |
| $T_5$ 75% NPK + 10 kg Mn ha$^{-1}$ | 118.1 | 12.4 | 105 | 11.3 | 441 | 214 | 21.6 | 149 |
| $T_6$ 75% NPK + 20 kg S ha$^{-1}$ | 123.2 | 14.0 | 110 | 13.4 | 465 | 188 | 23.5 | 156 |
| $T_7$ 75% NPK + 5 t FYM + 10 kg Mn ha$^{-1}$ | 135.8 | 14.6 | 120 | 13.4 | 511 | 257 | 25.7 | 189 |
| $T_8$ 75% NPK + 5 t FYM + 20 kg S ha$^{-1}$ | 142.6 | 16.6 | 127 | 15.9 | 537 | 223 | 30.7 | 199 |
| $T_9$ 100% NPK | 134.4 | 16.1 | 119 | 13.1 | 494 | 200 | 26.2 | 173 |
| CD (P= 0.05) | 8.67 | 0.79 | 6.17 | 0.62 | 33.5 | 15.2 | 2.9 | 14.1 |

**Uptake of nutrients**

Nitrogen uptake by oat plants increased significantly with different treatments over control (Table 2). The mean increase in N uptake was from 88.2 to 134.4 kg ha$^{-1}$ by oat crops with increase in the level of NPK from control to 100% NPK. The highest N uptake by oat crop was recorded with 75% NPK + 5t FYM + 20 kg S ha$^{-1}$. This increase in N uptake may be attributed to increased dry matter yield (Singh, 2017, Singh and Patra, 2017). Incorporation of 10 kg Mn ha$^{-1}$ along with 75% NPK + 5t FYM ha$^{-1}$ also improved the utilization of nitrogen by oat crop.The P uptake by oat crop ranged from 8.1 to 16.6 kg ha$^{-1}$. Application of NPK levels increased the P uptake by oat crop, which may be ascribed to increased dry matter production and improvement in P content in crop (Singh, 2017). Combined application of 75% NPK + 5t FYM + 20 kg S ha$^{-1}$ also improved the P uptake by the crop over control. Sulphur proved more beneficial than that of Mn in improving P uptake by oat crop. This may be due to more availability of P from soil with its application. The higher yield of dry matter under 75% NPK + 5t FYM + 20 kg S ha$^{-1}$ absorbed large quantities of K from the soil, thus depleting the soil more K consequently showing higher uptake in plants (Sharma *et al.* 2016, Pandey and Rana 2016). Application of 75% NPK + 5t FYM + 10kg Mn ha$^{-1}$ also improved the K uptake by the crop. All the treatments proved beneficial in increasing the uptake of S by oat over control (Table 2). The minimum (7.2 kg ha$^{-1}$) and maximum (15.9 kg ha$^{-1}$) values were recorded under control and 75% NPK + 5t FYM + 20 kg S ha$^{-1}$, respectively. The maximum uptake under 75% NPK + 5t FYM + 20 kg S ha$^{-1}$ may be due to increased availability of sulphur as a result of its addition. The uptake of micronutrient carious i e Fe, Mn, Cu and Zn by oat crop ranged from 341 to 537, 134 to 257, 17.0 to 30.7 and 117 to 199 g ha$^{-1}$, respectively. The highest uptake of Fe, Cu and Zn was recorded with 75% NPK + 5t FYM + 20 kg S ha$^{-1}$. On the other hand, maximum value of Mn uptake was recorded with 75% NPK + 5t FYM + 10 kg Mn ha$^{-1}$, which may be attributed to, increased availability of Mn as a result of its addition (Singh and Patra 2017). The minimum values of uptake of these micronutrients were recorded under control due to low dry matter yield of oat.

Table 3: Effect of integrated nutrient management on soil properties after harvest of oat crop (mean of two years)

| Treatments | pH | EC (dSm$^{-1}$) | Organic Carbon (g kg$^{-1}$) |
|---|---|---|---|
| $T_1$ Control | 8.10 | 0.20 | 3.5 |
| $T_2$ 5 t FYM ha$^{-1}$ | 7.95 | 0.19 | 3.9 |
| $T_3$ 75% NPK | 8.00 | 0.21 | 3.7 |
| $T_4$ 75% NPK + 5 t FYM ha$^{-1}$ | 7.95 | 0.20 | 4.3 |
| $T_5$ 75% NPK + 10 kg Mn ha$^{-1}$ | 8.05 | 0.20 | 3.7 |
| $T_6$ 75% NPK + 20 kg S ha$^{-1}$ | 7.90 | 0.21 | 3.8 |
| $T_7$ 75% NPK + 5 t FYM ha$^{-1}$ + 10 kg Mn ha$^{-1}$ | 7.90 | 0.20 | 3.7 |
| $T_8$ 75% NPK + 5 t FYM ha$^{-1}$ + 20 kg S ha$^{-1}$ | 7.85 | 0.20 | 4.4 |
| T9 100% NPK | 8.05 | 0.22 | 3.9 |
| CD (P= 0.05) | 0.020 | 0.01 | 0.20 |

**Soil fertility**

There was a marked difference in soil pH due to various nutrient management practices.The minimum value of soil-pH (7.85) was recorded under 75% NPK + 5t FYM + 20kg S $ha^{-1}$ treatment. There was also no marked difference in soluble salt content (EC) in the soil due to various treatments. It can be inferred that soil chemical properties are not deteriorated by nutrient management practices (Table 3). Use of different nutrient management practices caused a marked change in the organic carbon (SOC) content. The maximum amount of soil organic carbon in post harvest soil was noted with 75% NPK + 5t FYM + 20kg S $ha^{-1}$.This increase in organic carbon content may be attributed to addition of FYM. The available N status exhibited marked difference due to various nutrient management practices. The highest available nitrogen contents were obtained under 75% NPK + 5t FYM + 20kg S $ha^{-1}$ followed by 75% NPK + 2t FYM + 10kg Mn $ha^{-1}$. The lowest available N content was recorded in control. Available phosphorus status recorded significant variation due to treatment variations (Table 4). Highest available P content of 16.6 kg $ha^{-1}$ was recorded in 75% NPK + 5t FYM + 20kg S $ha^{-1}$ treatment. This treatment was followed by 100% NPK. The lowest available P content (8.1 kg $ha^{-1}$) was observed under control. Application of 75% NPK + 5t FYM + 20kg S $ha^{-1}$ showed significantly higher available potassium status. The lowest available potassium was recorded in control treatment. Available S content was affected significantly by variations in the treatments. Lowest and highest contents of DTPA-Zn in post harvest soil were recorded under control and 75% NPK + 5t FYM + 20 kg S $ha^{-1}$, respectively. This increase in available Zn in post harvest soil may be attributed to applied FYM to the soil. Available Fe content in post harvest soil was affected significantly by various nutrient management practices. The status of available Fe was higher under 75% NPK + 5t FYM + 20kg S $ha^{-1}$. The status of Mn and Cu in post harvest varied markedly with various nutrient management practices. The soil samples collected after harvest of oat contained relatively higher amounts of sulphur and Mn as both these elements were applied in oat crop.

Table 4: Effect of integrated nutrient management on status of available N, P, K, S (kg $ha^{-1}$) and Fe, Mn, Cu and Zn (mg $kg^{-1}$) in post harvest soil (mean of two years)

| Treatments | Nitrogen | P | K | Sulphur | Iron | Mn | Copper | Zinc |
|---|---|---|---|---|---|---|---|---|
| $T_1$ Control | 149.0 | 8.8 | 118.5 | 16.4 | 4.2 | 1.9 | 0.19 | 0.51 |
| $T_2$ 5 t FYM $ha^{-1}$ | 158.5 | 10.2 | 122.0 | 16.8 | 4.6 | 2.2 | 0.20 | 0.54 |
| $T_3$ 75% NPK | 166.0 | 12.5 | 126.6 | 16.6 | 4.3 | 2.0 | 0.20 | 0.52 |
| $T_4$ 75% NPK + 5 t FYM $ha^{-1}$ | 177.5 | 15.0 | 130.0 | 18.0 | 4.7 | 2.2 | 0.21 | 0.55 |
| $T_5$ 75% NPK + 10 kg Mn $ha^{-1}$ | 170.0 | 10.6 | 125.0 | 16.7 | 4.3 | 2.6 | 0.20 | 0.52 |
| $T_6$ 75% NPK + 20 kg S $ha^{-1}$ | 172.5 | 11.0 | 126.2 | 22.0 | 4.4 | 2.3 | 0.20 | 0.51 |
| $T_7$ 75% NPK + 5 t FYM + 10 kg Mn $ha^{-1}$ | 179.6 | 15.5 | 128.5 | 17.0 | 4.4 | 2.7 | 0.23 | 0.55 |
| $T_8$ 75% NPK + 5 t FYM + 20 kg S $ha^{-1}$ | 181.5 | 16.0 | 131.6 | 22.4 | 4.5 | 2.3 | 0.22 | 0.54 |
| $T_9$ 100% NPK | 184.5 | 16.7 | 134.5 | 16.8 | 4.5 | 2.2 | 0.20 | 0.54 |
| CD (P= 0.05) | 3.79 | 0.50 | 3.88 | 0.97 | 0.17 | 0.11 | 0.008 | 0.014 |

It may be concluded from the present investigation that 75% NPK + 5t FYM + 20kg S $ha^{-1}$ might be beneficial under semi-arid condition of Agra region of Uttar Pradesh for achieving higher productivity of oat besides improving quality of produce and maintaining soil fertility.

**REFERENCES**

Chesnin, L. and Yien, C.H. (1951) Turbidimetric determination of available sulphates. Proceeding of Soil Science Society of America **15**: 149-151.

Hossain, A., Kumar, D., Rana, D.S., Gangaiah, B., Dwivedi, B.S. and Sahoo, R.N. (2013) Productivity and profitability of Bt cotton (*Gossypium hirsutum*)-wheat (*Triticum aestivum*) cropping system as affected by nutrient omissions. *Indian Journal of Agronomy* **58**(2): 175-181.

Jackson M.L. (1973) *Soil chemical Analysis*.Pentice Hall of India Pvt. Ltd., New Delhi.

Lindsay, W.L. and Norvell, W.A. (1978) Development of a DTPA test for Zn, Fe, Mn and Cu. Soil Science Society America Journal **42**: 421-28.

Olsen, S.R, Cole, G.v., Watanable, F.S. and Dean, L.A. (1954) Estimation of available phosphorus in soils extraction with sodium bicarbonate. *Cire.* U.S. *Dept. Agric.* 939.

Pandey, M. and Chauhan, M. (2016) Effect of sulphur and zinc on yield, quality and uptake of nutrients in barley. *Annals of Plant and Soil Research* **18**(1): 74-78.

Pandey, M. and Kumar, M. (2017) Effect of solphur, manganese and zinc on yield, quality and uptake of nutrients by wheat (*Triticum aestivum*), *Annals of Plant and Soil Research* **19**(4): 403-407.

Pandey, M. and Rana, N. (2016) Response of wheat to sulphur and zinc nutrition in alluvial soil. *Annals of Plant and Soil Research* **18**(4):: 418-422.

Pandey, M. and Singh, O.P. (2017) Effect of balanced use of nutrients on yield, quality and uptake of nutrients by wheat (*Triticum aestivum*) *Annals of Plant and Soil Research* **19**(4):426-429.

Sharma, V.K. and Singhal, S.K. (2016) Maximizing rice (*Oryza sativa*) and wheat (*Triticum aestivum*) productivity and profitability using improved nutrient management practices. *Indian Journal of Agriculteral Sciences* **86**(9): 1179-82.

Singh, S.P. (2017) Productivity, quality and uptake of nutrient in wheat (*Triticum aestivum*) as influenced by integrated nutrient management. *Annals of Plant and Soil Research.***19**(1): 12-16.

Singh, V. (2017) Effect of balanced use of nutrients on productivity and economics of wheat (*Triticum aestivum*). *Annals of Plant and soil Research* **19**(1): 105-109.

Singh, V. and Patra, A. (2017) Effect of FYM and Manganese on yield and uptake of nutrients in wheat (*Triticum aestivum*). *Annals of Plant and Soil Research* **19**(4): 381-384.

Subbiah, B.V. and Asija, G.J. (1956) A rapid method for the estimation of available nitrogen in soils. *Current Science* **25**: 259-260.