



Residual Effect of Humic Acid, PSB and Phosphorus Nutrition on Soil Chemical Properties after Harvest of Rice Crop under the Subtropical Condition of Jammu

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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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 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 PSB treatments (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 (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 but shows in non-significant results. Furthermore, this treatment employing humic acid application, PSB & Phosphorous nutrition showed improvement in seed yield and straw yield but failed to show significant results in residual rice crop.

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 [1]. "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" [2].

PSB play an important role in solubilization of soil P through secretion of various organic acids and make it available to plant" [3]. "Application of P along with PSB, improved phosphorus uptake by plants and yields equally indicating that the PSB was able to solubilize phosphates and to mobilize phosphorus in residual crop plants" [4].

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. MATERIALS AND METHODS

Field experiments were conducted during the *Kharif* seasons of 2022 to investigate the enduring impact of Humic acid, *PSB* 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. Initially, soil exhibited low organic carbon content (5.01), as well as low levels of available nitrogen (214.12), but medium levels of available phosphorus (10.78) and potassium (158.01), maintaining an electrical conductivity within the acceptable range at the start of the experiment.

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 30×10 cm in *summer* season (march 2022) and seed rate of 15 kg/ha. The full dose of nitrogen (16 kg/ha) and a uniform basal application of 40 kg/ha P₂O₅ 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 in *kharif* season (June 2022). 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 to assess residual effects (Blackgram-rice cropping system). 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. Available phosphorus was determined using the method defined by Olsen *et al.* (1954), with color intensity measured at 660 nm and expressed. Available potassium was extracted with neutral normal ammonium acetate solution, determined by a flame photometer.

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.

3. RESULTS AND DISCUSSION

3.1 Chemical Properties of Soil after Harvest of Residual Rice Crop

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 Numerically higher value of organic carbon & EC was

recorded with the treatment of H₂ & H₄ (Soil Application of Humic acid @ 5kg/ha (Market ready & FYM) respectively, followed by H₁ and H₃ (Soil Application of Humic acid @ 2.5kg/ha (Market ready & FYM) 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 N₁, while the lowest organic carbon & EC was recorded under N₂. However, among Humic acid application, the Numerical higher value of pH was recorded with the treatment of H₅ followed by H₁ and H₃ H₂ & H₄ 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 N₁, while the lowest organic carbon was recorded under N₂.

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 (H₂), EC ranged from 0.29 to 0.31 and reported 3.226 % dip in values of EC to initial levels (H₂) and OC ranged from 0.54-0.58 and reported 3.448% dip in values of OC to initial levels (H₂) 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 (H₂), OC ranged from 0.57 to 0.58 and reported 3.226 % dip in values of OC to initial levels (P₁) and EC was about 0.30 and reported 3.333% dip in values of EC to initial levels (P₁) 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 (H₂), OC ranged from 0.57 to 0.58 and reported 1.754% dip in values of OC to initial levels (P₁) and EC was about 0.30 and reported 3.333% dip in values of EC to initial levels (P₁) respectively.

Changes in soil physiochemical properties might be due to build up of soil fertility due to the growing of legume crops & implementation of

different treatments and which contributed for the improvement of soil properties [5].

3.2 Available Nitrogen, Phosphorus & Potassium of Soil After Harvest of Residual Rice Crop

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 H₂ followed by H₄ , H₁ and H₃ respectively while the lowest available nitrogen was recorded under control (H₅). 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 N₁, while the available nitrogen was recorded under N₂.

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 H₂ followed by H₄ , H₁ and H₃ respectively while the lowest available phosphorus was recorded under control (H₅). 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 N₁, while the available phosphorus was recorded under N₂.

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 H₂ followed by H₄, H₁ and H₃ respectively while the lowest available Potassium was recorded under control (H₅). 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 N₁, while the available Potassium was recorded under N₂.

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 residual rice. Among Humic acid levels, available nitrogen ranged from 232.95 to 251.33 and reported a 2.523% dip in values of available nitrogen to initial levels of black gram crop (H₂), Available phosphorus ranged from 11.63 to 12.5 and reported 8.692% dip in values of available phosphorus to initial levels (H₂) and available potassium ranged from 148.88-159.61 and reported 14.20% dip in values of available potassium to initial levels (H₂) of black gram crop 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 (H₂), available phosphorus ranged from 0.57 to 0.58 and reported 8.618 % dip in values of available phosphorus to initial levels (P₁) and available potassium was about 0.30 and reported 7.21% dip in values of available potassium to initial levels (P₁) of black gram crop 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 (H₂) of black gram crop, available phosphorus ranged from 0.57 to 0.58 and reported 7.141% dip in values of available phosphorus to initial levels (P₁) and available potassium was about 0.30 and reported 6.61% dip in values of available potassium to initial levels (P₁) of black gram crop respectively. Rice being a heavy feeder of nutrients depletes the Available Nitrogen, Phosphorus & Potassium present in soil. 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". Kumawat et. al. [5].

Among the various applications of humic acid, its soil application resulted in the highest recorded nitrogen, phosphorus, and potassium content, outcome could be attributed to increased nutrient mineralization, enhanced nutrient availability, and elevated microbial activity in the soil [6,7]. Similarly, the use of Phosphorous Solubilizing Bacteria (PSB) contributed to comparable outcomes in parameters such as available nitrogen, phosphorus, and potassium. Similar results was reported by Biswas et. al. [8] & Ghosal et. al. [9]. However, statistical significance was not achieved, possibly due to 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. [10] & Ghosal et. al. [9].

3.3 Seed Yield & Stover Yield of Residual Rice Crop

A perusal of the data depicted in Table 1 & Fig 1 reveals that different treatment combinates non-significantly influenced the seed yield of rice crop. Treatment H₂ (Soil Application of Humic acid @ 5kg/ha (Market ready) recorded numerically highest seed yield (757.78 kg/ha) followed by treatment H₄ [Soil Application of Humic acid @ 5kg/ha (FYM)], treatment H₁ & H₃[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 P₁ (with PSB) recorded a numerically higher seed yield than treatment P₂ (without PSB). Among phosphorus nutrition, treatment N₁ [100% Recommended N:100% Recommended P (15:40 kg/ha)] recorded a numerically higher seed yield (706.71and kg/ha) than treatment N₂ [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.

A perusal of the data depicted in Table 1 & Fig 2 reveals that different treatment combinates non-significantly influenced the straw yield of rice crop. Treatment H₂ (Soil Application of Humic acid @ 5kg/ha (Market ready) recorded numerically highest straw yield (757.78 kg/ha) followed by treatment H₄ [Soil Application of Humic acid @ 5kg/ha (FYM)], treatment H₁ & H₃[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 P₁ (with PSB) recorded a numerically higher straw yield than treatment P₂ (without PSB). Among phosphorus nutrition, treatment N₁ [100%

Table 1. Effect of humic acid source and dose, PSB and phosphorus nutrition on soil properties & yield of residual rice crop

Treatments	pH	EC (dS/m)	Organic Carbon (g/kg)	Available Nitrogen (kg/ha)	Available Phosphorous (kg/ha)	Available Potassium (kg/ha)	Seed yield (kg/ha)	Straw yield (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	4132.37	7790.57
H ₂ Soil Application of Humic acid @ 5kg/ha (Market ready)	7.30	0.31	0.58	251.33	12.54	159.61	4186.03	8005.35
H ₃ Soil Application of Humic acid @ 2.5kg/ha (FYM)	7.33	0.29	0.56	242.99	11.76	151.53	4123.29	7722.24
H ₄ Soil Application of Humic acid @ 5kg/ha (FYM)	7.32	0.31	0.58	249.20	12.50	158.11	4179.30	7958.48
H ₅ Control	7.36	0.29	0.54	232.95	11.63	148.88	4082.90	7611.26
SEm±	0.17	0.01	0.01	5.33	0.26	3.53	97.17	169.85
CD (0.05)	NS	NS	NS	NS	NS	NS	NS	NS
P ₁ With PSB	7.32	0.30	0.57	245.60	12.30	154.64	4145.55	7864.54
P ₂ Without PSB	7.33	0.29	0.56	242.80	11.84	153.68	4136.01	7770.62
SEm±	0.11	0.00	0.01	3.37	0.16	2.23	61.45	107.42
CD (0.05)	NS	NS	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	4145.81	7847.57
N ₂ 100% Recommended N:75% Recommended P (15:30 kg/ha)	7.33	0.30	0.56	242.28	11.87	152.34	4135.74	7787.59
SEm±	0.11	0.00	0.01	3.37	0.16	2.23	61.45	107.42
CD (0.05)	NS	NS	NS	NS	NS	NS	NS	NS
H×P	NS	NS	NS	NS	NS	NS	NS	NS
P×N	NS	NS	NS	NS	NS	NS	NS	NS
N×H	NS	NS	NS	NS	NS	NS	NS	NS
H×P×N	NS	NS	NS	NS	NS	NS	NS	NS

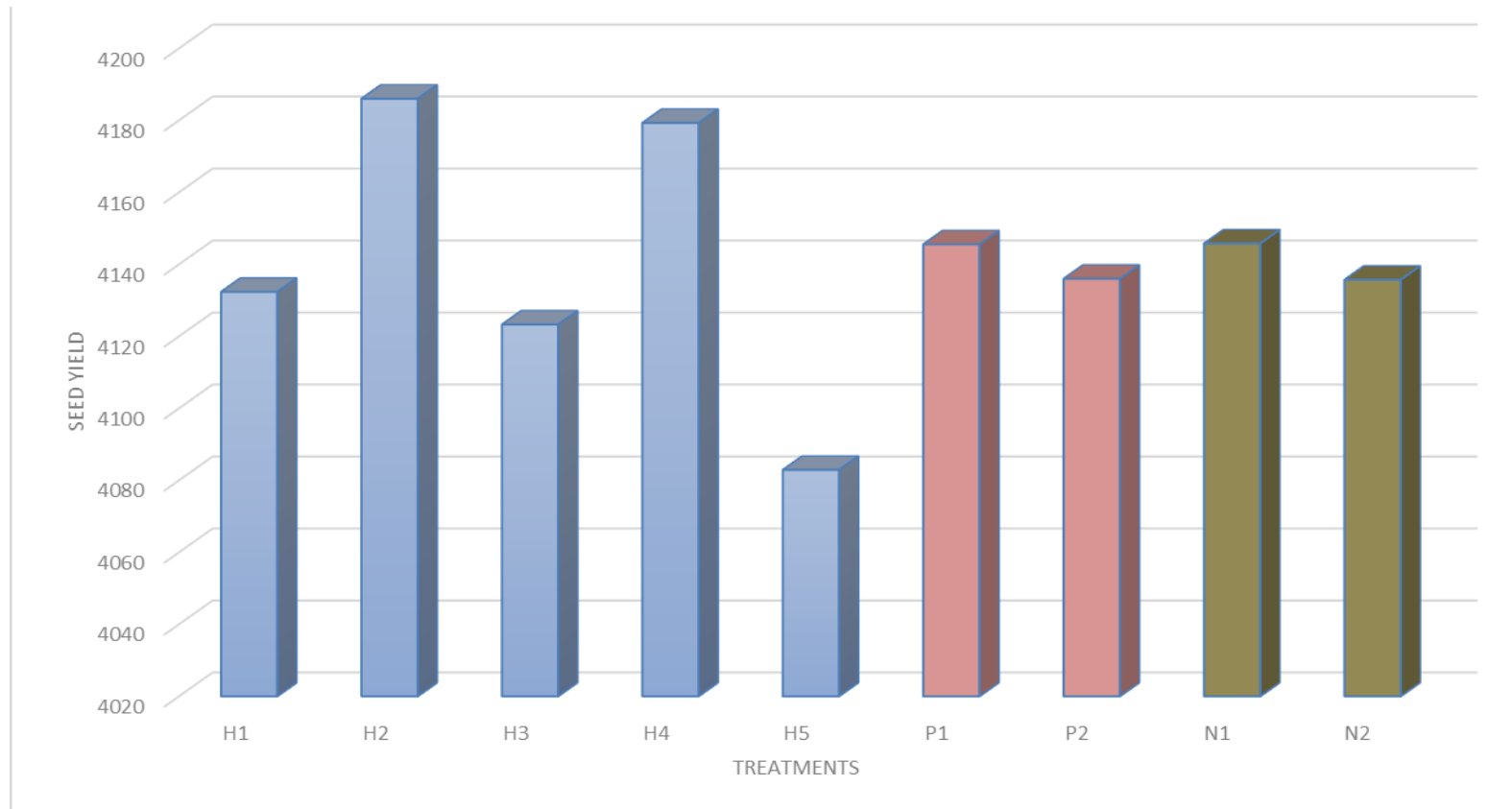


Fig. 1. Effect of humic acid source and dose, phosphorus solubilising bacteria (PSB) and phosphorus nutrition on Seed yield (kg/ha) of rice crop

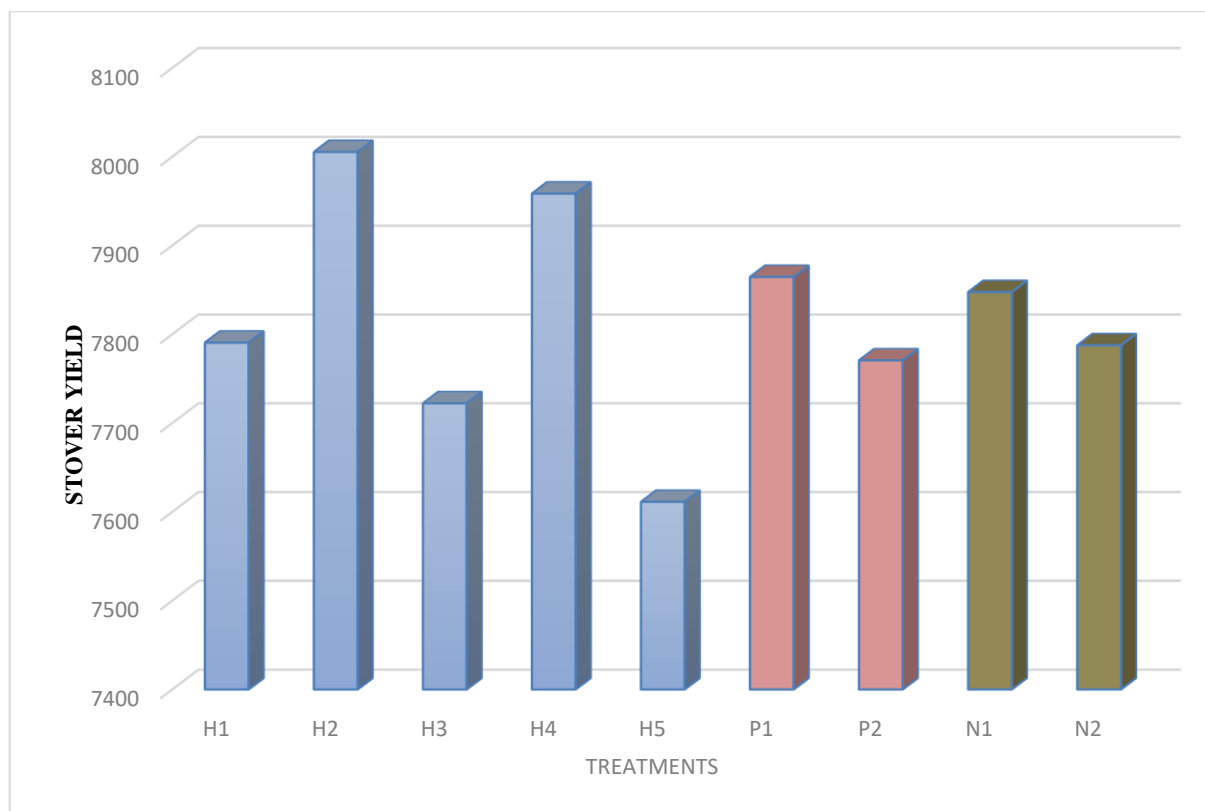


Fig. 2. Effect of humic acid source and dose, phosphorus solubilising bacteria (PSB) and phosphorus nutrition on straw yield (kg/ha) of rice crop

Recommended N:100% Recommended P (15:40 kg/ha)] recorded a numerically higher straw yield (706.71 and kg/ha) than treatment N₂ [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.

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.* [5].

Among the various applications of humic acid, its soil application resulted in seed and stover yield, in comparison to the control group. Similarly, the use of Phosphorous Solubilizing Bacteria (PSB) contributed to comparable outcomes in parameters such as seed and stover yield [8,9]. However, statistical significance was not achieved, possibly due to 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.* [10].

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 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 and yield of rice crop.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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