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# EFFECT OF PHOSPHORUS LEVELS, PHOSPHATE SOLUBILIZING BACTERIA (PSB) AND FARM YARD MANURE (FYM) ON PHYSICO - CHEMICAL PROPERTIES OF SOIL AND PERFORMANCE OF WHEAT CROP (*Triticum aestivum* L.)

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***Abstract:*** *A Field experiment was conducted during rabi season of 2010-11 at agricultural farm of U.P. Autonomous College, Varanasi at the research plots of the department of Agricultural Chemistry and soil Science to investigate the role of phosphorus levels, phosphate solubilizing bacteria (PSB) and farm yard manure (FYM) on soil properties and productivity under wheat crop.The treatments consisted of six levels of phosphorus with and without PSB and FYM such as control ($T_1$), 20 kg p $ha^{-1}$ +PSB($T_2$), 40 kg p $ha^{-1}$+PSB($T_3$), 40 kg p $ha^{-1}$+PSB + 5 t FYM $ha^{-1}$ ($T_4$), 60 kg p $ha^{-1}$ ($T_5$), and 80 kg p $ha^{-1}$($T_6$).The experiment was laid out in randomized block design(RBD).Application of phosphorus levels significantly augmented available nutrients content in soil,crop growth and yield and nutrients uptake by wheat crop .Application of 40 kg p $ha^{-1}$+PSB + 5 t FYM $ha^{-1}$ significantly enhanced the organic carbon and available N,P,K and S contents in the soil.This treatment also gave highest plant height,number of tiller,dry matter,grain and straw yield.The highest nutrients content (N,P,K and S) was recorded in treatment receiving 40 kg p $ha^{-1}$+PSB + 5 t FYM $ha^{-1}$.The effect of different treatments on nutrients availability and productivity of wheat crop was found in the order of $T_4>T_6>T_5>T_3>T_2>T_1$. Therefore,for the higher fertility status and productivity of wheat 20 kg p $ha^{-1}$of recommended dose of P fertilizer could be replaced with PSB and FYM in alluvial soil of eastern UP.*

***Key words****: Phosphorus, phosphate solubilizing bacteria, farm yard manure, wheat, productivity, soil properties.*

**Introduction:** Phosphorus is an essential element classified as primary nutrient and also knows as “life of plant”. Plant requires adequate P from the very early stages of growth for optimum crop production. Phosphorus is one of the three nutrient generally added to soil in form of fertilizer. One of the main roles of the phosphorus in plant is in transfer of energy through ATP and also involved in root development and in metabolic activities especially in synthesis of protein. The phosphorus concentration in soil usually ranges from 100 to 2000 mg P $kg^{-1}$ soil representing approximately 350 to 7000 kg P $ha^{-1}$ in the surface 25 cm of the soil, although only a small portion of this P is immediately available for crop uptake [1]. Phosphorus in soil solution is found in lower range from 0.001 mg/L to 1 mg/L [2].The soil low in organic matter may contain only 3% of their total phosphorus in organic form ,but highly organic soil may contain 50% or more of their total phosphorus in organic form [3]. Phosphorus is one of major growth limiting plant nutrient in soil play a key role in balanced nutrition of plants. Major part of water soluble phosphorus of added P soon become unavailable due to its chemical fixation in soil. Hence solubilizing of fixed soil P through the use of mobilizing/ solubilizing microorganism is available option to advancement the availability of P in easily available form for the crop.

Some certain soil microorganism like PSB have inherent capacity to dissolve part of fixed phosphorus and make it available to crop by secreting certain organic acid e.g., carboxylic acid [4]. Phosphate solubilizing bacteria assimilate soluble P and prevent it from adsorption or fixation [5]. PSB play a key role in soil phosphorus dynamics and subsequent availability of phosphate to plant [6]. Solubilization of fixed soil P through the use of PSB coupled with FYM is available option to augment the easily assimilable by the crop [7]. However information on the combined use of phosphorus solubilizing microorganism and FYM along with phosphorus levels in wheat and it's effect on soil fertility under rice wheat cropping system is lacking, the present experiment was therefore, undertaken for assessment of usefulness of PSB+FYM and phosphatic fertilizers in wheat crop.

## Materials and Methods

A field experiment was conducted in *Rabi* season (2010-2011) at agricultural farm of U.P. Autonomous College, Varanasi. The soil of experimental site was sandy clay loam in texture, slightly alkaline in reaction. The initial physico-chemical properties of experimental soil were bulk density 1.41 g $cm^{-3}$, particle density 2.65 g $cm^{-3}$, pH (1:2.5) 7.75, EC 0.71 dS $m^{-1}$, organic carbon 0.43 %, water holding capacity 41.5 %, available nitrogen 190 kg $ha^{-1}$, available phosphorus 9.0 kg $ha^{-1}$, available potassium 169 kg $ha^{-1}$ and available sulphur 7.85 kg $ha^{-1}$. The various treatments applied to rice crop were control ($T_1$), *20 kg P* $ha^{-1}$ *+PSB* ($T_2$), *40 kg P* $ha^{-1}$ *+PSB* ($T_3$), *40 kg P* $ha^{-1}$*+PSB+FYM t* $ha^{-1}$ ($T_4$), *60 kg P* $ha^{-1}$ ( $T_5$) and *80 kg P* $ha^{-1}$($T_6$).The treatments were triplicated in randomized block design (RBD). The recommended dose for wheat was 120-60-40 kg N-$P_2O_5$-$K_2O$ $ha^{-1}$. The crop received differential dose of P from inorganic fertilizer with and without FYM and PSB as per schedule of treatments. Nitrogen from urea was given as 50% basal, 25% after 45 days of transplanting and 25% after 60 days. The full dose of P and K through single super phosphate and mureate of potash were applied at time of sowing as basal dressing. The composition of FYM was 0.5% N, 0.2 % $P_2O_5$, 0.5% $K_2O$ and carpet waste was 2.5% N, 1.5 % $P_2O_5$ and 2% $K_2O$. The required quantities of FYM were applied 15 days before sowing as per treatment. Soil samples from 0-15 cm depth were collected in plastic bag from individual plots at 30 DAT and after harvest of the crop. Soil sample of each plot was collected ,air- dried, processed to pass through 2 mm round hole sieve and analyzed for organic carbon (1*N* $K_2Cr_2O_7$), available N (0.32% alkaline$KMnO_4$ oxidizable), P(0.5 M $NaHCO_3$ extractable), K (1 *N* neutral ammonium acetate extractable) and S (0.15% $CaCl_2$) following the methods described [8, 9, 10, 11 & 12], respectively. Soil pH was determined in 1:2 soil: water suspension with the help of glass electrode in digital pH meter and electrical conductivity of soil was measured in the supernatant liquid of soil water suspension (1:2) by conductivity bridge [13]. Bulk density in undisturbed samples collected with metal cores of 4.2 cm diameter and 5.8 cm height was measured [14].

Five plants of wheat cultivar of PBW–343 are marked randomly in each replicated plot and height was measured from base of plant to the tip of the upper most fully matured and stretched leaf before emergence of ear and from the base of plant to tip of ear after it emergence for calculating mean plant height at 30 and 120 days after transplanting (DAT). Number of tillers per meter in row length at different growth stages (30 DAT and at maturity) of crop were recorded. Dry matter of plants is taken at 60 DAT by cutting the plants in one meter row length in each plots then kept in shade for dry and weighed. After harvesting and threshing the weight of grain was recorded. Straw yield was calculated by subtracting grain yield from biological yield. Plant samples (grain and leaf) drawn at harvesting were dried in shade and then kept in oven at $70^0$C for 12 hours to make free from moisture. After there, samples were ground in grinder and the total P, K and S content in plant samples were determined by digesting the samples with di–acid ($HNO_3$:$HClO_4$ in 10:4) mixture [13] while N was determined by chromic acid [15]. Plant uptake of NPK and S were computed by multiplying the yield with the respective nutrient content. The data collected from field and laboratory were analyzed statistically using standard procedure of randomized block design [16]. Critical difference (C.D.) and standard error of mean (SEM) were calculated to determine the significance among treatment means.

## Results and Discussion

**Organic Carbon:** Organic carbon content of the soil increased significantly in the plots that had received 40 kg P $ha^{-1}$+PSB+5 t $ha^{-1}$ FYM ($T_4$) than those plots which had received phosphorus or PSB alone or in combination without FYM. Whereas difference in values of organic carbon between treatment $T_2$ (20 kg P $ha^{-1}$+PSB) and $T_3$ (40 kg P $ha^{-1}$+PSB), and between $T_5$ (60 kg P $ha^{-1}$) and $T_6$ (80 kg P $ha^{-1}$) was found at par at maturity stage of crop. The effect of different treatments on organic carbon content of soil was found in order of $T_4 > T_6 > T_5 > T_3 > T_2 > T_1$, and the values were varied between0.49 to 0.64

% at 30 DAS and 0.43 to 0.56 % at completion of experiment. The increase in organic carbon content in $T_4$ (40 kg P ha$^{-1}$+PSB+FYM 5 t ha$^{-1}$) was 30% more over $T_1$ (control) and 19% over $T_2$ (20 kg P ha$^{-1}$+PSB) at completion of experiment. The increase in organic carbon content in treatment $T_4$ (40 kg P ha$^{-1}$+PSB+FYM 5 t ha$^{-1}$) may be attributed to the direct incorporation of organic materials PSB and better root growth. The subsequent decomposition of these materials might have resulted in enhanced organic carbon content of soil. These results are in consonance with the findings [17, 18, 19, 20, 21, 22].

**Table1:** Effect of phosphorus levels**,** phosphate solubilizing bacteria and FYM on organic carbon, available N.P.K. and S of soil under wheat crop.

| Treat-ments | Organic carbon (%) | | Available nutrients (kg ha$^{-1}$) | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | N | | P | | K | | S | |
| | 30 DAS | At har-vesting | 30 DAS | At har-vesting | 30 DAS | At har-vesting | 30 DAS | At har-vesting | 30 DAS | At har-vesting |
| $T_1$ | 0.49 | 0.43 | 230.5 | 190.7 | 18.2 | 13.2 | 195.3 | 178.0 | 10.1 | 7.2 |
| $T_2$ | 0.52 | 0.47 | 242.4 | 206.5 | 22.3 | 17.1 | 212.2 | 190.0 | 12.0 | 9.0 |
| $T_3$ | 0.54 | 0.48 | 250.6 | 218.8 | 25.1 | 20.5 | 219.0 | 194.0 | 13.0 | 10.0 |
| $T_4$ | 0.64 | 0.56 | 274.2 | 244.6 | 31.2 | 26.3 | 242.1 | 213.3 | 18.6 | 14.2 |
| $T_5$ | 0.55 | 0.51 | 254.0 | 222.1 | 26.0 | 21.0 | 225.7 | 200.9 | 13.74 | 10.9 |
| $T_6$ | 0.59 | 0.53 | 261.3 | 230.2 | 28.2 | 23.0 | 230.5 | 205.5 | 16.0 | 12.2 |
| SEm(±) | 0.0162 | 0.0146 | 3.209 | 2.805 | 0.326 | 0.265 | 2.812 | 2.497 | 0.174 | 0.133 |
| CD (P=0.05) | 0.0352 | 0.0316 | 6.964 | 6.086 | 0.708 | 0.576 | 6.102 | 5.419 | 0.378 | 0.289 |

*DAS=Days after sowing*

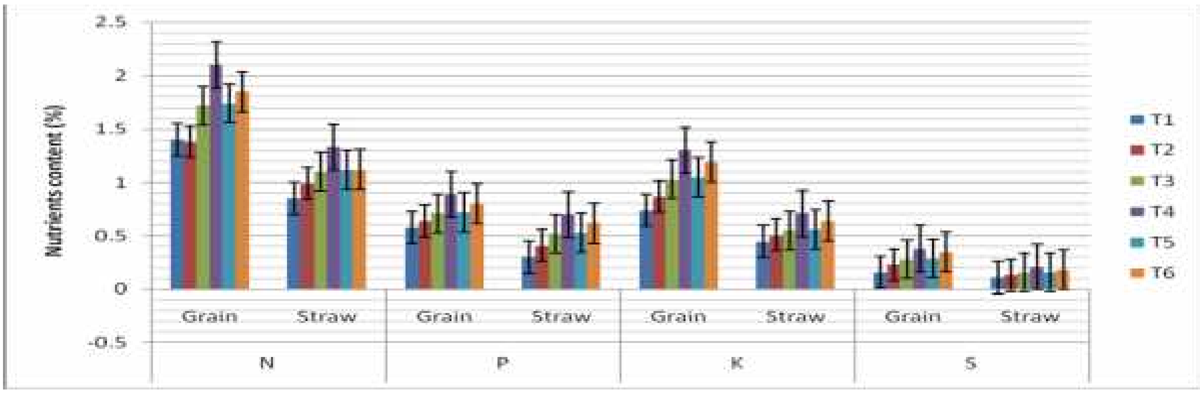
**Table2:** Effect of phosphorus levels**,** phosphate solubilizing bacteria and FYM on physico-chemical properties of soil under wheat crop.

| Treatments | Soil pH | | EC (dS m$^{-1}$) | | Bulk density (g cm$^{-3}$) | |
|---|---|---|---|---|---|---|
| | 30 DAS | At harvesting | 30 DAS | At harvesting | 30 DAS | At harvesting |
| $T_1$ | 7.41 | 7.63 | 0.37 | 0.40 | 1.36 | 1.44 |
| $T_2$ | 7.2 | 7.52 | 0.35 | 0.39 | 1.34 | 1.41 |
| $T_3$ | 7.06 | 7.4 | 0.34 | 0.37 | 1.33 | 1.39 |
| $T_4$ | 6.35 | 6.85 | 0.27 | 0.31 | 1.31 | 1.35 |
| $T_5$ | 7.0 | 7.25 | 0.32 | 0.36 | 1.32 | 1.38 |
| $T_6$ | 6.72 | 6.94 | 0.31 | 0.35 | 1.33 | 1.36 |
| SEm(±) | 0.088 | 0.091 | 0.0087 | 0.01 | 0.0167 | 0.0173 |
| CD (P=0.05) | 0.190 | 0.198 | 0.0188 | 0.0217 | 0.0362 | 0.0376 |

**Table3:** Effect of phosphorus levels**,** phosphate solubilizing bacteria and FYM on performance by wheat crop.

| Treatments | plant height (cm) | | No of tillers (m$^{-2}$) | | Grain yield (Q ha$^{-1}$) | Straw yield (Q ha$^{-1}$) |
|---|---|---|---|---|---|---|
| | 30 DAS | At harvesting | 30 DAS | At harvesting | | |
| $T_1$ | 14.4 | 71.5 | 210 | 330 | 38.2 | 62.2 |
| $T_2$ | 15.5 | 75.3 | 218 | 342 | 41.8 | 63.5 |
| $T_3$ | 17.5 | 80.2 | 229 | 351 | 43.5 | 66.1 |
| $T_4$ | 22.56 | 88.5 | 255 | 418 | 48.1 | 73.5 |
| $T_5$ | 17.9 | 81.0 | 240 | 372 | 45.1 | 68.2 |
| $T_6$ | 20.2 | 84.3 | 246 | 390 | 46.8 | 70.1 |
| SEm(±) | 0.229 | 1.027 | 2.9583 | 4.5887 | 0.5613 | 0.851 |
| CD (P=0.05) | 0.498 | 2.229 | 6.4196 | 9.9574 | 1.2181 | 1.8467 |

**Fig:** Effect of phosphorus levels, phosphate solubilizing bacteria and FYM on N, P, K and S contents in wheat grain and straw



**Available Nitrogen:** The plots treated with 40 kg P $ha^{-1}$+PSB+FYM 5 t $ha^{-1}$ ($T_4$) were recorded significantly higher available nitrogen content as compared to the plots which were treated with only phosphorus or PSB or in combination. Increase in available nitrogen status in $T_4$ (40 kg P $ha^{-1}$+PSB+FYM 5 t $ha^{-1}$) was 28% over $T_1$ (control). Decline in nitrogen content with increasing time can be attributed to rise in N requirement for crop with age. PSB promote orthophosphate ions which might be enhance mineralization of nitrogen to build up of higher available nitrogen. Available nitrogen content increase with phosphorus, PSB and FYM application in soil [23] and greater multiplication of soil microbes, which could convert organically bound N to inorganic [24, 20, 25]. noticed that enhancement in available N content of soil with the use of organics.

**Available Phosphorus:** The plots received 40 kg P $ha^{-1}$+PSB+FYM 5 t $ha^{-1}$ ($T_4$) have shown the significant increase in the available phosphorus content of soil as compared to other treatments. The available phosphorus content of $T_4$ (40 kg P $ha^{-1}$+PSB+FYM 5 t $ha^{-1}$*)* showed a significant increase of 99% over $T_1$ (control), 53% over $T_2$ (20 kg P $ha^{-1}$+PSB) and 28% over $T_3$ (40 kg P $ha^{-1}$+PSB) at harvesting of wheat crop. Increase in available phosphorus content of soil due to increasing level of phosphorus might be attributed to direct addition of phosphorus to solution pool of phosphorus in soil. The increase in available phosphorus content of soil due to the incorporation of FYM and PSB may be attributed to the direct addition of phosphorus as well as solubilization of native phosphorus through release of various organic acids through during the decomposition of FYM and PSB. These result conformity [26, 20, 27, 22 & 17] also reported that the application of *PSB* was effective when applied with inorganic *P.*

**Available Potassium:** The effect of various treatment on available potassium content was found in the order $T_4 > T_6 > T_5 > T_3 > T_2 > T_1$. The treatment ($T_4$) has registered a significant increase in available potassium content was 19% over $T_1$ (control). The difference between treatment $T_2$ (20 kg P $ha^{-1}$+PSB), $T_3$ (40 kg P $ha^{-1}$+PSB) and treatment $T_5$ (60 kg P $ha^{-1}$), $T_6$ (80 kg P $ha^{-1}$) was remained at par at harvesting stage. Increase in available K due to phosphorus, PSB and FYM application may be attributed to the direct addition of potassium to the available pool of soil. The beneficial effect of farmyard manure on available K might also be attributed to the reduction in fixation and release of K due to interaction of FYM with clay besides the direct K addition to the available K pool of soil [28, 19, 29 & 21].

**Available Sulphur:** Application of phosphorus fertilizer, PSB and FYM has shown a significant variation in available sulphur content of wheat plots. The addition of *40 kg P $ha^{-1}$+PSB+FYM 5 t $ha^{-1}$ ($T_4$)* in wheat plots have shown a remarkable significant increase in available sulphur content of experimental soil. The treatment $T_4$ (*40 kg P $ha^{-1}$+PSB+FYM 5 t $ha^{-1}$)* has recorded a significant increase in available sulphur content of wheat plots over control ($T_1$) to the extent of 97% at the completion of experiment. The application of treatment $T_4$ showed an increase in 30% residual S over treatment $T_5$ (60 kg P $ha^{-1}$) and 16% over $T_6$ (80 kg P $ha^{-1}$). Decline in sulphur content of soil with increasing time might be attributed to rise in sulphur requirement for wheat with growing period[30].Application of phosphorus, PSB and FYM significantly increased the available sulphur in might be due to PSB promote the activity of beneficial which break organic bound amino acid and increase the sulphur content in soil. This result corroborates with the findings [21, 17 & 29].

**Soil pH:** The significantly lower soil pH was recorded with addition of phosphorus, PSB and FYM as compared to phosphorus fertilizer and PSB without FYM at all growth stages during experiment. The effect of various treatment on soil pH could be arranged in the order $T_1>T_2>T_3>T_5>T_6>T_4$ and the values varied between from 6.35 to 7.63among various treatments. The release of organic acids during the process of decomposition of FYM and also acid release during activity of PSB may be attributed to decline in soil pH. Results are corroborating with the findings [31, 32 & 33].

**Electrical Conductivity:** Application of FYM with phosphate fertilizer + PSB recorded significantly lower electrical conductivity as compared to other treatment at all growth stages. The effect of different treatments on EC of soil was found in the order $T_1 > T_2 > T_3 > T_5 > T_6 > T_4$ and the values varied from 0.27 to 0.40 dS $m^{-1}$ among the treatments. The difference between treatment $T_1$ (control), $T_2$ (20 kg P $ha^{-1}$+PSB) and $T_5$ (60 kg P $ha^{-1}$), $T_6$ (80 kg P $ha^{-1}$) was remained at par at maturity of the crop. Similar results were obtained [33].

**Bulk Density:** The data showed that bulk density of soil under various treatments varied from 1.31 g $cm^{-3}$ to 1.44 g $cm^{-3}$. The effect of various treatment on bulk density of soil was found in the order $T_1$> $T_2$> $T_3$> $T_5$> $T_6$> $T_4$. Application of FYM with phosphatic fertilizer and PSB significantly decrease the bulk density of soil as compared to other treatments this might be attributed to the fact that better aggregation, high porosity and low bulk density of FYM. This result corroborates with the findings [34]. In general, the bulk density of wheat plots increased gradually with time due to natural consolidation and compaction of soil particles. This effect was also noted [33].

**Plant Height:** Use of phosphorus fertilizers with PSB and FYM gave a significant effect on the plant height of wheat crop. The addition of *40 kg P $ha^{-1}$+PSB+FYM 5 t $ha^{-1}$* ($T_4$) in wheat plots have shown a significant increase in plant height at all growth stages over $T_1$ (control) and $T_2$ (20 kg P $ha^{-1}$+PSB) and was upto the extent of 23.5% and 17%, respectively. The difference between $T_3$ (40 kg P $ha^{-1}$+PSB) and $T_5$ (60 kg P $ha^{-1}$) was remained at par at all growth stages of crop. The increase in plant height due to the addition of phosphorus, FYM and PSB (Phosphorus Solubilizing Bacteria) was found to be statistically significant over control at all stages of growth. Increase in plant height might be attributed to higher and continuous supply of nutrients to plant in phosphorus, PSB and FYM treated plots. This result is corroborating with the findings [35].

**Plant Tillers:** The addition of *40 kg P $ha^{-1}$+PSB+FYM 5 t $ha^{-1}$* ($T_4$) in wheat plots have shown a significant increase in plant tiller at both growth stages over other treatments. The treatment $T_4$ (*40 kg P $ha^{-1}$+PSB+FYM 5 t $ha^{-1}$*) has shown a significant increase in the plant tiller of wheat crop to the extent of 26% and 22% over $T_1$ (control) and $T_2$ (20 kg P $ha^{-1}$+PSB) respectively. It was also found that increasing level of phosphorus increased number of tillers**.** Significantly higher number of tiller was found with application of PSB and FYM might be attributed to higher and continuous supply of nitrogen, phosphorus and potassium. This result is corroborating with the findings [35, 36 & 37].

**Grain and Straw Yield:** Application of phosphatic fertilizer along with PSB and FYM ($T_4$) recorded significant higher yield in comparison to other treatments. The data revealed that the grain yield of wheat was found in the order $T_4$ >$T_6$>$T_5$>$T_3$>$T_2$>$T_1$ and the values of grain yield were 48.1, 46.8, 45.1, 43.5, 41.8 and 38.2 q $ha^{-1}$ under respective treatment. The application of 40 kg P $ha^{-1}$ along with PSB and FYM was significantly superior to 60 and 80 kg P $ha^{-1}$ applied to wheat. The treatment $T_4$ (*40 kg P $ha^{-1}$+PSB+FYM 5 t $ha^{-1}$*) increased grain yield by 25% and 15% over $T_1$ and $T_2$ respectively. The present experimental results suggest that reduction in one forth quantity of recommended dose of phosphatic fertilizer (20 kg $ha^{-1}$) could be made with the application of PSB and FYM without any decrease in yield. The beneficial effect of phosphorus, PSB and FYM on yield might be due to the continuous and additional supply of plant nutrients as well as improvement in over physico-chemical properties of soil [38]. Similar improvement in yield of wheat due to integrated use of phosphorus, PSB and FYM has been also by other worker noted [39, 25, 40].

On the other hand effect of phosphorus, PSB and FYM application on straw yield of wheat was found in the order $T_4$>$T_6$>$T_5$>$T_3$>$T_2$>$T_1$ and the values varied between 62.2 to 70.1 q $ha^{-1}$ under various treatments. Significantly higher straw yield was recorded in case of $T_4$ (*40 kg P $ha^{-1}$+PSB+FYM 5 t $ha^{-1}$*) as compared to other treatment and was 20% more over $T_1$ (control). Similar results were also recorded.

**Nutrients Content in Wheat Grain and Straw:** Significant effect of integrated use of inorganic phosphorus PSB and FYM was recorded. The maximum nutrient contain (N, P, K and S) was recorded with $T_4$ (40 kg P $ha^{-1}$+PSB+FYM). The effect of various treatment on nutrient contain could be arranged in order of $T_4$>$T_6$>$T_5$>$T_3$>$T_2$>$T_1$ .It was also observed that nutrient content increased with increasing dose of fertilizer.

The higher content of N, P, K and S in grain and straw may be due to application of phosphorus and FYM with PSB and may be described as the better supply of available N, P, K and S directly to the plants and decomposition of FYM, solubilizing effect of PSB on fixed form of phosphorus nutrient also provide better soil physical environment. These results are in consonance with the findings [41, 42 & 43].

**Conclusion:** It is conclusively evident from this investigation that integrated application of inorganic form of phosphorus (40 kg $ha^{-1}$) along with PSB and FYM reduced the phosphorus fertilizer requirement by 20 kg $ha^{-1}$ of recommended dose without any loss of yield which also improve physico-chemical properties of soil.

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