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Influence of Arbuscularmycorrhizal Fungi and Phosphate Solubilizing Bacteria on Growth and Yield of Baby Corn

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Abstract

The soil phosphorus availability is limited to the plants despite parent material is having abundant amount of phosphorus. In soil, there are several microorganisms which enhance solubility/availability of phosphorus in the soil. The study was aimed to investigate the response ofArbuscularMycorrhiza Fungi (AMF) and Phosphate Solubilizing Bacteria (PSB) on phosphorus availability, growth and yield attributes of baby corn. Different combinations of AMF and PSB were investigated against improved availability of soil phosphorus to the plants. The co-inoculation of RDF (without P) + Mycorrhiza 75% + PSB 25% have a significant impact on growth and yield attributes of baby corn. Yield of baby cob was reported maximum in recommended dose of fertilizer (RDF) however, it was at par with treatment RDF (without P) + Mycorrhiza 75% + PSB 25% and RDF (without P) + Mycorrhiza100%.

Introduction

Maize is a tall annual grass that yields light yellow to orange yellow coloured grains set in rows on a cob. Mesoamerican region is the origin for maize crop. Maize holds a significant importance by considering its utilization as food, feed and fodder for the both humans and animals beside several industrial uses (Yadav et al., 2014). It is a versatile and miracle crop with a phenomenon yield potential therefore, distributed widely all around the world. It has

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the ability to use solar energy more efficiently therefore called as C4 plant (Zhu et al., 2008). It is a heavy feeder of the nutrients with the higher genetic yield potential. The area under maize globally is 177 mha with the overall production and yield of 967 mt and 5.46 t/ha (USDA, 2013-14). In Asia, maize has a commendable role in finance and farming sectors. India Estimated production of maize crop is 27.14 million tonnes on an area of 9.5 lakh hectares during 2017-18.In Punjab, the area under maize cultivation was 1.29 lakh hectares with production of 4.71 lakh metric tons in 2013-14 (Department of Food Processing Punjab 2013).

With the passage of time, alteration in the traditional usage of maize as the victual has been observed. The proliferation in consumption of baby corn is more in big and developed areas (Kleffmann Group, Newsletter, 2019). Baby corn is a small and immature stalk taken from cob which is harvested prior to silking. The desirable length and width of baby corn is from 6-11 cm and 1-1.5 cm. Thailand is the country sharing major contribution in baby corn production followed by Sri Lanka, Taiwan, and India.In India baby corn is famous in Delhi, Uttar Pradesh, Haryana, Meghalaya, Andhra Pradesh, Karnataka and Maharashtra (Pandey et al., 2010).

For proper growth of baby corn, phosphorus plays a major role. It provides strength, good root growth and areal growth to the plant. Soil is having abundant P in the form of parent material however; its availability is highly limited since a major fraction of soil P is in unavailable form. Supplying inorganic source of phosphorus suffice the requirement of crop. However, at present, sustainable agriculture is a huge concern and there is need of shifting from inorganic to organic farming. There are several organic practices available to manage the nutrient requirements of plants. Arbuscularmycorrhizal Fungi (AMF) is the soil fungi that lives in symbiotic relationship with plant roots (Rodriguez and Sanders, 2015) by colonizing

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the roots of plants and surrounding soil obtaining carbon compounds and other nutritional requirements (Alizadeh and Nadian, 2010).Phosphorus 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 P soluble (He et al., 2002).

2. Materials and Methods

Present study was conducted with baby corn (variety 'Prakash') inkharif season, during month of August till October, 2018. A field trial was conducted at Agronomy research field of Lovely Professional University, Jalandhar, Punjab. Location is situated at Latitude at 31.253 N and Longitude at 75.703E at the altitude of 240.0 m above the sea level and in Agronomy post graduate lab as well.The soil belongs to entisols order with the loamy sand texture in upper 60 cm.

2.1 Experimental Details

The design was arranged in Randomized block design with four replications and seven 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)+ Mycorrhiza75%+PSB 25% and RDF (without P) + Mycorrhiza 25% +PSB75%.Overall, 28 experimental plots were made each with an area of 15 m^2(5m×3m). Experimental field was prepared including three ploughingsfollowd by making well-compacted earthen bund from all sides. Microbial cultures (Mycorrhiza and PSB @4 kg $acre^{-1}$ each) were applied in furrows followed by sowing of baby corn seed with spacing of 20×30 cm and placed in 3-4 cm depth (seed rate; 14 kg ha^{-1}).

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2.2 Soil Analysis

Before the sowing of crop, the soil samples were collected from the soil surface (0-15 cm) and analysed in the laboratory. Soil texture was determined by International pipette method (Piper, 1966), physical analysis (bulk and particle density) by core method (Black, 1971), organic carbon by Walkley-Black wet-digesionmethod (Jackson, 1973), pH and Electrical conductivity by using 1:2.5 soil:watersuspension (Sparks, 1996), available N (Subbiah and Asija 1956), available P (Olsen et al. 1954), and available K by using flame photometer (Jackson 1973).

2.3 Growth Parameters and Yield Analysis

Five plants were randomly selected and sampled for taking the measurements of plant growth parameters such as plant height, stem girth and chlorophyll content (SPAD). For yield attributes number of cobs, cob length, cob girth, fodder weight, cob yield and harvest index was determined. The yield was taken from 2 m^2 of area from each plot. To evaluate percent colonization caused by VAM in the plants, root samples from tagged plants were taken from the depth of 30 cm and washed in the running water for the removal of soil followed by tripan blue staining (Vierheilig et al. 2005).

2.4Statistical Analysis

Data was put through analysis of variance protocols as introduced by Bernstein (1926) for Randomized Block Design. Significance among different treatments was assessed using SPSS (Tukey) test. The main significant interactive effects of treatments were separated by Least Significant Differences Test(LSD) at $p < 0.05$.

3. Result and Discussion

3.1 Growth Parameters

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The growth attributes such as plant height, stem girth and chlorophyll content were significantly influenced by VAM and PSB treatments.

3.1.1 Plant Height

The results of plant height as influenced by different doses of AMF and PSB have been presented in figure 1. The inoculation of AMF and PSB has significantly increased the plant height as compared to the non-inoculated treatment while the maximum plant height was attained by the treatment withfull recommended dose of N, P and K (T1) as synthetic fertilizers at the appropriate intervals with 55.5 to 183.5 cm from 20 to 60 days after sowing.

The coinoculationof both the biofertilizers (RDF (without P) + AMF 75% + PSB 25%) was significantly at par with T1, having plant height 53.2, 142.5 and 181.2 at 20, 40 and 60 DAS respectively than that of chemical fertilizer applied treatment. The lowest height of plant was noticed in control as 48.7, 126and 162 at subsequent stages of corn due to the less availability of P. The treatment with sole application of AMF was recorded better plant height than the PSB which may be due to the improved physical soil conditions by AMF.

The biofertilizers showed maximum increase in height after 20-25 days from sowing due to mineralization of organic P and better absorbing network of hyphae which enhanced the partition of stem whereas in control it goes on decreasing till 60 DAS as compared to other treatment plants. The close conformity of results reported by Singh et al. (2018) by getting enhanced plant height using recommended dose of macronutrients in combination with organic fertilizers.

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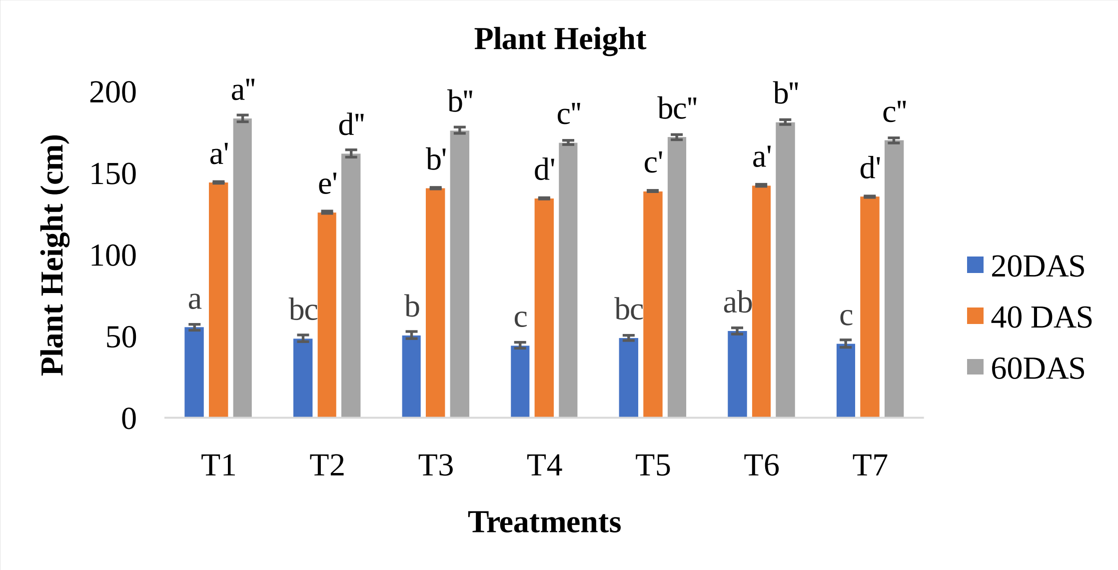

Figure 1: Plant heightat 20, 40 and 60 days after sowing. Where, T_1: RDF; T_2: RDF(without P); T_3: RDF(without P) +Mycorrhiza; T_4: RDF(without P) +PSB100%; T_5: RDF(without P) +Mycorrhiza 50% +PSB50%; T_6: RDF(without P) + Mycorrhiza 75% + PSB 25%; T_7: RDF(without P) + Mycorrhiza 25% + PSB 75%. Similar Letter to above the bars represents non significance at ($P \leq 0.05$).

3.1.2 Stem Girth

Stem girth as influenced by different doses of AMF and PSB is presented in figure 5. Inoculation of AMF and PSB has significantly increased the stem girth as compared to the non-inoculated treatment while the highest stem girth was attained by the treatment with full recommended dose of N, P and K with 2.42, 5.54 and 7.61 cm.

The coinoculation of both the biofertilizers (RDF (without P) + AMF 75% + PSB 25%) was significantly at par having girth of 2.35, 5.47 and 7.52 cm as compared to chemical fertilizer applied treatment followed by the sole application of AMF as 2.25, 5.39 and 7.39 at 20, 40 and 60 days after sowing. The minimum stem girth of plant was noticed in control with 1.88, 3.77 and 5.13 cm at subsequent stages of corn due to the less availability of P. The development in girth was almost similar till 15-20 days from sowing but later biofertilizers showed maximum increase whereas in control it got decreased till 60 DAS as compared to

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other treatment plants. The biofertilizers inoculation have significant effect on the stem girth from initial to later stages till harvesting due to higher uptake and accumulation of nutrients, promoting the vegetative growth in plant maintaining the soil fertility. Results are in close proximity to results reported, Wagh (2002) and Singh (2018) reporting significantly higher crop growth parameters.

3.1.3 Chlorophyll Content

The highest chlorophyll content was obtained in T1 i.e. 41.9 and 44.8 SPAD unit followed by T6 with a slight fall up to 39.97 and 42.51 SPAD unit at 30 and 60 days after sowing (Figure 3). The lowest photosynthetic activity was performed by T2 (34.27 and 35.12 SPAD unit) because of minimum amount of P level following T5 with 35.3 and 36.9 SPAD unit chlorophyll content. The treatments showed very less difference in chlorophyll at 60 days as compare to 30 DAS due the higher amylate storage capacity in leaves at younger stages which goes on decreasing as the plant proceeds to maturity. The chlorophyll content of plant leaves was taken by usingSPAD meter at 30 and 60 days after sowing. The deficiency of P content may therefore restrict the chlorophyll synthesis resulting in to chlorosis. It happened due to the synergistic effect of AMF and PSB on the crop plant and converting the tri-calcium phosphate to mono and di-basic phosphates resulting into increased availability of nutrients. The positive effect of AMF and PSB application on growth can directly influence chlorophyll content in plant (Sheng, 2008).

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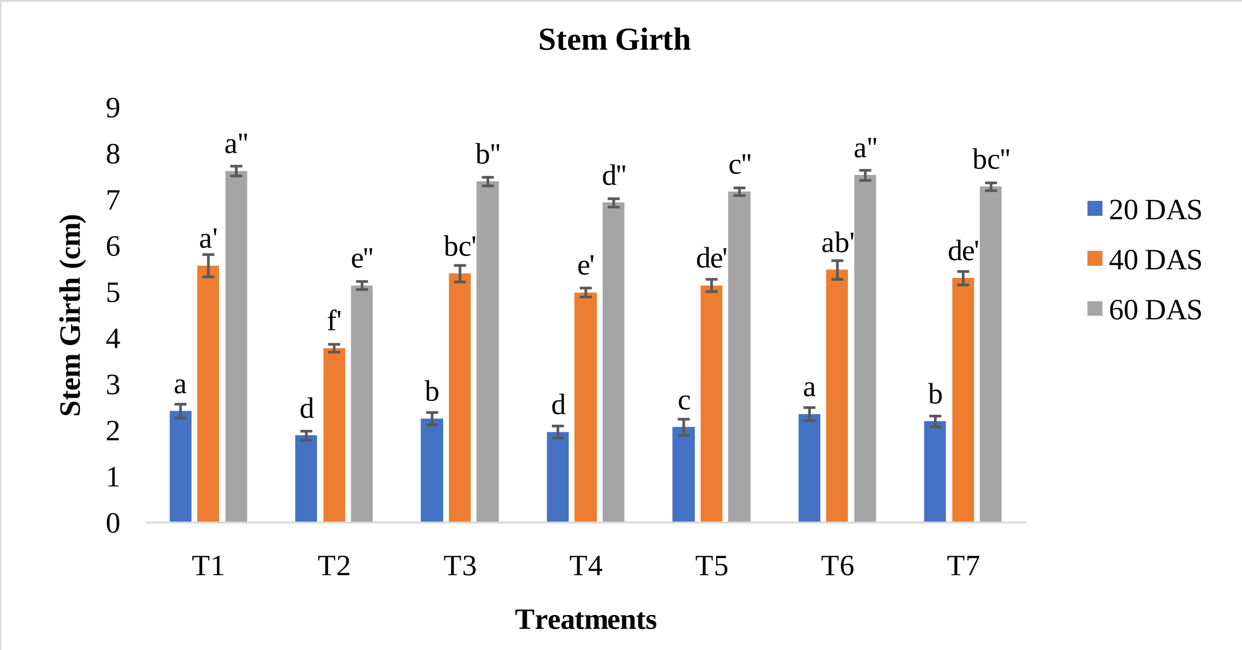

Figure 2: Stem Girth at 20, 40 and 60 Days After Sowing. Treatment details are similar as mentioned above in Figure 1.

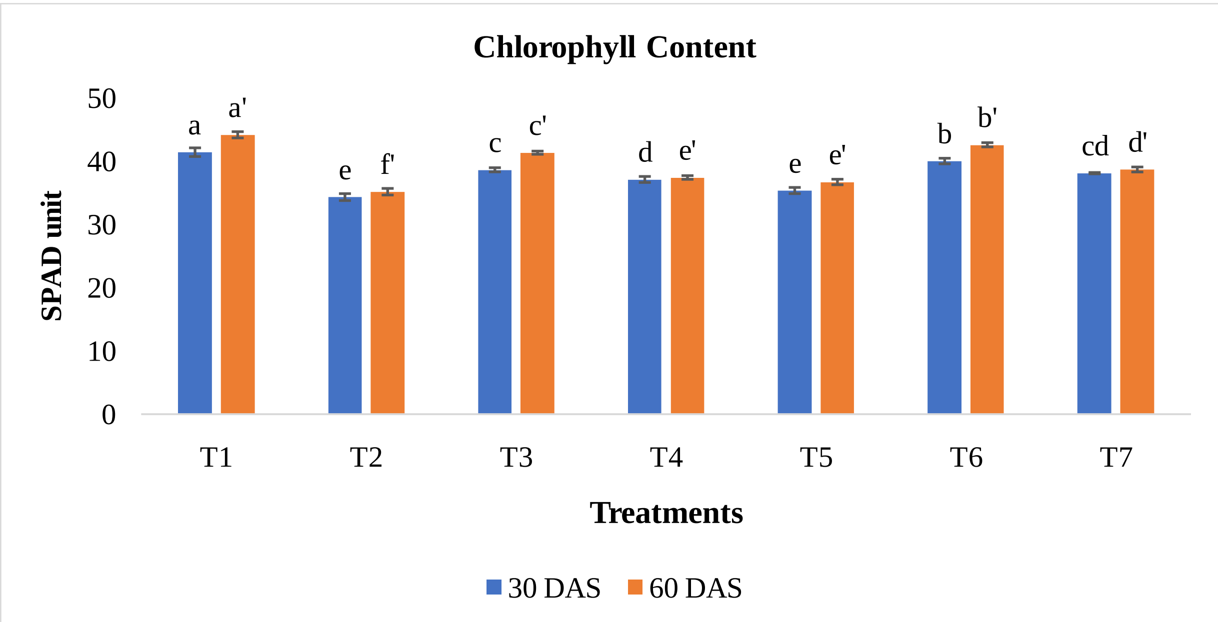

Figure 3: Chlorophyll Content at 30 and 60 Days After Sowing. Treatment details are similar as mentioned above in Figure 1.

3.2 Yield Parameters

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The yield attributes such as number of cobs, cob length and girth, dry matter weight, yield with and without husk, green fodder and harvest index were significantly influenced by AMF and PSB treatments.

3.2.1 Cob Attributes

Number of cobs per plant was directly influenced by different doses of AMF and PSB (Figure 4). The result of recommended dose of chemical fertilizers (N, P, K) and the biofertilizers (RDF (without P) + AMF 75% + PSB 25%) was at par i.e. 2.7 cobs per plant as the P dose was fulfilled by combination of both. The early emergence was too seen in both of the above treatments. The effect of AMF was more than PSB inoculation with early reproductive maturity of baby corn while the average numbers of baby corns were 2.5 and 2.2 cob per plant. The plants under control treatment were having a lesser number of baby corns with an average 1.5 and even the cob emergence was also late as compared to all other along with late emergence.

The longest cob was obtained from T1 (RDF) which was significantly equal to the application of co-inoculated biofertilizers, i.e. T6 (RDF (without P) + AMF 75% + PSB 25%) with 10.67 and 10.52 cm while the shortest length was of control (RDF (without P)) 8.05 cm of length. The treatments with individual inoculation of AMF (100%) and PSB (100%) coupled with RDF omitting P were having the difference of about 0.8 cm in the length of cobs.The cobs under control were showing P deficiency symptoms by not only decrease in length up to 8.05 cm but also by having purple spots on cob husk.

The girth of cob was maximum in T1 (RDF) and T6 i.e. 4.57 and 4.42 cm respectively. The width of cobs in all the other treatments was at par except the control (RDF (without P)) with least cob girth of 3.87 cm. The girth was less in control due to low availability of P content and lack of proper development in vegetative as well as in reproductive stages.

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Cob yield (with and without husk) was also estimated (Figure 5) for all the treatments. It is reported that as compare to T2 (without P) all treatments having a significant impact on yield. Maximum cob yield was reported in T1 (RDF) and T6 i.e. 82.75and 80.5 q/ha (with husk) and 13.0 and 12.9 q/ha (with husk) respectively.

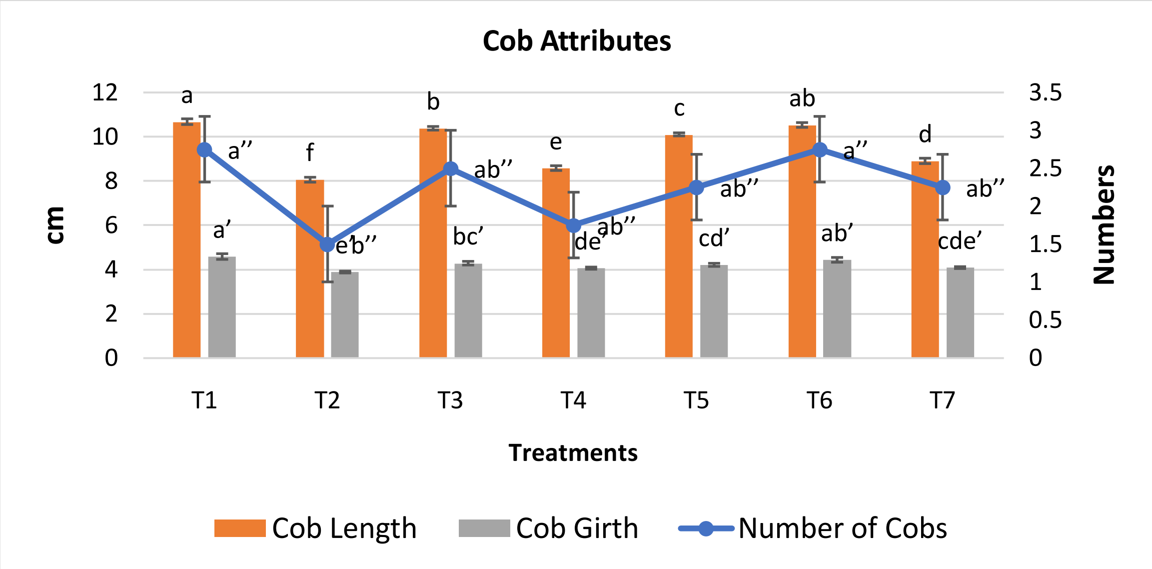

Figure 4: Number of cobs, cob length and girth at harvesting.Treatment details are similar as mentioned above in Figure 1.

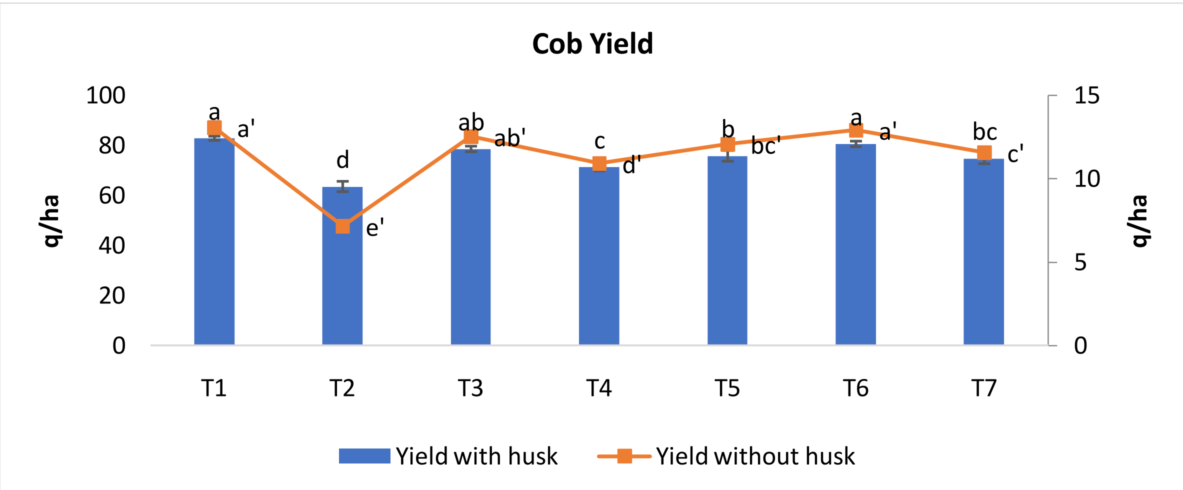

Figure 5: Yield of cob with and without husk. Treatment details are similar as mentioned above in Figure 1.

3.2.2 Fodder Weight

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Fresh and dry fodder weight was also estimated (figure 5). Fresh fodder weight was reported in the range of 233.5 to 336.2 q/ha for T2 and T6 respectively. Similarly dry fodder weight was reported in the range of 46.7 to 67.6 q/ha for T2 and T6 respectively. As compare to absolute control (T2 i.e. without P) a significant increase was reported in all the treatments and response of T6 is at par with T1 (RDF).

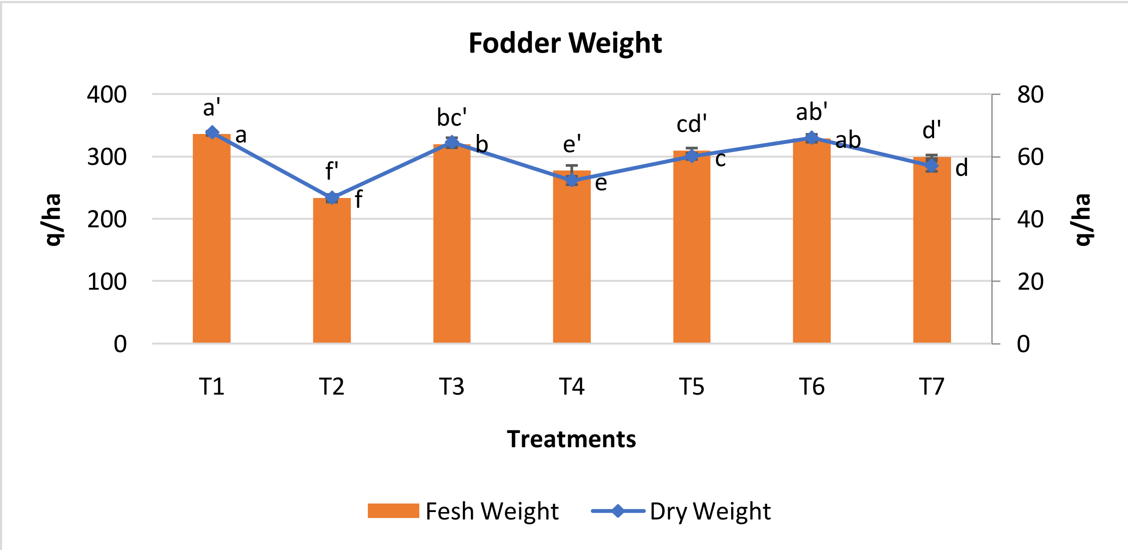

Figure 6: Fodder weight after harvesting. Treatment details are similar as mentioned above in Figure 1.

3.2.3 Harvest Index

A significant difference in harvest index of baby corn was observed (Figure 7). The harvest index was significantly highest in T6 with 16.03% followed by T3 (15.95%) and T5 (15.94%) which were statistically at par. The value of T1 was significantly lower with 15.74% of harvesting index. The sole application of AMF and PSB were having the remarkable difference in index as AMF performed much better than PSB inoculation with values of 15.95% and 15.31%. The significantly lowest index value 11.22% was noticed in control. The enhanced dosage of macronutrient with the combined application of RDF and biofertilizers in different quantities leads to improved growth and development of plant

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resulting in increased economical and biological yield. The similar results were reported by Mahapatra (2018) by using biofertilizers in baby corn.

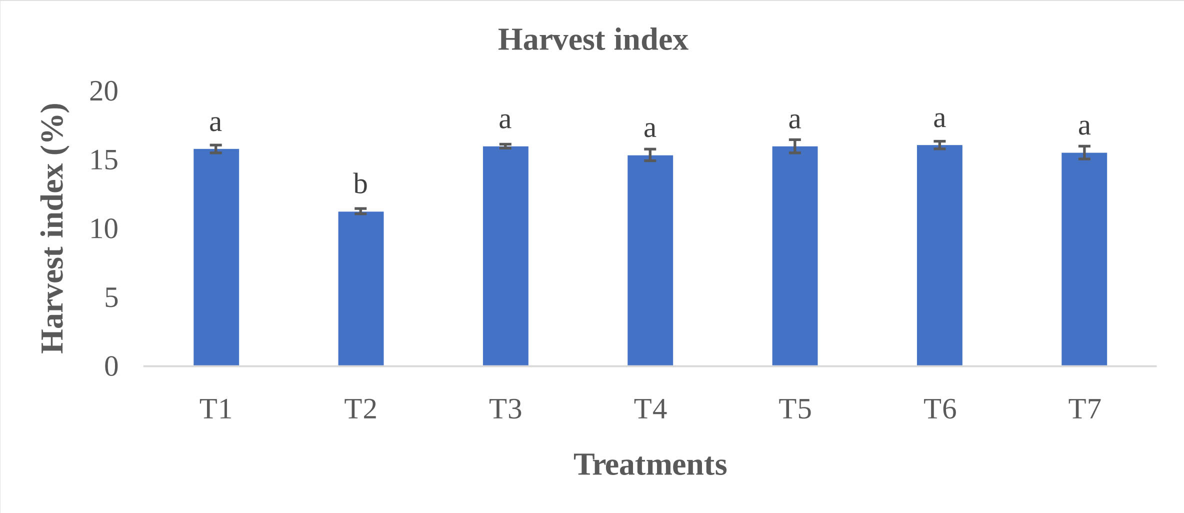

Figure 7: Harvest index after harvesting.Treatment details are similar as mentioned above in Figure 1.

Conclusion

From the present investigation, it can be concluded that application of RDF (without P) + Mycorrhiza 75%+ PSB 25% is more beneficial for growth and yield parameters of baby corn. The soil physiochemical properties were adversely affected by transforming and mineralization of in-labile to labile nutrients and creating a favorable environment for the microbial activities that would eventually facilitate the plant root system to uptake the available nutrients. The combination of organic and inorganic fertilizers is an eco-friendly symbiotic method of cultivation which can further help to achieve our goal of sustainable agriculture.

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