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Effect of biofertilizers with different levels of nitrogen and phosphorus on growth and growth attributes of baby corn (*Zea mays* L.)

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Abstract
A field experiment was carried out to study the effect of biofertilizers with different levels of nitrogen and phosphorus on growth and growth attributes of baby corn (*Zea mays* L.). The experiment was laid out in randomized block design with twelve treatments combination *viz.*T_1(60 kg h^{-1} N+ 50 kg h^{-1} P+ *Azotobacter*), T_2(60 kg h^{-1} N+50 kg $^{h-1}$ P+ *Azospirillum*),T_3(60 kg h^{-1} N+ 75 kg h_{-1}+ Azotobacter), T_4(60 kg h^{-1} N+5 kg h^{-1} P+ *Azospirillum*), T_5(80 kg h_{-1} N+ 50 kg h^{-1} P+ *Azotobacter)*, T_6 (80 kg h^{-1} N+50 kg h^{-1} P+ *Azospirillum)*, T_7(80 kg h^{-1}N+ 75 kg h^{-1} P+ *Azotobacter*), T_8(80 kg h^{-1} N 75 kg h^{-1} P +*Azospirillum*), T_9(100 kg h^{-1}N+ 50 kg h^{-1}P+ *Azotobacter*), T_{10}(100 kg h^{-1} N+50 kg h^{-1} P + *Azospirillum*), T_{11}(100 kg h^{-1} N + 75 kg h^{-1} P + *Azotobacter*) and T_{12}(100 kg h^{-1} N+ 75 kg h^{-1} P + *Azospirillum*) in three replications. In general, application of different levels of nitrogen, phosphorus and seed treatment with *Azotobacter* and *Azospirillum* significantly influenced the growth and growth attributes of baby corn. Statistically Significantly higher average plant height (57.45cm), number of leaves per plant (8.31), dry matter production per plant (33.61 g) and leaf area (1852.80 cm^2) were recorded in treatment T_{12} due to application of 100 kg ha^{-1} N and 75 kg P ha^{-1} along with *Azospirillum* at different crop growth stages as compared to rest of the treatments. Furthermore, chlorophyll concentration before and after tasselling were significantly influenced by different treatments, among the treatments application 100 kg ha^{-1} N and 75 kg P ha^{-1} along with *Azospirillum* registered significantly higher chlorophyll concentration before tasselling (53.87%) and after tasselling (44.0%) as compared to other treatments. However, application of 100 kg ha^{-1} N and 75 kg P ha^{-1} along with *Azospirillum* recorded less number of days to tasselling (45.45) and days to cob emergence (49.45) respectively.

Keywords: Baby corn, biofertilizers, growth and growth attributes, nitrogen, phosphorus

Introduction
Corn has been considered a third important crop in Afghanistan next to wheat and rice. Baby corn is an important crop of Thailand, Taiwan and India; recently, baby corn has gained popularity as valuable vegetable in Delhi, Uttar Pradesh, Haryana, Maharashtra, Karnataka, Andhra Pradesh, Rajasthan and Meghalaya States of India. In India, it is grown on 9.43 m ha area with the production and productivity of 24.35 m t and 2583 kg ha^{-1}, respectively. Baby corn production being a recent development has proved enormously successful in countries like Thailand, Taiwan, Sri Lanka and Myanmar. The countries like Zambia, Zimbabwe and South Africa have also started cultivation. Today, Thailand and China are the world leaders in baby corn production. Attention is now being paid to explore its potential in India for earning foreign exchange besides higher economic returns to the farmers. Baby corn cultivation is now picking up in Meghalaya, Western Uttar Pradesh, Haryana, Maharastra, Karnataka and Andhra Pradesh. (Singh *et al*., 2015) [11]. Baby corn (*Zea mays* L.) is very young cob with undeveloped seeds, obtained from a corn plant at about 45-60 days after sowing or 2-3 days after silking. In baby corn processing, uniform size of the corn is very important. Baby corn provides tremendous avenues for crop diversification, value addition and revenue generation as this new vegetable is becoming increasingly popular among progressive farmers around big cities. The corn ear used as vegetable for cooking purpose is popularly known as baby corn. The young fresh finger like green ear is harvested before or just at the time of silk emergence as a vegetable. Its flavor and crispy nature contribute to increasing popularity making as an indispensable ingredient in many fancy dishes today. It is well established that improvement in productivity, soil fertility status and economic returns could be made possible with combined application of organic and inorganic fertilizer. Baby corn is dehusked maize ear, harvested

young especially when the silk have either not emerged or just emerged and no fertilization has taken place or we can say the shank with un pollinated silk is baby corn. The economic product is harvested just after silk emergence (1-2 cm long). Baby corn is used as an ingredient in choosey (chines dish), soup, deep fried baby corn with meat, rice and other vegetable. Baby corn production has proved an enormous successful venture in many foreign countries. Attention is now being paid to explore its potential in India. Shifts in living standards of people and changes in food habits from non-vegetarian to vegetarian diet may make the cultivation of baby corn popular (Dadarwal. 2009)[3]. Nitrogen is a vital plant nutrient and a major yield determining factor required for Baby corn production. It is very essential for baby corn growth and also enhances the utilization of P. An adequate supply of N is associated with dark green colour, high photosynthetic activity and vigorous growth. When nitrogen supply is adequate and the conditions are favorable for growth. Nitrogen is an essential element for both fodder quantity and quality as it is a component of chlorophyll. It is thus, essential for photosynthesis, vegetative and reproductive growth and it often determines yield of baby corn (Kheibari *et al*., 2012) [6]. Phosphorus among other things is essential, for cell membranes, chloroplast and mitochondria, ATP, ADP, nucleic acids, phospholipids and plays an important role in energy transformations and metabolic processes in plant including root growth. It is inevitable for cell differentiation and development of tissue. Phosphorus is essential for cell division because it is a constituent element of nucleoprotein which is involved in the cell reproduction processes. It is important for seed formation and crop maturation. Phosphorus hastens the ripening of seed thus counteracting the effect of excess nitrogen application to the soil. It helps to strengthen the skeletal structure of the plant thereby preventing lodging. However, the requirement and utilization of these nutrients (nitrogen and phosphorus) in baby corn depends on environmental factors like rainfall, varieties and expected yield (Kheibari *et al*., 2012) [6]. Biofertilizers play an important role in increasing availability of nitrogen and phosphorous. Biofertilizers are microbial inoculants of selective microorganisms like bacteria, algae, fungi, already existing in nature. They increase the biological fixation of atmospheric nitrogen and enhance phosphorous availability to baby corn crop. Therefore, introduction of efficient strain of *Azospirillum* in the soil which is poor in nitrogen may be helpful in boosting up production and consequently more nitrogen fixation. Among several bio agents, *Azospirillum*, and *Azotobacter* is known to fix atmospheric nitrogen and increased about 10-15 per cent grain yield in baby corn. On an average 20 and 22 kg of nitrogen ha^{-1} can be saved by inoculation of baby corn seed before sowing with *Azotobacter* or *Azospirillum*, respectively. Many researchers optimistically predicted that microorganisms (*Azotobacter* and *Azospirillum*) associations could be lucratively managed to reduce dependence on chemical fertilizers, but promises concerning the applied value of *Azotobacter* in agriculture have been more rhetorical than deliverable (Dawson *et al*,.2017) [4].

Methodology

The present experiment was carried out at Agronomy Crop Research Farm, Naini Agricultural Institute, Sam Higginbottom University of Agriculture, Technology and Sciences, Allahabad, Uttar Pradesh, India during summer season, 2019 in Randomized Block Design with three replications. Baby corn *G-5414* variety was chosen for the study. The treatments were consisting of twelve combinations of different levels of nitrogen and phosphorus treated with biofertilizers *viz*. T_1(60 kg h^{-1} N + 50 kg h^{-1} P + *Azotobacter*), T_2 (60 kg h^{-1} N+ 50 kg $^{h-1}$ P + *Azospirillum*),T_3(60 kg h^{-1} N+ 75 kg h_{-1}+ Azotobacter), T_4(60 kg h^{-1} N + 5 kg h^{-1} P+ *Azospirillum*), T_5(80 kg h_{-1} N+ 50 kg h^{-1} P+ *Azotobacter)*, T_6 (80 kg h^{-1} N+50 kg h^{-1} P+ *Azospirillum)*, T_7(80 kg h^{-1}N+ 75 kg h^{-1} P+ *Azotobacter*), T_8(80 kg h^{-1} N 75 kg h^{-1} P + *Azospirillum*), T_9(100 kg h^{-1}N+ 50 kg h^{-1}P+ *Azotobacter*), T_{10}(100 kg h^{-1} N+50 kg h^{-1} P + *Azospirillum*), T_{11}(100 kg h^{-1} N + 75 kg h^{-1} P + *Azotobacter*) and T_{12}(100 kg h^{-1} N+ 75 kg h^{-1} P + *Azospirillum*). The soil of the experimental area was sandy loam with moderately alkaline pH (7.14), available N (159.80 kg ha^{-1}) and medium in available P (14.39 kg ha^{-1}) during the year 2019. Before Sowing Baby corn seeds were pre-treated with bio fertilizers and sown were dibbled @ the rate of 2-3 seeds/hole grown at 45 × 20 cm spacing with line and covered with the soil. Chemical fertilizers as basal dose @ 120:60:40 Kg ha^{-1} (N: P_2O_5:K_2O) was applied at the time of sowing. The entire quantity of P and half the recommended doses of N and full does K were applied as basal and remaining quantity of N were top dressed at knee high stage (25 DAS) of Baby corn. Standard cultural Practices were followed and irrigation was given as per requirement. Plant height of five randomly selected baby corn plants was recorded at and interval of 10 days and it was measured from the base of the plants to the tip of last fully emerged leaf, average value for each treatment was computed and expressed in cm. Number of leaves per plant of baby corn and component crops were counted from five tagged plants in each plot and the mean value was calculated. Leaf area of baby corn was measured from the base to the tip, the leaf breadth was taken at the midst point of the leaf lamina, the product of the leaf length and breadth was multiplied by the factor 0.75 and the sum of all the leaves was expressed as leaf area in cm^2 plant. To determine the plant dry weight for baby corn five plants were randomly uprooted from sampling zone of each plot, the samples were air dried and then kept in oven for 72 hours at 70º C, dry weight per plant was then calculated and the average was expressed in $plant^{-1}$(Reddy *et al* 2009) [11]. Readings for chlorophyll were performed using the portable meter of chlorophyll SPAD-502 (Soil- Plant Analysis Development (SPAD) Section, Minolta Camera Co., Ltd, Japan) (Araújo *et al*. 2017) [1].

Result and Discussion

In general, growth and growth attributes of baby corn significantly influenced by N, P and biofertilizers at different crop growth stages. Among the treatments statistically significantly average of higher plant height (57.45cm), number of leaves per plant (8.3), dry matter production per plant (33.61g) and leaf area (1840.37cm^2) recorded in treatment with application of 100 kg ha^{-1} N and 75 kg P ha^{-1} along with *Azospirillum* at different crop stages as compared to rest of the treatments. Furthermore, chlorophyll concentration before and after tasselling were significantly influenced by different treatments, among the treatments application of 100 kg ha^{-1} N and 75 kg P ha^{-1} along with *Azospirillum* registered significantly higher chlorophyll concentration before tasselling (53.87%) and after tasselling (44.0%) as compared to other treatments. However, application of 100 kg ha^{-1} N and 75 kg P ha^{-1} along with *Azospirillum* recorded significantly less number of days to tasselling (45.45) and days to cob emergence (49.45) respectively.

Statistically significantly higher growth and growth attributes in treatment with application of 100 kg ha^{-1} N and 75 kg P ha^{-1} along with *Azospirillum* might be due to adequate nitrogen application which increases the cell division, cell elongation, nucleuses formation as well as green foliage. It also encourages the shoots growth. Therefore, higher dose of nitrogen and phosphorus increased the chlorophyll content which increased the rate of photosynthesis and extension of stem resulting increased plant height (Hooda and Kawatra 2013) [5]. Inoculation of *Azospirillum* showed significantly taller plant as compared to *Azotobacter* at different crop growth stages and this might be due to the growth promoting effect showed by the beneficial microbe. This finding is also supported by Bhaladhare *et al.* (2018) [2], Kumar *et al.* (2007) [8], Kole (2010) [7] and (Rafiq *et al.* (2010) [9].

Table 1: Effect of different levels of nitrogen and phosphorus along with seed inoculation with *Azotobacter* and *Azospirillum* on plant height (cm), Number of leaves per plant, Dry production and Leaf area at different crop growth stages in baby corn

Treatments	Average of Plant height, No of Leaves, Dry matter production and Leaf area at 10,20,3040 and 50 DAS			
	Plant Height (cm)	Number of leaves plant $^{-1}$	Dry matter production (g plant^{-1})	Leaf area (cm^2)
T_1: 60 kg h^{-1} N+ 50 kg h^{-1} P+ *Azotobacter*	42.71	7.03	12.39	1670.41
T_2: 60 kg h^{-1} N+50 kg h^{-1} P+ *Azospirillum*	43.57	7.15	12.81	1705.04
T_3: 60 kg h^{-1} N+ 75 kg h^{-1}+ *Azotobacter*	44.83	7.24	13.66	1709.78
T_4: 60 kg h^{-1} N+5 kg h^{-1} P+ *Azospirillum*	45.57	7.37	14.54	1713.16
T_5: 80 kg h^{-1} N+ 50 kg h^{-1} P+ *Azotobacter*	46.37	7.45	14.95	1732.53
T_6: 80 kg h^{-1} N+50 kg h^{-1} P+ *Azospirillum*	48.44	7.53	15.30	1772.08
T_7: 80 kg h^{-1}N+ 75 kg h^{-1} P+ *Azotobacter*	51.20	7.71	15.60	1783.28
T_8: 80 kg h^{-1} N 75 kg h^{-1} P +*Azospirillum*	51.92	7.75	17.01	1784.92
T_9: 100 kg h^{-1}N+ 50 kg h^{-1}P+ *Azotobacter*	53.15	7.79	17.65	1820.56
T_{10}:100 kg h^{-1} N+50 kg h^{-1} P + *Azospirillum*	53.39	7.96	22.06	1829.05
T_{11}: 100 kg h^{-1} N + 75 kg h^{-1} P + *Azotobacter*	54.00	8.03	25.83	1840.37
T_{12}: 100 kg h^{-1} N+ 75 kg h^{-1} P + *Azospirillum*	57.45	8.31	33.61	1852.80
S.Em.±	1.18	0.15	0.77	2.48
C.D. at 5%	3.47	0.43	2.27	7.26

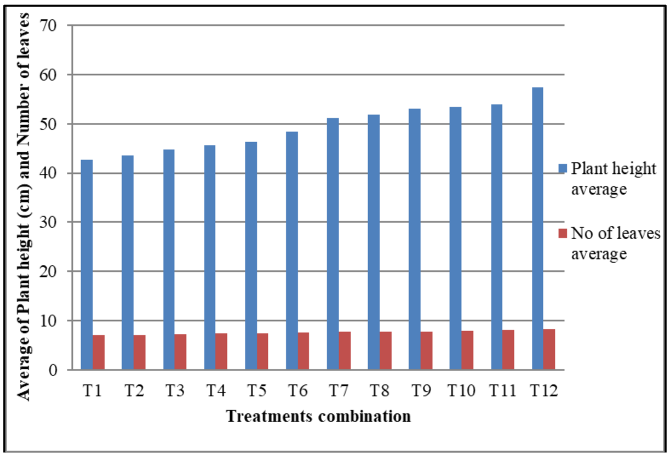

Fig 1: Effect of NP and Biofertilizers on Plant height and Number of leaves of Baby corn at Different Crop Growth Stages

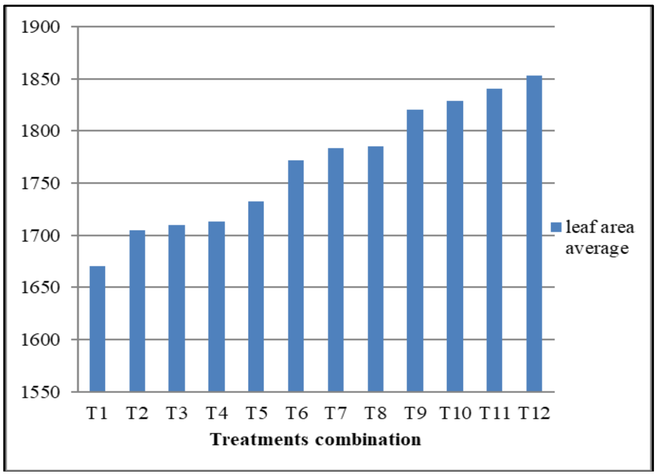

Fig 2: Effect of NP and Biofertilizers on leaf area of Baby corn at Different Crop Growth Stages

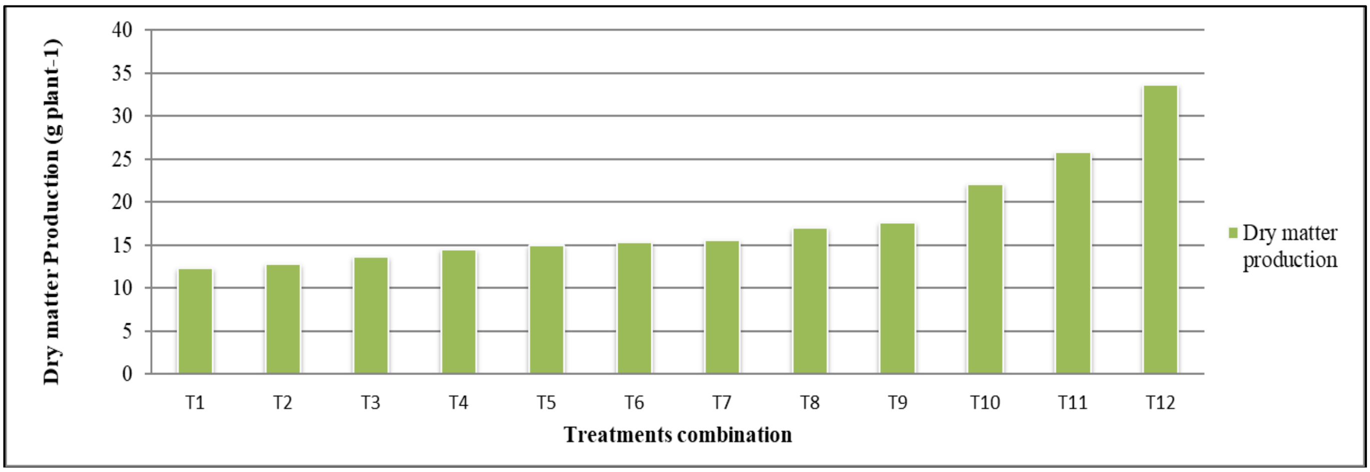

Fig 3: Effect of NP and Biofertilizers on Dry matter production of Baby corn at Different Crop Growth Stages

Table 2: Effect of different levels of nitrogen and phosphorus along with seed inoculation with *Azotobacter* and *Azospirillum* on days to tasselling, days to cob emergence, chlorophyll concentration before and after tasselling in baby corn

Treatments	Days to tasselling	Days to cob emergence	Before tasselling	After tasselling
T_1: 60 kg h^{-1} N+ 50 kg h^{-1} P+ *Azotobacter*	51.76	54.43	49.00	39.43
T_2: 60 kg h^{-1} N+50 kg h^{-1} P+ *Azospirillum*	51.21	53.47	49.93	40.09
T_3: 60 kg h^{-1} N+ 75 kg h^{-1}+ *Azotobacter*	50.20	53.53	51.48	40.32
T_4: 60 kg h^{-1} N+5 kg h^{-1} P+ *Azospirillum*	48.98	52.98	51.50	40.43
T_5: 80 kg h^{-1} N+ 50 kg h^{-1} P+ *Azotobacter*	49.35	53.35	51.56	40.58
T_6: 80 kg h^{-1} N+50 kg h^{-1} P+ *Azospirillum*	48.42	52.75	51.69	40.82
T_7: 80 kg h^{-1}N+ 75 kg h^{-1} P+ *Azotobacter*	48.27	52.27	52.02	41.17
T_8: 80 kg h^{-1} N 75 kg h^{-1} P +*Azospirillum*	47.98	51.98	52.24	41.64
T_9: 100 kg h^{-1}N+ 50 kg h^{-1}P+ *Azotobacter*	47.63	51.63	52.76	42.36
T_{10}:100 kg h^{-1} N+50 kg h^{-1} P + *Azospirillum*	47.54	51.54	53.00	42.36
T_{11}: 100 kg h^{-1} N + 75 kg h^{-1} P + *Azotobacter*	46.52	50.52	53.03	43.29
T_{12}: 100 kg h^{-1} N+ 75 kg h^{-1} P + *Azospirillum*	45.45	49.45	53.87	44.00
S.Em.±	0.42	0.37	0.81	0.56
C.D. at 5%	1.22	1.09	2.38	1.63

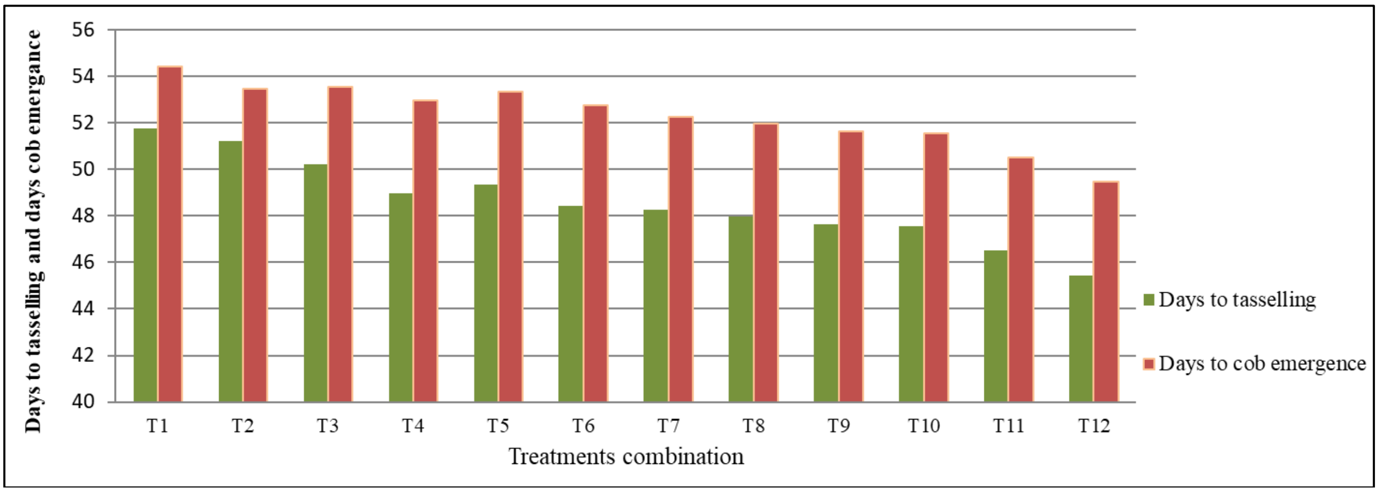

Fig 4: Effect of NP and Biofertilizers on days tasselling and Days cob emergance of Baby corn

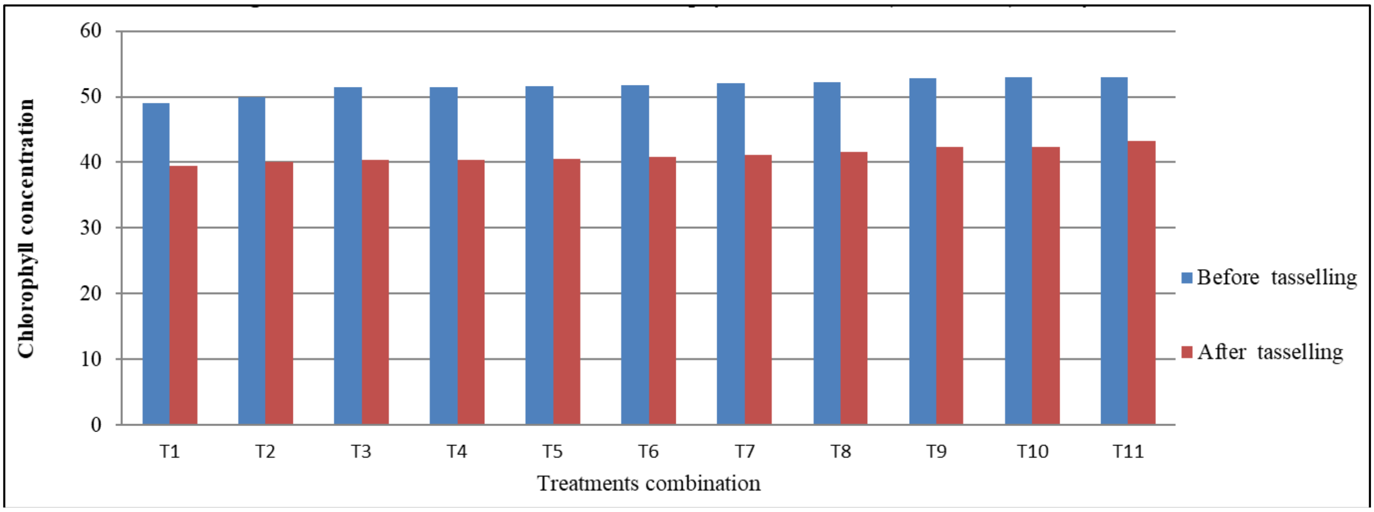

Fig 5: Effect of NP and Biofertilizers on Chlorophyll concentration (SPAD value) of Baby corn

Conclusion

On the basis of above findings, it's concluded that application of 100 kg ha^{-1} N +75 kg ha^{-1} P through *Azospirillum* inoculation will give significantly higher growth and growth attributes as compared to rest of the treatments

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