Original Research Article

Residual effect of Humic acid, PSB ~~&~~ and Phosphorus Nutrition on soil chemical properties after harvest of rice crop under the subtropical condition of Jammu

ABSTRACT

Field experiments were conducted during *Kharif* season of 2022 at the Research Farm, WMRC, SKUAST- J, Chatha. The soil of the experimental site was sand clay loam in texture, slightly alkaline in reaction, low in organic carbon and available nitrogen and potassium but medium in phosphorus and potassium. The experiment was laid out in Factorial RBD with three factors replicated thrice. Twenty treatment combinations comprising of five Humic acid treatments (Control, Soil Application of Humic acid @ 2.5kg/ha & 5kg/ha (Market ready), and Soil Application of Humic acid @ 2.5kg/ha & 5kg/ha (FYM), two Phosphorous Solubilizing Bacteria (PSB) applications (With and without PSB) and two levels of Phosphorus nutrition (100% Recommended N:100% Recommended P - 15:40 kg/ha and 100% Recommended N:75% Recommended P - 15:30 kg/ha). The utilization of Humic acid at a rate of 5 kg/ha, sourced from both Market Ready and Farm Yard Manure (FYM), combined with seed treatment employing ~~Phosphorous Solubilizing Bacteria (~~PSB~~)~~ and a nutrient application of 100% recommended nitrogen (N): 100% recommended phosphorus (P) - 15:40 kg/ha, exhibited a more pronounced and favorable residual impact on soil properties. This was evidenced by notable improvements in organic carbon, available nitrogen, phosphorus, and potassium levels, surpassing their initial values. Furthermore, this treatment regime~~n~~ exerted a modest influence on both seed and stover yields.

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Keywords: *Residual effect, Humic Acid, PSB, Phosphorus nutrition, soil properties Yield*

1. INTRODUCTION

The ongoing expansion of industrial operations, urbanization, and infrastructure development is progressively encroaching upon substantial land areas previously allocated for agricultural, forestry, and pasture purposes. This encroachment disrupts the physical, chemical, and biological characteristics of the soil, leading to soil degradation. Consequently, preserving organic matter in the soil becomes imperative to enhance soil fertility and optimize crop yield per unit area. In this context, the application of plant growth-promoting substances, such as humic acid, represents an innovative and promising strategy to confer significant advantages to agriculture.

Humic substances, encompassing humic and fulvic acids, play a crucial role in soil fertility and plant nutrition. Plants cultivated in soil enriched with sufficient humic and fulvic acids demonstrate reduced stress levels, improved growth, and increased yields. Humic acids act as stimulants for ~~root development,~~ fostering root growth. Moreover, they serve as soil conditioners, enhancing aggregate stability, aeration, and improving the soil's water-holding and nutrient-supplying capacity (Pettit, 2004). Humic acid stimulates plant growth, thereby increasing yields by facilitating the uptake of plant nutrients and influencing various mechanisms such as cellular respiration, photosynthesis, protein synthesis, and enzyme activities. Additionally, this substance regulates plant growth hormones through the production of indole acetic acid or its precursors. Humic acid also acts as an effective adsorption and retention complex for inorganic plant nutrients (Mayhew, 2004).

Inadequate nutrient availability during the crucial phases of crop development results in nutrient stress, contributing to suboptimal crop yield and productivity. Humic acid functions as an inert nutrient reservoir, facilitating the mobilization of soil nutrients and potentially exerting residual effects. Against this backdrop, the current study was conducted to assess the residual impact of humic acid on enhancing both yield and soil chemical properties in rice cultivation.

2. MATERIAL AND METHODS

Field experiments were conducted during the *Kharif* seasons of 2022 to investigate the enduring impact of Humic acid, *PSB* ~~(Phosphorous-solubilizing bacteria),~~ and phosphate nutrition on the physio-chemical characteristics of soil subsequent to the harvest of rice crops in subtropical conditions at the Research Farm, WMRC, SKUAST-J, Chatha. The experimental site, located at 32.6529° N latitude and 74.8071° E longitude, with an elevation of 332 meters above mean sea level, featured sandy loam textured soil that was slightly alkaline. The soil exhibited low organic carbon content, as well as low levels of available nitrogen and potassium, but medium levels of available phosphorus, maintaining an electrical conductivity within the acceptable range.

The experimental design employed a Factorial Randomized Block Design (RBD) with three factors replicated thrice. Twenty treatment combinations, including five Humic acid treatments (Control, Soil Application of Humic acid @ 2.5kg/ha & 5kg/ha (Market ready), and Soil Application of Humic acid @ 2.5kg/ha & 5kg/ha (FYM), two PSB applications (With and without PSB) and two levels of Phosphorus nutrition (100% Recommended N:100% Recommended P - 15:40 kg/ha and 100% Recommended N:75% Recommended P - 15:30 kg/ha). The main crop i.e. black gram, was sown with a spacing of 30 x* 10 cm and seed rate of 15 kg/ha. The full dose of nitrogen (16 kg/ha) and a uniform basal application of 40 kg/ha P_2O_5 per hectare were applied to all treatments through urea and DAP. Subsequently, puddled transplanted rice crops were sown after black gram to evaluate the residual effects of treatments applied to black gram. Rice was sown at a spacing of 20 cm with two plants per hill. The recommended NPK dose for rice crops was 50:30:20 kg/ha, with urea, diammonium phosphate, and muriate of potash serving as sources for nitrogen, phosphorus, and potassium, respectively. Half of the nitrogen, along with the full dose of phosphorus and potassium, was applied at sowing as a basal dose. The remaining nitrogen was top-dressed in two equal splits - at the tillering stage and 60 days after transplanting (DAT) of the rice crop. The experiment was conducted at the same site without changing the randomization of treatments for consecutive years to assess residual effects. Black gram (cv. PU-31) was sown in the third week of March, and the residual crop, rice, was sown in mid-June and harvested in September 2022.

Soil samples were randomly collected from five different spots in the field after harvesting the residual rice crop. The composite soil sample was air-dried, ground, and passed through a 2 mm sieve for analysis of various chemical properties. The initial soil analysis indicated that the experimental field's soil was sandy clay loam, slightly alkaline, low in organic carbon and available nitrogen, but medium in available phosphorus and potassium. Post-harvesting of the black gram crop, treatment-wise soil samples were taken from all plots at the surface (0-15 cm) for pH, organic carbon (OC), available nitrogen, phosphorus, and potassium determination. The samples were dried, ground, and sieved before analysis. The available nitrogen was determined using the modified alkaline permanganate method, expressed in N kg per ha. Available phosphorus was determined using the method defined by Olsen *et al.* (1954), with color intensity measured at 660 nm and expressed as P_2O_5 kg/ha. Available potassium was extracted with neutral normal

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ammonium acetate solution, determined by a flame photometer, and expressed as K2O kg/ha.

Statistical analysis involved the use of analysis of variance (ANOVA), and F-tests of significance were applied to treatment means based on the null hypothesis (Cochran and Cox, 1957). Standard errors, along with critical differences at 5% significance, were computed where necessary to discern treatment effects for chance effects. The degrees of freedom used in ANOVA were determined as part of the key for statistical analysis.

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3. RESULTS AND DISCUSSION

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Chemical properties of soil after rice crop harvest

The data presented in Table 1 indicated that different treatments and their interaction showed a non-significant influence on soil chemical properties such as pH and organic carbon in rice after harvest stage.

Among Humic acid applications, the n~~N~~umerically higher value of organic carbon ~~&~~and EC was recorded with the treatment of H_2 & H_4 followed by H_1 and H_3 respectively while the lowest organic carbon & EC was recorded under control. Among PSB Applications, the highest value of organic carbon & EC was recorded in the soil application of PSB as compared to the treatment without PSB. Between phosphorus Nutrition treatments, a numerically higher value of organic carbon & EC was recorded under Treatment N_1, while the lowest organic carbon & EC was recorded under N_2. However, among Humic acid application, the Numerical higher value of pH was recorded with the treatment of H5 followed by H_1 and H_3 H_2 & H_4 respectively while the lowest pH was recorded under control. between PSB Application treatments, the highest value of pH was recorded in seed treatment with PSB as compared to the treatment without PSB. Between phosphorus Nutrition, a numerically higher value of organic carbon was recorded under Treatment N_1, while the lowest organic carbon was recorded under N_2.

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Available nitrogen

The data concerning the available nitrogen in the soil is presented in Table 1 which revealed non-significant results the Numerically higher value of available nitrogen was recorded with the treatment of H_2 followed by H_4 , H_1 and H_3 respectively while the lowest available nitrogen was recorded under control (H_5). Among PSB applications, the highest value of available nitrogen was recorded in the soil application of PSB as compared to the treatment without PSB. Between phosphorus nutrition treatments, a numerically higher value of available nitrogen was recorded under Treatment N_1, while the available nitrogen was recorded under N_2.

Available Phosphorus

The data concerning the available phosphorus in the soil is presented in Table 1 which revealed non-significant results the Numerically higher value of available phosphorus was recorded with the treatment of H_2 followed by H_4 , H_1 and H_3 respectively while the lowest available phosphorus was recorded under control (H_5). Among PSB applications, the highest value of available phosphorus was recorded in the soil application of PSB as compared to the treatment without PSB. Between phosphorus nutrition treatments, a numerically higher value of available phosphorus was recorded under Treatment N_1, while the available phosphorus was recorded under N_2.

Available Potassium

The data concerning the available potassium in the soil is presented in Table 1 which revealed non-significant results the Numerically higher value of available Potassium was recorded with the treatment of H_2 followed by H_4, H_1 and H_3 respectively while the lowest available Potassium was recorded under control (H_5). Among PSB applications, the highest value of available Potassium was recorded in the soil application of PSB as compared to the treatment without PSB. Between phosphorus nutrition treatments, a numerically higher value of available Potassium was recorded under Treatment N_1, while the available Potassium was recorded under N_2.

Seed yield

A perusal of the data depicted in the Fig 1 reveals that different treatment combinates non- significantly influenced the seed yield of rice crop. Treatment H_2 (Soil Application of Humic acid @ 5kg/ha (Market ready) recorded numerically highest seed yield (757.78 kg/ha) followed by treatment H_4 [Soil Application of Humic acid @ 5kg/ha (FYM)], treatment H_1 & H_3[Soil Application of Humic acid @ 2.5kg/ha (Market ready and FYM respectively)]. Whereas, the lowest seed yield was observed with treatment H5 (control). Among phosphorus solubilizing bacteria application (PSB), treatment P_1 (with PSB) recorded a numerically higher seed yield than treatment P_2 (without PSB). Among phosphorus nutrition, treatment N_1 [100% Recommended N:100% Recommended P (15:40 kg/ha)] recorded a numerically higher seed yield (706.71and kg/ha)than treatment N_2 [100% Recommended N:75% Recommended P (15:30 kg/ha)] . The data presented on the interaction effect for all factors *viz*. humic acid source and dose, phosphorus solubilizing bacteria and phosphorus nutrition, showed a non-significant effect on the seed yield was observed.

Straw yield

A perusal of the data depicted in the Fig 2 reveals that different treatment combinates non- significantly influenced the straw yield of rice crop. Treatment H_2 (Soil Application of Humic acid @ 5kg/ha (Market ready) recorded numerically highest straw yield (757.78 kg/ha) followed by treatment H_4 [Soil Application of Humic acid @ 5kg/ha (FYM)], treatment H_1 & H_3[Soil Application of Humic acid @ 2.5kg/ha (Market ready and FYM respectively)]. Whereas, the lowest straw yield was observed with treatment H5 (control). Among phosphorus solubilizing bacteria application (PSB), treatment P_1 (with PSB) recorded a numerically higher straw yield than treatment P_2 (without PSB). Among phosphorus nutrition, treatment N_1 [100% Recommended N:100% Recommended P (15:40 kg/ha)] recorded a numerically higher straw yield (706.71and kg/ha)than treatment N_2 [100% Recommended N:75% Recommended P (15:30 kg/ha)] . The data presented on the interaction effect for all factors *viz*. humic acid source and dose, phosphorus solubilizing bacteria and phosphorus nutrition, showed a non-significant effect on the straw yield was observed.

Discussion

Chemical properties of soil after harvest of rice crop

The data presented in Table 1 indicated that different treatments and their interaction showed a non-significant contribution on soil chemical properties *viz.* pH, EC and organic carbon of soil after harvest of rice. Among Humic acid levels, pH ranged from 7.30 to 7.36 and reported a 1.781% dip in values of pH to initial levels (H_2), EC ranged from 0.29 to 0.31 and reported 3.226 % dip in values of EC to initial levels (H_2) and OC ranged from 0.54-0.58 and reported 3.448% dip in values of OC to initial levels (H_2) respectively.

Among PSB levels, pH ranged from 7.32 to 7.33 and reported a 1.639% dip in values of pH to initial levels (H_2), OC ranged from 0.57 to 0.58 and reported 3.226 % dip in values of OC to initial levels (P_1) and EC was about 0.30 and reported 3.333% dip in values of EC to initial levels (P_1) respectively.

Among Phosphorous nutrition, pH ranged from 7.32 to 7.33 and reported a 1.639% dip in values of pH to initial levels (H_2), OC ranged from 0.57 to 0.58 and reported 1.754% dip in values of OC to initial levels (P_1) and EC was about 0.30 and reported 3.333% dip in values of EC to initial levels (P_1) respectively.

Available nitrogen, Phosphorus and Potassium after harvest of black gram crop

The data presented in Table 1 indicated that different treatments and their interaction showed a non-significant contribution on soil available nitrogen, phosphorus and potassium after harvest of rice. Among Humic acid levels, available nitrogen ranged from 232.95 to 251.33and reported a 2.523% dip in values of available nitrogen to initial levels (H_2), Available phosphorus ranged from 11.63 to 12.5and reported 8.692% dip in values of available phosphorus to initial levels (H_2) and available potassium ranged from 148.88-

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159.61 and reported 14.20% dip in values of available potassium to initial levels (H_2) respectively. Among PSB levels, available nitrogen ranged from 7.32 to 7.33 and reported a 2.52% dip in values of available nitrogen to initial levels (H_2), available phosphorus ranged from 0.57 to 0.58 and reported 8.618 % dip in values of available phosphorus to initial levels (P_1) and available potassium was about 0.30 and reported 7.21% dip in values of available potassium to initial levels (P_1) respectively. Among Phosphorous nutrition, available nitrogen ranged from 7.32 to 7.33 and reported a 2.523 % dip in values of available nitrogen to initial levels (H_2), available phosphorus ranged from 0.57 to 0.58 and reported 7.141% dip in values of available phosphorus to initial levels (P_1) and available potassium was about 0.30 and reported 6.61% dip in values of available potassium to initial levels (P_1) respectively.

Seed and Stover yield

The residual effects observed in the experiments were lower with control for the preceding crop. This could be due to lesser nutrient availability in the plots due to nutrient losses and or mining of soil nutrient pool by the preceding crop caused much poorer effect on the residual crop. the maximum improvement in seed and Stover yield might be associated with increased yield attributes due to a concomitant increase in dry matter accumulation. This is in accordance with the findings of Kumawat *et al.* (2009).

Among the various applications of humic acid, its soil application resulted in the highest recorded nitrogen, phosphorus, and potassium content, as well as seed and stover yield, in comparison to the control group. This outcome could be attributed to increased nutrient mineralization, enhanced nutrient availability, and elevated microbial activity in the soil. Spier and Ross, (1976), Chaitra and Math (2018). reported that enzymes activity in soil increased due to the addition of organic matter to soil. Similarly, the use of Phosphorous Solubilizing Bacteria (PSB) contributed to comparable outcomes in parameters such as available nitrogen, phosphorus, and potassium, as well as seed and stover yield. Similar results was reported by Biswas et. al. (2021) & Ghosal et. al. (2018). However, statistical significance was not achieved, possibly due to ~~unfavorable~~unfavourable temperature conditions during the kharif season in specific subregions of Jammu, which may have adversely affected microbial populations. The practice of puddling soil for rice cultivation in the plot could also contribute to reduced nutrient mineralization. While the phosphorus dose applied to the black gram crop was deemed sufficient, it failed to yield a significant difference, possibly indicating limited availability in the puddled soil. Similar results was reported by Bochalya et. al. (2021) & Ghosal et. al. (2018).

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4. CONCLUSION

The utilization of Humic acid at a rate of 5 kg/ha, sourced from both Market Ready and Farm Yard Manure (FYM), combined with seed treatment employing Phosphorous Solubilizing Bacteria (PSB) and a nutrient application of 100% recommended nitrogen (N):

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100% recommended phosphorus (P) - 15:40 kg/ha, exhibited a more pronounced and favorable residual impact on soil properties. This was evidenced by notable improvements in organic carbon, available nitrogen, phosphorus, and potassium levels, surpassing their initial values. Furthermore, this treatment regimen exerted a modest influence on both seed and stover yields.

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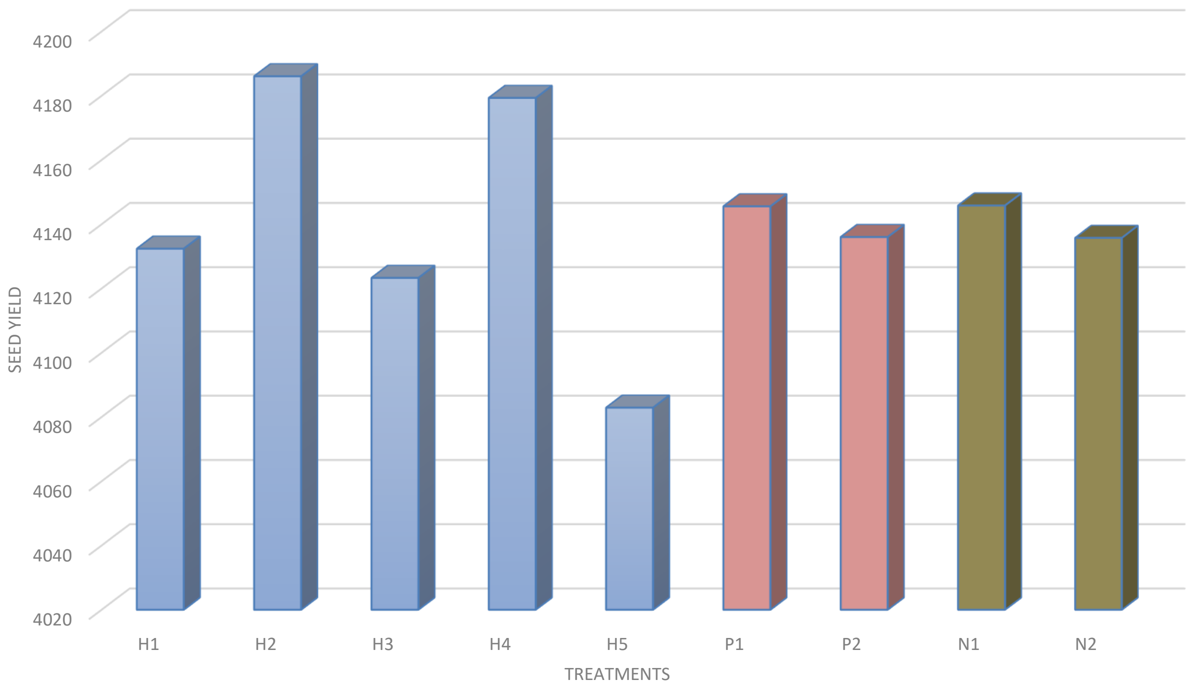
Table 1. Effect of humic acid source and dose, phosphorus solubilising bacteria (PSB) and phosphorus nutrition on soil properties of rice crop

Treatments	pH	EC (dS/m)	Organic Carbon (g/kg)	Available Nitrogen (kg/ha)	Available Phosphorous (kg/ha)	Available Potassium (kg/ha)
H_1 Soil Application of Humic acid @ 2.5kg/ha (Market ready)	7.32	0.29	0.57	244.52	11.94	152.68
H_2 Soil Application of Humic acid @ 5kg/ha (Market ready)	7.30	0.31	0.58	251.33	12.54	159.61
H_3 Soil Application of Humic acid @ 2.5kg/ha (FYM)	7.33	0.29	0.56	242.99	11.76	151.53
H_4 Soil Application of Humic acid @ 5kg/ha (FYM)	7.32	0.31	0.58	249.20	12.50	158.11
H_5 Control	7.36	0.29	0.54	232.95	11.63	148.88
SEm±	0.17	0.01	0.01	5.33	0.26	3.53
CD (0.05)	NS	NS	NS	NS	NS	NS
P_1 With PSB	7.32	0.30	0.57	245.60	12.30	154.64
P_2 Without PSB	7.33	0.29	0.56	242.80	11.84	153.68
SEm±	0.11	0.00	0.01	3.37	0.16	2.23
CD (0.05)	NS	NS	NS	NS	NS	NS
N_1 100% Recommended N:100% Recommended P (15:40 kg/ha)	7.32	0.30	0.57	246.11	12.28	155.98
N_2 100% Recommended N:75% Recommended P (15:30 kg/ha)	7.33	0.30	0.56	242.28	11.87	152.34
SEm±	0.11	0.00	0.01	3.37	0.16	2.23
CD (0.05)	NS	NS	NS	NS	NS	NS
H×P	NS	NS	NS	NS	NS	NS
P×N	NS	NS	NS	NS	NS	NS
N×H	NS	NS	NS	NS	NS	NS
H×P×N	NS	NS	NS	NS	NS	NS

Fig:1 Effect of humic acid source and dose, phosphorus solubilising bacteria (PSB) and phosphorus nutrition on Seed yield (kg/ha) of rice crop



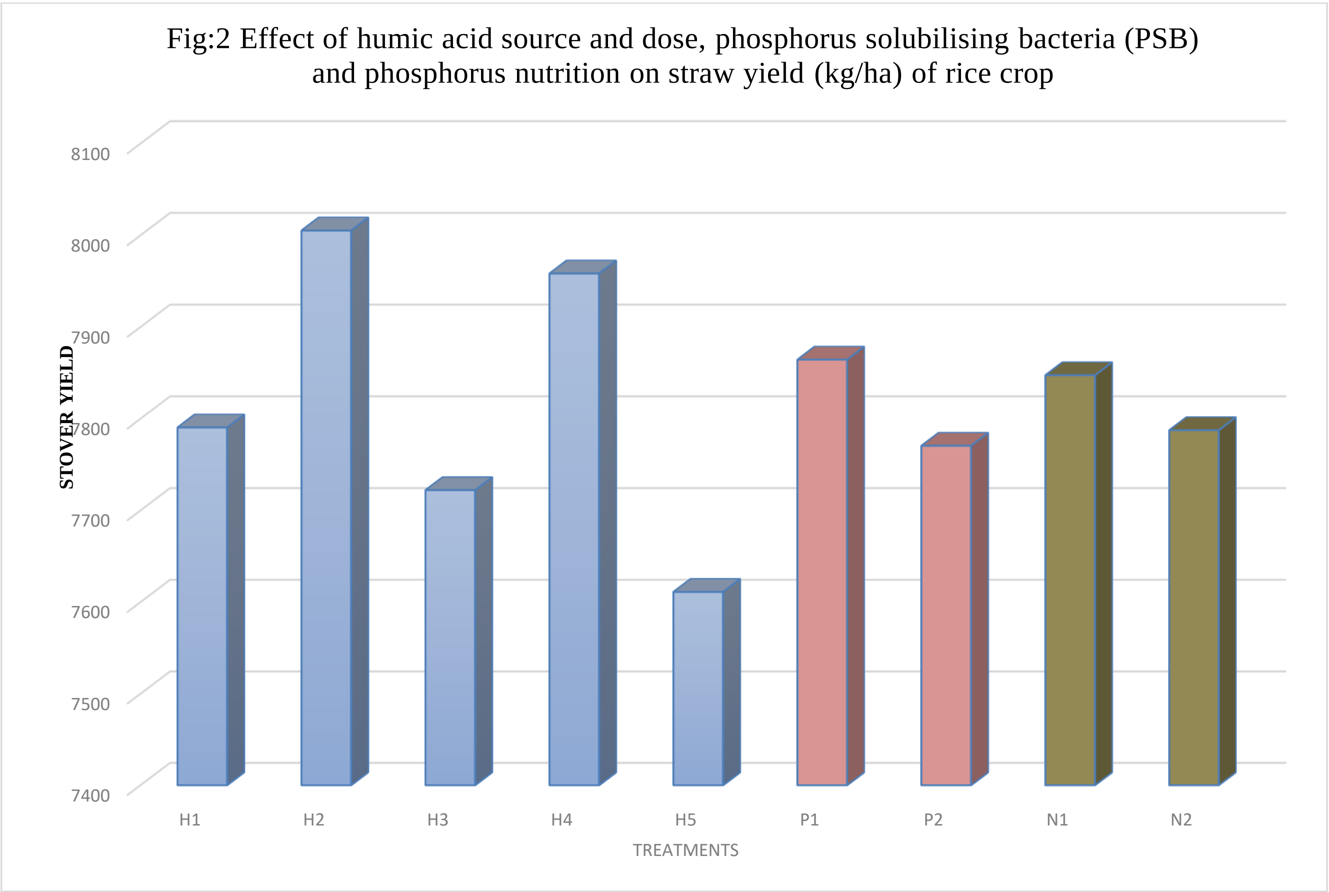


Fig:2 Effect of humic acid source and dose, phosphorus solubilising bacteria (PSB) and phosphorus nutrition on straw yield (kg/ha) of rice crop
STOVER YIELD
8100
8000
7900
7800
7700
7600
7500
7400
H1
H2
H3
H4
H5
P1
P2
N1
N2
TREATMENTS