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PHOSPHORUS UPTAKE AND QUALITY OF BABY CORN AS INFLUENCED BY ARBUSCULAR MYCORRHIZAL FUNGI AND PHOSPHATE SOLUBILIZING BACTERIA

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Abstract

A field experiment was conducted during during kharif season of 2018 to study the response of Arbuscular mycorrhizal fungi (AMF) and Phosphate solubilizing bacteria (PSB) on phosphorus uptake and quality attribute of baby corn. Results reviled that co-inoculation of AMF (75%) and PSB(25%) along with recommended dose of fertilizer (without phosphorus) have a significant impact on phosphorus uptake and the value was at par with RDF (full dose of phosphorus). and quality characters i.e. protein, fiber, starch and ash content.

***Keywords*:** AMF, PSB, Baby corn, Phosphorus uptake, Quality attribute.

Introduction

The structural, physical and agronomical characters of baby corn are different from the grain crop due to the high vigour and rapid growth. Being a C4 plant, the nutrient response of baby corn is very high. This leads to opting the nutrient management system for the higher production. Phosphorus is the component of ATP and plays an important role in respiration and photosynthesis processes. It enhances root development, allowing early growth and vigour to plant (López-Bucio, 2003). It hastens the maturity and raises the resistance against drought and cold temperatures. Plants uptake P in form of primary, secondary and both type of orthophosphate at pH <7.0, >8.0 and neutral.

To make all the macro and micro nutrients available to plants, soil microbial community plays an important role. This community do vital ecosystem assistance such as plant productivity, nutrient cycling, carbon storage, organic matter dynamics etc. (Ascota-Martinez *et al.*, 2010). The Ectomycorrhizal fungi can increase inhabitants of the phosphorus solubilizing bacteria in soil via fungal transude and act as carbon source for the microbes after fungal hyphae dies (Saddiqui and Pichtel, 2008). Arbuscular mycorrhiza is the soil fungi that lives in symbiotic relationship with plant roots (Rodriguez and Sanders, 2014) by colonizing the roots of plants and surrounding soil obtaining carbon compounds and other nutritional requirements (Alizadeh and Nadian, 2010). This high nutritional status has contributed in building up the defence signalling against plant and roots diseases (St-Arnaud *et al.*, 1995; Smith and Read, 2008; Khan *et al.*, 2010). It maintains the soil structure by forming accretion via hyphae networks and biological glue (glomalin) production. Phosphate solubilizing bacteria is used to convert unavailable P form to available through solubilization of precipitated phosphates and mineralization of organic form of P in soil (Chen *et al.,* 2006). The microorganisms secrete organic acids (malic acid, lactic acid, gluconic acid, succinic acid, fumaric and acetic acid) that dissolves the phosphatic mineral and make the inorganic form of soluble P (Iqbal Hussain *et al.*, 2013). In the presence of labile carbon as sink for phosphorus, these bacteria by swiftly immobilizing it even in low P availability in soil (Bünemann *et al.*, 2012). Bacteria performs better than phosphorus solubilizing fungi in potential of solubilizing P in soil as it composes 1-50% of P which is much higher than 0.5-1% P of fungi (Chen *et al.*, 2006). The population of phosphorus solubilizing bacteria rely upon different physiological and chemical properties of the soil and the cultural practices performed on it (Kim *et al.*, 1998).

Materials and Methods

Present study was aimed to investigate the influence of AMF and PSB application on phosphorus uptake and quality (nutritional) aspect of baby corn. Crop was grown under field conditions with seven different treatments i.e. 100% Recommended Dose of Fertilizer (RDF); RDF (without P), RDF (without P) + Mycorrhiza 100%; RDF (without P) + PSB 100%; RDF (without P) + Mycorrhiza + PSB50%; RDF (without P) + Mycorrhiza 75% + PSB 25% and RDF (without P) + Mycorrhiza 25% + PSB 75%. Sequential harvesting was done from each plot and samples were tested for enhanced phosphorus uptake and quality attributes like crude protein, fiber, starch and ash content.

Determination of available phosphorus in soil

Available phosphorus content in the soil was estimated by Olsen's method (Olsen *et al.* 1954). One gram of soil sample was added to 100 ml of flask. 1 ml Darco-G-60 and 20 ml bicarbonate extractant was added to the flask and then it was transferred to the mechanical shaker for 30minutes of shaking followed by filtering the solution with whatman's filter paper no. 40. 5ml of aliquot was taken in to 25 ml volumetric flask. 5 ml of molybdate reagent was pipetted out in the flask and shaken slowly before and after adding 20 ml distilled water for dilution. Final volume was makeup upto 25 ml succeeding the addition of 1 ml working solution of stannous chloride. The blank was also prepared parallel to the test sample without adding soil to it. The reading was taken from the colorimeter by adjusting transmittance reading to 100 with 100-set knob in 10 minutes due to the lack of longer colour stability.

$$\text{Phosphorus content}\left(\frac{\text{kg}}{\text{ha}}\right) = \left(\text{Conc of P from standard curve} \times \text{dilution factor}\right) \times 2.24$$

Determination of total phosphorus in stalk and cob

Quantitative measurement of total phosphorus in baby corn stalk and cob was estimated using the method of Koeing and Johnson (1942). Samples were digested using Diacid

(3:1: Nitric acid: Perchloric acid). 10 ml of dilute was taken in 50 ml volumetric flask and 10 ml of ammonium molybdate vandate was added to it. Volume was makeup upto 50 ml and transmittance/ absorbance were recorded at 420 mμ. Standard curve was also prepared using 0, 1, 2, 3, 4 and 5ml of 50 ppm P solution to 50 ml volumetric flask. Total P (%) was calculated using the formula:

$$\text{Total P}(\%) = \frac{\text{Factor(F)} \times \text{Reading sample} \times 100 \times 100}{10000 \times 1000 \times 10 \times 1}$$

Estimation of crude protein

Crude protein in baby corn cob was estimated using Bradford methods (1976). From each treatment three replicate samples were taken for analysis. The Standard Protein Solution (BSA), bradford regent and 0.2 M Phosphate Buffer was made prior to start of experiment. 0.2-1 ml standard solution was pipetted out into test tubes. The sample weighing 0.5 g and 1 g was taken in another tubes and phosphate buffer and Bradford reagent was added to all making the final volume up to 2 ml. Sample was mixed properly followed by incubation at 37°C for 15 minutes. The blank was also prepared parallel to the test sample without adding sample to it. Finally colour complex was measure at 595 nm. Concentration of protein was estimated using the formula:

$$\text{Concentration of protein} = \frac{\text{OD(test)}}{\text{OD(std)}} \times \frac{\text{Conc(std)}}{\text{Aliquot(test)}} \times 100$$

Estimation of crude fibre

Crude fiber content in cob of baby corn was estimated using method of Van Soest and McQueen, (1973). From each treatment three replicate samples were taken for analysis. The sample weighing 1 g was taken in the crucible, to which 100ml neutral detergent solution, 2 ml Deca hydronaphthalene and 0.5 g sodium sulphite was added. Heating was done till boiling and then left for 60 minutes to let it come near to room temperature. The sample was filtered and rinse with hot water followed by washing with acetone twice. After this, the crucibles were left for 8 hrs. in the hot air oven at 100˚C. The left over residue was ashed in the muffle furnace and the crucible was weighed.

Cell contents = 100 – cell wall constituents

Estimation of ash content

Ash content was estimated using the method of AOAC (2003). The crucible was kept in muffle furnace for 1 hour followed by cooling in desiccator and then weighed (taken as W1). The 2 g of each sample (W2) was put in to the crucible and heated at low flame to char the sample. This charred material was kept in previously set muffle furnace and heated for 6-8 hours till the greyish white ash appears. The crucible was cooled in the desiccator again and weighed (W3).

Estimation of starch

Starch content was estimated using DNS method (Jeong *et al.*, 2010). 0.5 g of sample was taken to which 1.5 ml of 80% ethanol was added. It was then supersonified for 10 minutes followed by centrifugation at 13000 rpm for 10 minutes at 4°C. After discarding the supernatant, 1 ml distilled water, 50 µl 2M sodium acetate and 50 µl of α-amylase (which should be heat resistance and 10-fold diluted) was added to it. It was kept at room temperature for 30 minutes before centrifuging for 10 minutes at 4°C and 13000 rpm. After that, 200 µl of supernatant and dinitrosalicyclic acid reagent was mixed thoroughly. The solution was kept at 100°C for 5 minutes and absorbance was checked at 535 nm.

Statistical Analysis

Data was analysed using SPSS (Tukey) test. LSD values were calculated for those parameters, which exhibited significant difference. Differences between individual means were compared at 5% level of probability.

Results and Discussion

The data of P content in soil as influenced by different doses of AMF and PSB as presented in figure 1. Total available phosphporus in the rhizospheric soil was estimated at different time intervals i.e. 20, 40 and 60 days. At the initial phase i.e. 20 DAS maximum available phosphorus was reported in T1 i.e. 100% RDF and minimum was reported in T2 i.e. control (without RDF). However, at 40DAS a decrease in available P was reported in T1 and T2. i.e. because available phosphorus has been taken up by plants and therefore there was a decline in availability of P. However, in AMF and PSB treated soil increase in available P was reported i.e. because PSB, solubilize the unavailable form of P to available form of P in the soil and also AMF enhance the availability of phosphorus to the plants.

Total phosphorus was also estimated in plant stalk and cob. Maximum P content was reported in the plants treated with full dose on RDF (Figure 2). However it was at par with treatment T3 and T6 i.e. with AMF and coinoculation of mycorrhiza (75%) and PSB (25%). Minimum phosphorus was reported in the plants with no fertilizer application. The increase in P content in coinoculation is due to the transforming and mineralization of in-labile to labile nutrients and creating a favourable environment for the microbial activities that would eventually facilitate the plant root system to uptake the available nutrients. The decurtation trend in T1 and T2 is due to the absence of the biofertilizers.

Protein Content

The data of protein content as influenced by different doses of AMF and PSB have been given in figure 15. It can be concluded from data that significant difference in stem girth of baby corn can be observed at harvesting. Significantly higher protein content was observed in T_6 (17.23 g) which was statistically at par with T_1 (RDF) with 17.21 g followed by T_3 with 17.05 g. The treatments T_5 and T_7 were having significantly equal protein content with the small difference in values.

The sole application of AMF and PSB were having the remarkable difference in content as AMF performed much better than PSB inoculation with value of 16.7 g. The significantly lowest protein content with 5.54 g was observed in control (T_2). The variation in protein content due to the recommended dose of fertilizers and biofertilizers inoculation. The higher availability of nutrients was caused by the release of plant growth promoting bacteria and fungus which enhanced the biochemical reactions increasing the protein content in cobs. The results were supported by Kizilog *et al.* (2001).

Crude Fibre Content

The data of fibre content as influenced by different doses of AMF and PSB have been given in figure 16. It can be concluded from data that significant difference in fibre

content of baby corn can be observed at harvesting. Significantly higher fibre content was observed in T_1 (RDF) with 6.16 g which was statistically at par with T_6 (6.10 g) followed by T_3 with 6.04 g. The treatments T_5, T_7 and T_4 were showing the trend of decurtation in fibre content with the difference of 0.1 g.

The significantly lowest fibre content with 5.54 g was observed in control (T_2). The sole application of AMF and PSB were having the remarkable difference in content as AMF performed much better with 16 % higher fibre than PSB inoculation with 5.73 g. The variation in fibre content due to the recommended dose of fertilizers and biofertilizers inoculation. The higher availability of nutrients was caused by the release of plant growth promoting bacteria and fungus which enhanced the biochemical reactions increasing the fibre content in cobs. The results were supported by Hooda and Katwatra, (2013).

Ash Content

The data of ash content as influenced by different doses of AMF and PSB have been given in figure 17. It can be concluded from data that significant difference in ash content of baby corn can be observed at harvesting. Significantly higher ash content was observed in T_1 (RDF) with 5.76 g which was statistically at par with T_6 followed by T_3 with 5.6 g. The treatments T_5 and T_7 were having significantly equal ash content. The sole application of AMF and PSB were having the remarkable difference in content as AMF performed much better than PSB inoculation with value of 5.6 g and 5.44 g.

The control treatment gave lowest values of 5.1 g of ash content. The variation in ash content due to the recommended dose of fertilizers and biofertilizers inoculation. The higher availability of nutrients was caused by the release of plant growth promoting bacteria and fungus which enhanced the biochemical reactions increasing the ash content in cobs. The results were supported by Hooda and Katwatra, (2013).

Starch Content

The data of starch content as influenced by different doses of AMF and PSB have been given in figure 18. There is no clear difference reported in starch content. It was reported in the range of 15.4 g to 15.43 g. Starch content was observed in T_6 with 15.43 which was statistically at par with T_1 and T_3 with 15.42 g. The treatments T_5 and T_6 were having significantly equal starch content and remained non significant with control (T_1). The sole application of AMF and PSB were having the minute difference in starch content as AMF performed better than PSB inoculation with value of 15.42 g.

The minute variation in starch content due to the recommended dose of fertilizers and biofertilizers inoculation. The higher availability of nutrients was caused by the release of plant growth promoting bacteria and fungus which enhanced the biochemical reactions increasing the starch content in cobs. The results were supported by Hooda and Katwatra, (2013).

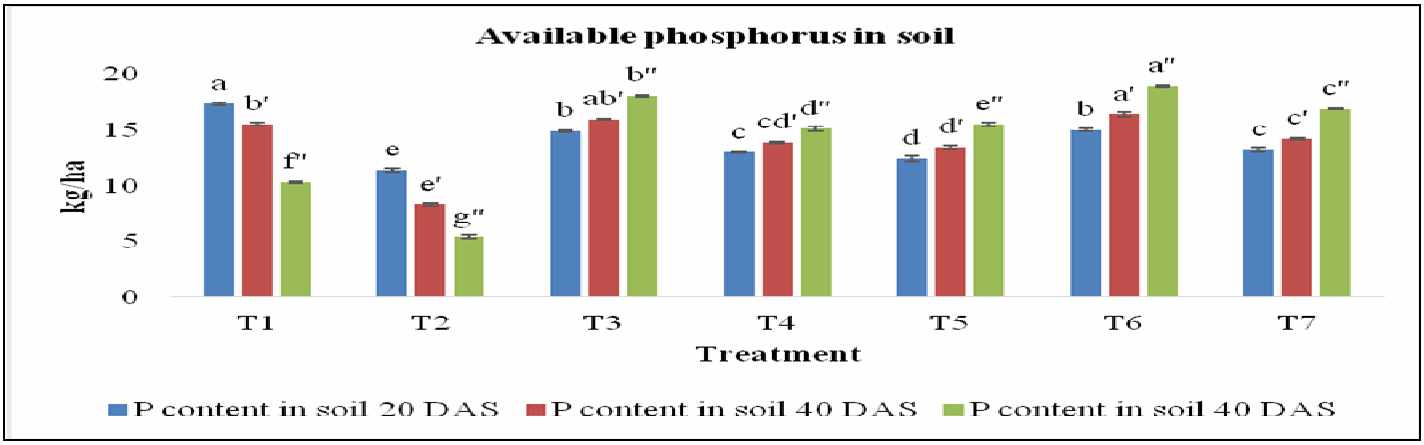

Fig. 1 : P content in soil at 20, 40 and 60 days after sowing where, T_1: RDF; T_2: RDF-P_2O_5; T_3: RDF-P_2O_5+Mycorrhiza; T_4: RDF-P2O5+PSB100%; T_5: RDF-P_2O_5+Mycorrhiza 50% +PSB50%; T_6: RDF-P_2O_5 + Mycorrhiza 75% + PSB 25%; T_7: RDF-P_2O_5 + Mycorrhiza 25% + PSB 75%. Similar Letter to above the bars represents non significance at ($P \leq 0.05$).

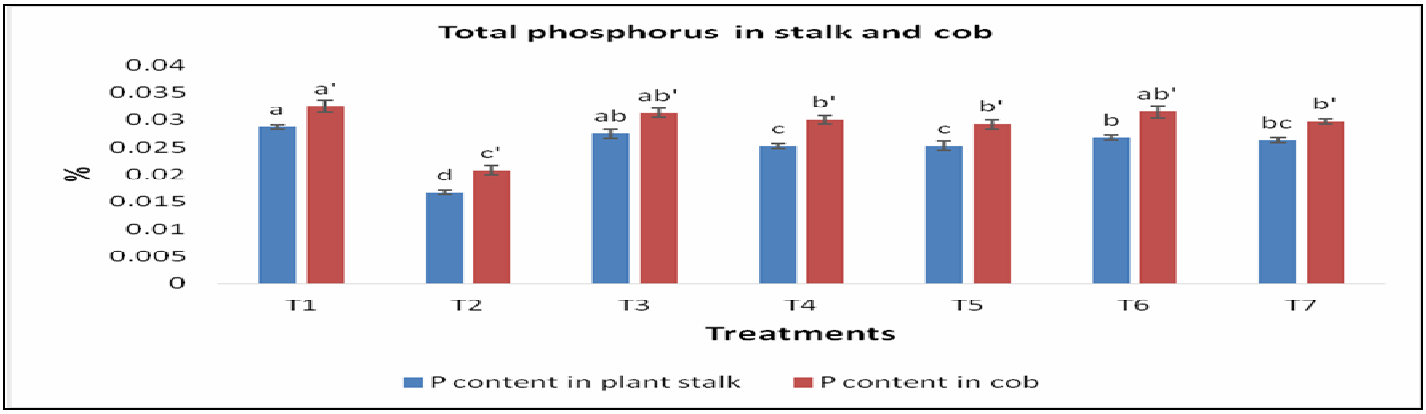

Fig 2 : P content in plant stalk and cob after harvesting where, T_1: RDF; T_2: RDF-P_2O_5; T_3: RDF-P_2O_5+Mycorrhiza; T_4: RDF-P2O5+PSB100%; T_5: RDF-P_2O_5+Mycorrhiza 50% +PSB50%; T_6: RDF-P_2O_5 + Mycorrhiza 75% + PSB 25%; T_7: RDF-P_2O_5 + Mycorrhiza 25% + PSB 75%. Similar Letter to above the bars represents non significance at ($P \leq 0.05$).

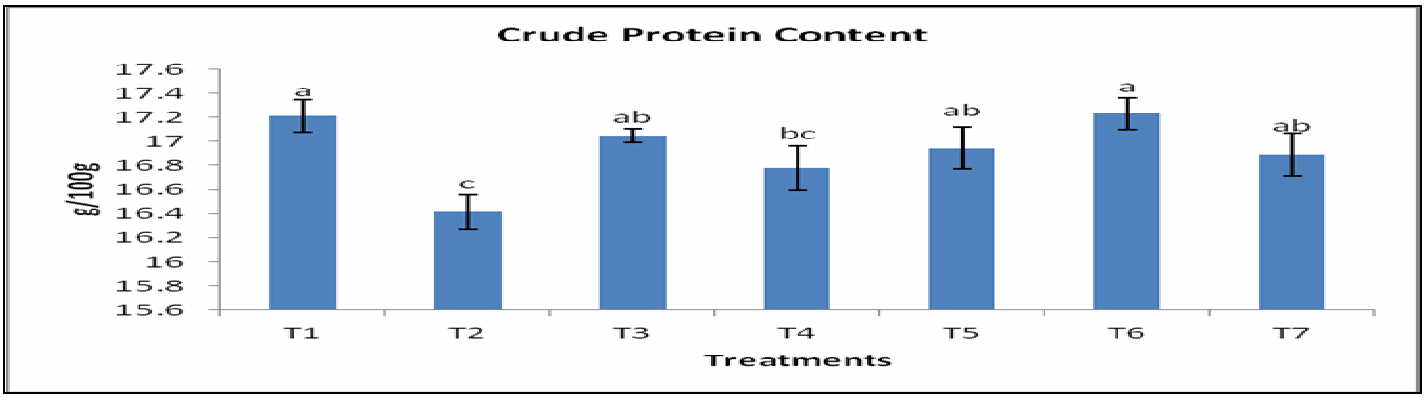

Fig. 3 : Crude Protein in cob after harvesting where, T_1: RDF; T_2: RDF-P_2O_5; T_3: RDF- P_2O_5+Mycorrhiza; T_4: RDF-P_2O_5+PSB100%; T_5: RDF-P_2O_5+Mycorrhiza 50% +PSB50%; T_6: RDF-P_2O_5 + Mycorrhiza 75% + PSB 25%; T_7: RDF-P_2O_5 + Mycorrhiza 25% + PSB 75%. Similar Letter to above the bars represents non significance at ($P \leq 0.05$).

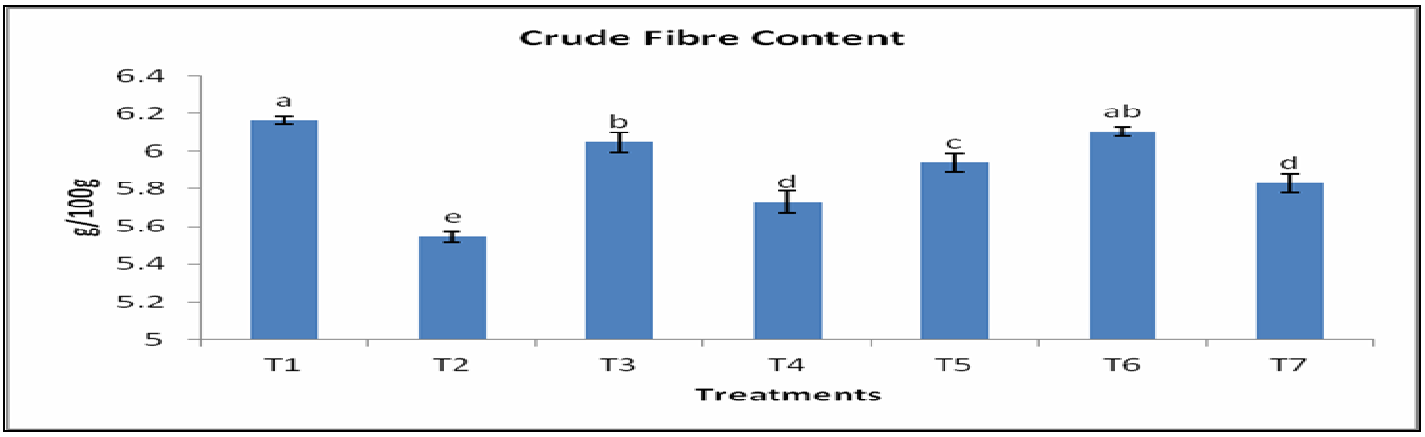

Fig. 4 : Crude Fibre in cob after harvesting where, T_1: RDF; T_2: RDF-P_2O_5; T_3: RDF- P_2O_5+Mycorrhiza; T_4: RDF-P_2O_5+PSB100%; T_5: RDF-P_2O_5+Mycorrhiza 50% +PSB50%; T_6: RDF-P_2O_5 + Mycorrhiza 75% + PSB 25%; T_7: RDF-P_2O_5 + Mycorrhiza 25% + PSB 75%. Similar letter to above the bars represents non significance at ($P \leq 0.05$).

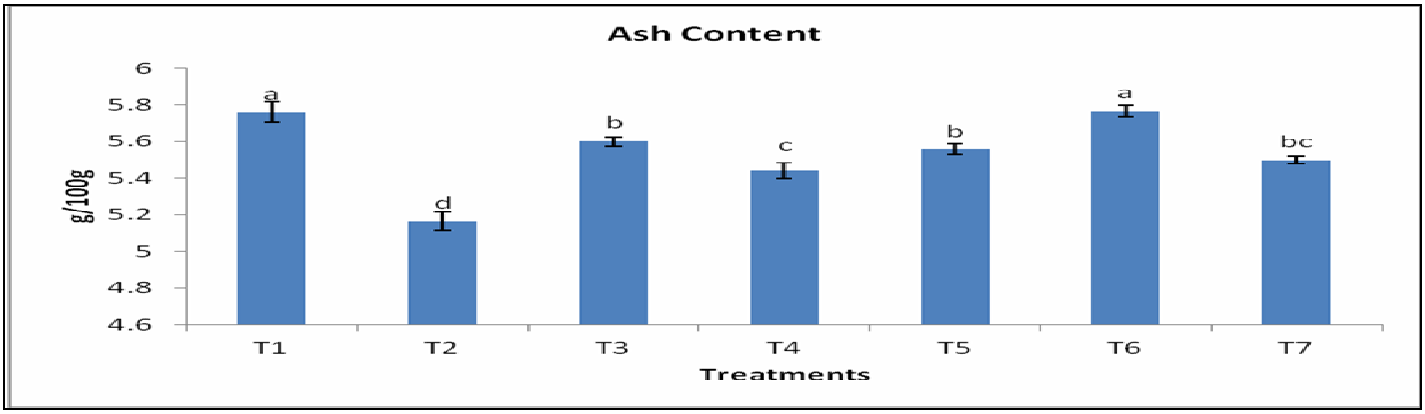

Fig. 5 : Ash Content in cob after harvesting where, T_1: RDF; T_2: RDF-P_2O_5; T_3: RDF- P_2O_5+Mycorrhiza; T_4: RDF-P_2O_5+PSB100%; T_5: RDF-P_2O_5+Mycorrhiza 50% +PSB50%; T_6: RDF-P_2O_5 + Mycorrhiza 75% + PSB 25%; T_7: RDF-P_2O_5 + Mycorrhiza 25% + PSB 75%.Similar Letter to above the bars represents non significance at ($P \leq 0.05$).

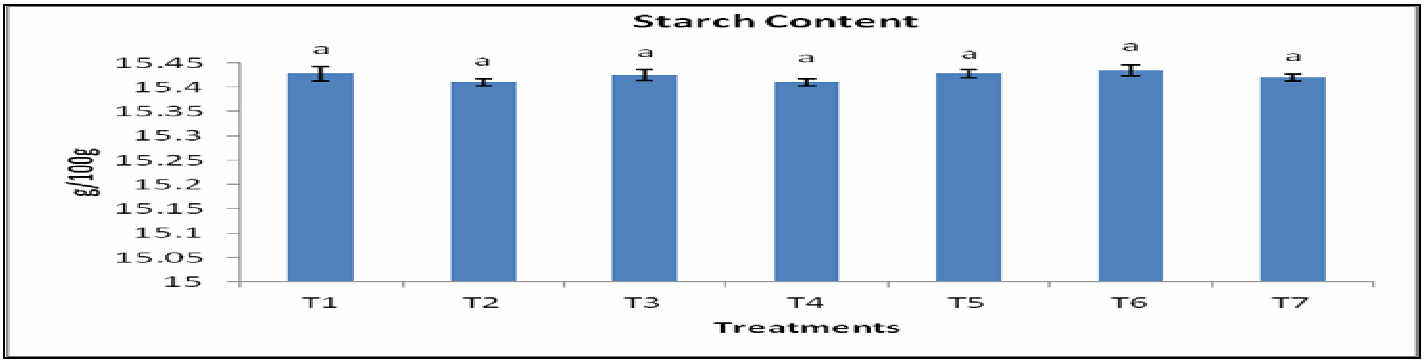

Fig. 6 : Starch Content in cob after harvesting where, T_1: RDF; T_2: RDF-P_2O_5; T_3: RDF- P_2O_5+Mycorrhiza; T_4: RDF-P_2O_5+PSB100%; T_5: RDF-P_2O_5+Mycorrhiza 50% +PSB50%; T_6: RDF-P_2O_5 + Mycorrhiza 75% + PSB 25%; T_7: RDF-P_2O_5 + Mycorrhiza 25% + PSB 75%. Similar Letter to above the bars represents non significance at ($P \leq 0.05$).

Conclusion

From the present investigation, it may be concluded that the AMF and PSB having a significant impact on enhancing the availability of soil phosphorus to the plants that ultimately impact on high nutritional value of baby corn. As compare to PSB; AMF was having the more impact on enhancing quality attributes of baby corn. However, coinoculation of AMF and PSB in the ratio of 75% and 25% of recommended dose was found most effective among all the selected treatments.

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