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# Effect of integrated use of nutrients and FYM on yield, quality and uptake of nutrients by barley (*Hordeum valgare*)

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## ABSTRACT

*A field experiment was conducted during rabi season of 2015-16 and 2016-17 at R.B.S. College Research farm, Bichpuri, Agra (U.P.) to study the effect of integrated use of fertilizers and FYM on yield, quality and uptake of nutrients in barley (Hordeum vulgare). The experiment was laid out in randomized block design with eight treatments and three replications. The results revealed that the plant height, number of tillers and dry matter production yield attributes of barley crop increased significantly up to 100% NPK over control. The grain (55.26 q ha$^{-1}$) and straw yield (88.42 q ha$^{-1}$) at 100% NPK were 53.0 and 44.0% higher than that obtained in the control. The maximum values of growth, yield attribute and grain (59.15 q ha$^{-1}$) and straw (98.15 q ha$^{-1}$) yields were recorded with 100% NPK + 5t FYM ha$^{-1}$ closely followed by 100% NPK + 20 kg S + 5 kg Zn ha$^{-1}$. The maximum content of protein (3.5%) and protein yield (709.6 kg ha$^{-1}$) were recorded with 100% NPK + S + Zn and 100% NPK + FYM, respectively. The uptake of N, P, K, S, and Zn by the crop was highest with 100% NPK + 5t FYM ha$^{-1}$ and lowest in control. The amounts of available N, P, K and organic carbon in post harvest soil were maximum with the application of 100% NPK + FYM. The status of available sulphur and zinc was highest with 100% NPK + 20 kg S + 5kg Zn ha$^{-1}$.The minimum amounts of organic carbon and available nutrients in post harvest soil were recorded under control.*

**Keywords:** Fertilizers, FYM, yield, quality, soil fertility, barley

## INTRODUCTION

Barley (*Hordeum vulgare*) is the world's fourth most important cereal crop after wheat, rice and maize. It is grown throughout the temperate and tropical region of the world. It is usually used as food for human beings and feed for animals and poultry. It is also a valuable input for industries for extracting malt. Because of its lower cost of cultivation and low input demand, it is preferred by the resource poor farmers in the area. Barley grain contains 12.5% moisture, 11.5% albuminoids, 74.0% carbohydrates, 1.3% Fat, 3.9% Crude fiber and 1.5% minerals. Intensive agriculture involving exhaustive high yielding varieties of barley has led to heavy withdrawal of nutrients from the soil so; it is time to look for measure to stimulate sustainability in production of cereals on a long-term basis. Among the factors responsible for poor productivity, inadequate fertilizer use and emergence of multiple-nutrient deficiency due to unbalanced use of fertilizers are important. Besides N, P and K, Zn is the important micronutrient for cereals as it plays major role in synthesis of tryptophan, which is precursor of indole acetic acid**.** Zinc is essential for promoting certain metabolic reactions. It is necessary for the production of chlorophyll and carbohydrates. Sulphur is one of the nutrients essential in plant growth. It is involved in the metabolic and enzymic processes of all living cells. It is required for the synthesis of sulphur containing amino acids, cystine, cysteine and methionine. Sulphur is involved in the formation of chlorophyll and activation of enzymes. It is component of co-enzyme A, which is responsible for acylation of acetate and other fatty acids thiaminopyro-phosphate (TPP), vitamins such as biotin, thiamin and lipoic acid etc. The application of FYM in the soil helps in increasing the fertility of the soil as well as the physical condition including its water holding capacity. Organic manures, which were perhaps the major sources of plant nutrient in traditional agriculture, received less emphasis with the advent of high analysis chemical fertilizers. Keeping the above facts in view, the present investigation was carried out using barley as test crop.

## MATERIALS AND METHODS

A field experiment was conducted during rabi season of 2015-16 and 2016-17 at R.B.S, College Research farm, Bichpuri, Agra (U.P.). The experimental soil was sandy loam in texture having pH 7.9, organic carbon 3.5 g $ktg^{-1}$, available N,P,K,S and DTPA Zn 165, 10, 125, 16 kg $ha^{-1}$ and 0.56 mg $kg^{-1}$, respectively. The experiment was laid out in randomized block design with three replicatios. The experiment included eight treatments, viz.,$T_1$ Control, $T_2$ 100 kg N $ha^{-1}$, $T_3$ 100 kg N + 60 kg $P_2O_5$ $ha^{-1}$, $T_4$ 100 kg N + 60 kg $P_2O_5$ + 40 kg $K_2O$ $ha^{-1}$, $T_5$ 100 kg N + 60 kg $P_2O_5$ + 40 kg $K_2O$ + 20 kg S $ha^{-1}$, $T_6$ 100 kg N + 60 kg $P_2O_5$ + 40 kg $K_2O$ + 5 kg Zn $ha^{-1}$, $T_7$ 100 kg N + 60 kg $P_2O_5$ + 40 kg $K_2O$ + 20 kg S + 5 kg Zn $ha^{-1}$,$T_8$ 100 kg N + 60 kg $P_2O_5$ + 40 kg $K_2O$ + 5 t FYM $ha^{-1}$. Nitrogen was supplied in the form of urea as per treatments. Diammonium phosphate and muriate of potash were used as sources for $P_2O_5$ and $K_2O$, respectively. Full quantities of P and K fertilizers were given at the time of sowing. Nitrogen was applied as basel and at first irrigation. Zinc and sulphur were applied as zinc chloride and elemental sulphur, respectively at the time of sowing. Well-decomposed FYM (0.65% N, 0.25% P and 0.55% K) was added to the plots as per treatment one week before sowing. The seeds of barley BH-946 were sown in lines at 20 cm apart, using an uniform seed rate of 100 kg ha-1 in the month of November 2016. The lines were opened through pointed spade by human labour and after sowing planking were done to cover the seed. The crop was irrigated as and when required. At harvest, growth characters (Plant height, tillers/ plant and dry matter accumulation/plant) were recorded. Ear length, grains/ear and test weight were recorded at harvest. The grain and straw yields were recorded at maturity. The grain and straw samples were analysed for their N, P, K, S and Zn by adopting standard methods (Jacskon, 1973). The soil samples collected after harvest of the crop were analysed for organic carbon and available nutrients (Page *et al.*, 1982).

## RESULTS AND DISSCUSSION

Addition of inorganic fertilizers (100 kg N + 60 $P_2O_5$ + 40 kg $K_2O$ $ha^{-1}$ showed a positive and significant effect on plant height and number of tillers. This may be due to poor fertility with regard to N, P and K status of the soil. Application of 100 kg N + 60 kg $P_2O_5$ + 40 kg $K_2O$ + 20 kg S $ha^{-1}$($T_5$) recorded relatively taller plants and higher number of tillers than those of 100% NPK. This increase in plant height may be attributed to greater availability of nutrients (S and Zn) in soil (Pandey and Rana 2016). The tallest plants (83.5 cm) and maximum number of tillers of barley were recorded with 100 kg N + 60 kg $P_2O_5$ + 40 kg $K_2O$ + 5t FYM $ha^{-1}$. This increase in these attributes may be attributed to increased availability of nutrients due to mineralization of FYM or through solubilization of the nutrients from the native source during the process of decomposition.(Singh 2017). Application of inorganic fertilizers alone and in combination with FYM increased the dry matter accumulation significantly over control (Pandey and Singh 2017). The dry matter accumulation was further enhanced when NPK fertilizer was applied in combination with 20 kg S and 5 kg Zn $ha^{-1}$. (Pandey and Rana 2016). The highest dry matter accumulation, of course, was obtained with 100 kg N + 60 kg $P_2O_5$ + 40 kg $K_2O$ + 5 t FYM $ha^{-1}$. This increase in dry matter accumulation is probably due to enhanced root growth leading to more height and development of plants (Singh 2017).

Table 1: Effect of various treatments on growth and yield attribute barley crop

| Treatments | Plant Height (cm) | Number of tillers | Dry matter / plant (g) | Ear length (cm) | Grains/ ear | Test weight |
|---|---|---|---|---|---|---|
| $T_1$ CONTROL | 56.8 | 3.2 | 11.2 | 6.80 | 23.2 | 36.3 |
| $T_2$ N 100 | 68.0 | 5.2 | 14.0 | 8.05 | 26.5 | 39.5 |
| $T_3$ N100 +P60 | 71.6 | 5.7 | 15.1 | 8.52 | 27.0 | 40.2 |
| $T_4$ N100 +P60+k40 | 76.0 | 6.0 | 15.8 | 8.81 | 27.5 | 40.8 |
| $T_5$ N100 +P60+k40+S20 | 78.5 | 6.5 | 16.9 | 9.05 | 28.1 | 41.2 |
| $T_6$ N100 +P60+k40+Zn5 | 77.8 | 6.3 | 16.0 | 8.92 | 28.0 | 41.0 |
| $T_7$ N100 +P60+k40+S20 + Zn 5 | 80.5 | 6.6 | 17.6 | 9.25 | 28.6 | 41.5 |
| $T_8$ N100 +P60+k40+FYM 5 | 83.5 | 6.7 | 18.5 | 9.30 | 29.0 | 41.8 |
| SEm± | 1.34 | 0.14 | 0.65 | 0.16 | 0.37 | 0.32 |
| CD (P=0.05) | 2.72 | 0.29 | 1.31 | 0.33 | 0.75 | 0.65 |

### Yield attributes and yield

Yield attributes increased with inorganic fertilizers which might be due to more requirements of major elements (Singh 2017). The combined application of NPK + S and NPK + Zn resulted in an additive effect on these characters probably due to beneficial effect (Pandey and Kumar 2017). The maximum impact on yield attributing characters was recorded under 100 kg N + 60 kg $P_2O_5$ + 40 kg $K_2O$ + 5 t FYM $ha^{-1}$. As a result almost all yield attributes were significantly influenced by FYM and combined with N, P and K. (Singh and Patra 2017). The minimum yields of grain and straw of barley were recorded in control plots (no fertilizer), which may be attributed to low fertility status of the soil. The increases in grain and straw yield with 100 kg N $ha^{-1}$ + 60 kg $P_2O_5$ $ha^{-1}$ + 40 kg $K_2O$ $ha^{-1}$ over control were 53.0 and 44.0, per cent, respectively. Application of S (20 kg $ha^{-1}$) along with NPK fertilizer further improved the crop production which may be attributed to a sustained availability of sulphur (Singh 2017). Similarly, yields of barley also increased with NPK + 5 kg Zn $ha^{-1}$ over control, which may be attributed to deficiency of DTPA-Zn in soil. The maximum grain and straw yields were recorded with 100 kg N + 60 kg $P_2O_5$ + 40 kg $K_2O$ + 5t FYM $ha^{-1}$. The increases in grain and straw yields with this treatment over control respectively were 63.7 and 59.8 percent. Pandey and Rana (2016) also reported similar results.

Table 2: Effect of various treatments on yield quality of barley crop

| Treatments | Grain yield (q $ha^{-1}$) | Straw yield (q $ha^{-1}$) | Protein (%) | | Protein yield (Kg $ha^{-1}$) | Starch (%) |
|---|---|---|---|---|---|---|
| | | | Grain | Straw | | |
| $T_1$ | 36.12 | 61.40 | 11.2 | 2.9 | 404.5 | 52.2 |
| $T_2$ | 47.04 | 78.55 | 11.6 | 3.1 | 545.6 | 51.6 |
| $T_3$ | 51.39 | 85.30 | 11.7 | 3.2 | 601.2 | 52.3 |
| $T_4$ | 55.26 | 88.42 | 11.9 | 3.3 | 657.6 | 52.4 |
| $T_5$ | 57.21 | 94.39 | 12.0 | 3.4 | 686.0 | 52.6 |
| $T_6$ | 56.85 | 90.96 | 11.9 | 3.4 | 676.5 | 52.5 |
| $T_7$ | 58.18 | 97.16 | 12.1 | 3.5 | 704.0 | 52.7 |
| $T_8$ | 59.13 | 98.15 | 12.0 | 3.4 | 709.6 | 53.0 |
| SEm± | 0.61 | 1.71 | 0.10 | 0.04 | 9.80 | 0.08 |
| CD (P=0.05) | 1.32 | 3.71 | 0.21 | 0.09 | 19.86 | NS |

### Qualitative studies

### Starch content

The starch content in barley grain ranged from 51.6% at 100 kg N $ha^{-1}$ to 53.0 % with $N_{100}$ + $P_{60}$ + $K_{40}$ + $FYM_5$ treatment. However, slightly higher starch content in barley grain was recorded with NPK + S and NPK + Zn. The maximum value of starch content in barley grain was recorded with $N_{100}$ $P_{60}$ $K_{40}$ $FYM_5$ treatment. There was significantly higher percentage of protein in grain and straw under all the treatments as compared to control. From quality point of view, application of 100 kg N + 60 kg $P_2O_5$ + 40 kg $K_2O$ + 5 t FYM $ha^{-1}$ appear to be the best. Application of NPK + S + Zn proved superior in respect of protein content. In general; the minimum protein yield of barley grain was recorded under control which may be attributed to lower yield of barley grain. The protein yield of barley was improved with chemical fertilizers over control. The addition of FYM (5 t $ha^{-1}$) along with 100 kg N + 60 kg $P_2O_5$ + 40 kg $K_2O$ enhanced the protein yield of barley significantly over chemical fertilizers. This improvement may be attributed to increased crop production and enhanced protein content with FYM and inorganic fertilizers application. There was a significant increase in protein yield with NPK + 20 kg S $ha^{-1}$ and Zn + NPK (Pandey and Chauhan 2016). The maximum protein yields of wheat crop were recorded under 100 kg N + 60 kg $P_2O_5$ + 40 kg $K_2O$ + 5t FYM $ha^{-1}$ showing the beneficial effect on grain and straw production (Singh and Patra 2017).

### Uptake studies

Nitrogen uptake by grain and straw ranged from 65.0 to 114.1 kg $ha^{-1}$ and 28.2 to 53.9 kg $ha^{-1}$ respectively. Application of chemical fertilizers improved the nitrogen uptake by barley crop over control. The uptake of

Table 3: Effect of various treatments on uptake of N, P, K, S kg ha$^{-1)}$ Zn (g ha$^{-1}$) by barley crop

| Treatments | Nitrogen | | Phosphorus | | Potassium | | Sulphur | | Zinc | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Grain | Straw | Grain | Straw | Grain | Straw | Grain | Straw | Grain | Straw |
| $T_1$ | 65.0 | 28.4 | 6.8 | 5.5 | 15.8 | 111.7 | 7.2 | 6.1 | 84.8 | 101.3 |
| $T_2$ | 87.4 | 39.2 | 9.4 | 7.8 | 21.6 | 143.7 | 9.8 | 8.6 | 112.8 | 135.1 |
| $T_3$ | 96.6 | 44.3 | 11.8 | 10.2 | 23.1 | 161.2 | 10.2 | 8.5 | 117.6 | 145.0 |
| $T_4$ | 104.9 | 46.8 | 11.0 | 9.7 | 27.0 | 166.2 | 11.6 | 9.6 | 135.3 | 153.8 |
| $T_5$ | 109.8 | 51.9 | 12.5 | 11.3 | 26.8 | 175.9 | 14.3 | 13.2 | 135.0 | 171.7 |
| $T_6$ | 108.6 | 49.1 | 10.2 | 10.0 | 26.1 | 163.7 | 13.0 | 11.8 | 176.2 | 180.3 |
| $T_7$ | 112.8 | 54.4 | 12.2 | 12.6 | 27.9 | 182.6 | 15.1 | 14.5 | 171.6 | 189.4 |
| $T_8$ | 114.1 | 53.9 | 13.0 | 12.7 | 28.9 | 186.4 | 14.7 | 13.7 | 163.1 | 176.6 |
| SEm± | 2.30 | 1.65 | 0.95 | 0.71 | 1.65 | 4.14 | 0.33 | 0.26 | 1.89 | 2.12 |
| CD (P=0.05) | 4.66 | 3.34 | 1.92 | 1.44 | 3.34 | 8.39 | 0.67 | 0.53 | 3.83 | 4.29 |

nitrogen also increased when 20 kg S and 5 kg Zn ha$^{-1}$ were applied together with 100% NPK. The magnitude of increase in nitrogen uptake was lower with Zn than S. Higher values of N uptake with FYM addition are apparently the result of favourable effect of FYM on N absorption coupled with greater yields. The maximum values of N uptake by the crop were recorded with 100 kg N + 60 kg $P_2O_5$ + 40 kg $K_2O$ + 5t FYM ha$^{-1}$ which may be ascribed to higher grain and straw production of barley. The P uptake by grain and straw ranged from 6.8 to 13.0 kg ha$^{-1}$ and from 5.5 to 12.7 kg ha$^{-1}$. Combined application of NPK + S and NPK + Zn also improved the P uptake by grain and straw over control. Similar results were also reported by Pandey and Rana(2016). The maximum values of P uptake by barley grain and straw were recorded with N + P + K + FYM application, which may be attributed to increased yield and P content in barley crop (Pandey, 2018).The values of K uptake by grain increased from 15.8 kg ha$^{-1}$ at control to 28.9 kg ha$^{-1}$ with N + P + K + FYM treatment. The corresponding increase in K uptake by straw was from 111.7 kg ha$^{-1}$ to 186.4 kg ha$^{-1}$. The higher yields of grain and straw under NPK coupled with 20 kg S ha$^{-1}$ and 5 kg Zn ha$^{-1}$ absorbed large quantities of K from the soil thus depleting the soil more K consequently showing its higher uptake in plants (Pandey and Rana 2016). The maximum values of K uptake by barley crop were recorded under N + P + K + FYM treatment, which may be ascribed to higher availability of K to the plants. Moreover, higher amount of K was received in straw than grain; it was merely because of higher content of K in straw of the crop

Application of N, P and K improved the utilization of sulphur by barley crop over control. Application of 20kg S ha$^{-1}$ along with NPK enhanced S uptake significantly by the crop over NPK alone. This increase in S uptake may be attributed to increased availability of S in soil due to its addition. Application of NPK + 5 kg Zn ha$^{-1}$ also improved the uptake of S by barley crop over control (Pandey and Chauhan 2016). The higher yields of grain and straw under NPK coupled with 5 FYM ha$^{-1}$ absorbed large quantities of S from the soil (Pandey, 2018). The zinc uptake in grain increased from 84.8 g ha$^{-1}$ at control to 176.2 g ha$^{-1}$ with N + P + K + Zn. The corresponding increase in Zn uptake in straw was from 101.3 to 189.4 g ha$^{-1}$. Application of NPK + 5t FYM ha$^{-1}$ further enhanced the Zn uptake by the crop over NPK alone. This increase in Zn uptake may be ascribed to increased grain and straw yield and Zn content. Zinc uptake by the crop also increased significantly with NPK + S and NPK + Zn treatments over control. This increase may be attributed to increased grain and straw production and improvement in Zn content with application of zinc (Pandey and Rana 2016).

**Soil fertility**

The results (Table 4) showed that the pH in post harvest soil varied from 7.6 to 8.1. Soil treated with NPK + FYM recorded comparatively lower value (pH 7.6). On the other hand, relatively, higher value (8.1) was noted in soil treated with 100 kg N + 60 kg $P_2O_5$ + 40 kg $K_2O$ ha$^{-1}$, EC of soil ranged between 0.40 and 0.48 dSm$^{-1}$. The lower value (0.40 dSm$^{-1}$) of EC was recorded in NPK + FYM treatment. On the other hand, higher value of EC (0.48 dSm$^{-1}$) was recorded under 100 kg N + 60 kg $P_2O_5$ + 40 kg $K_2O$. The lowest value of organic carbon in soil



after harvest of the barley crop was recorded in control. The combined application of NPK improved the status of organic carbon in soil. The organic carbon was further improved with NPK addition with 5 t FYM ha$^{-1}$, which may be ascribed to the supply of organic carbon through organic matter addition to the soil. Organic matter addition along with NPK fertilizer significantly enhanced the available nitrogen status in soil over NPK alone. This increase may be attributed to supply of available nitrogen to the soil with FYM addition. Application of NPK + S and NPK + Zn also improved the status of available nitrogen in post harvest soil (Pandey and Rana 2016). The lowest amount of available phosphorus was recorded in control. Application of NPK + FYM significantly improved the status of available P in soil, which may be ascribed to the solubilization effect of organic acids liberated during the decomposition of organic matter. The combined application of S and NPK improved the available P in soil. Available P in soil was not affected significantly with NPK + Zn.

Table 4: Effect of various treatments on physico chemical properties and avaiabale nutrients in post harvest soil

| Treatments | PH | EC ($dSm^{-1}$) | O. carbon ($g\ kg^{-1}$) | Nitrogen ($kg\ ha^{-1}$) | phosphorus ($kg\ ha^{-1}$) | potassium ($kg\ ha^{-1}$) | sulphur ($mg\ kg^{-1}$) | zink ($mg\ kg^{-1}$) |
|---|---|---|---|---|---|---|---|---|
| $T_1$ | 8.0 | 0.74 | 3.1 | 135 | 8.5 | 102.0 | 8.2 | 0.50 |
| $T_2$ | 7.9 | 0.48 | 3.3 | 160 | 9.0 | 104.0 | 8.4 | 0.51 |
| $T_3$ | 8.0 | 0.47 | 3.3 | 166 | 11.5 | 105.0 | 8.8 | 0.50 |
| $T_4$ | 8.1 | 0.48 | 3.5 | 167 | 11.3 | 130.5 | 8.3 | 0.51 |
| $T_5$ | 7.9 | 0.46 | 3.4 | 169 | 10.0 | 107.0 | 12.8 | 0.52 |
| $T_6$ | 7.9 | 0.46 | 3.4 | 169 | 9.5 | 106.0 | 8.3 | 0.62 |
| $T_7$ | 7.8 | 0.45 | 3.6 | 171 | 10.2 | 107.5 | 12.5 | 0.62 |
| $T_8$ | 7.6 | 0.40 | 4.0 | 180 | 11.8 | 132.0 | 8.5 | 0.58 |
| SEm± | 0.06 | 0.05 | 0.07 | 2.55 | 0.18 | 2.46 | 0.11 | 0.010 |
| CD (P=0.05) | 0.13 | 0.11 | 0.15 | 5.17 | 0.37 | 4.99 | 0.23 | 0.021 |

Available K in soil ranged from 102.0 kg $ha^{-1}$ at control to 132.0 kg $ha^{-1}$ with $T_8$ treatment. Application of NPK + S and NPK + Zn slightly improved the status of available K in post harvest soil over control. Application of NPK + FYM increased organic colloids, which probably caused greater adsorption of K from the soil solution, besides this, native K becomes more available due to organic acids liberated during decomposition of organic matter. The maximum value of available K (132.0 kg $ha^{-1}$) was recorded under $T_8$ treatment. Available S status in post harvest ranged from 8.2 to 12.5 mg $kg^{-1}$. Application of NPK + FYM significantly improved the status of available S in soil, which may be ascribed to the solublization effect of organic acids liberated during the decomposition of organic matter. These results are in close conformity with the findings of Pandey (2018). The combined application of S and NPK further improved the status of available S in soil. Pandey and Chauhan (2016) reported similar results. Application of NPK + Zn had no beneficial effect of status of available S in soil (Pandey and Rana 2016). Available Zn status in soil ranged from 0.50 to 0.62 mg $kg^{-1}$ and lowest amount of available Zn was noted in control. The status of Zn in post harvest soil improved with inorganic fertilizers and FYM. It may be attributed to increased availability of Zn in soil with FYM addition. (Pandey 2018) reported similar results. The maximum value of available Zn in soil was recorded under N + P + K + Zn treatment. Aplication of NPK + S did not influence the status of available Zn in post harvest soil over NPK alone (Pandey and Chauhan 2016).



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