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Effect of NPK, biofertilizer and zinc foliar nutrition on growth and growth attributes of babycorn (*Zea mays* L.)

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Abstract
A field experiment was conducted to study the effect of NPK, Zinc, biofertilizers and zinc foliar nutrition on growth and growth attributes of baby corn (*Zea mays* L.). The experiment was laid out in randomized block design with thirteen treatments combination *viz.* T_1(Control), T_2(75% RDF + 5 kg Zn ha^{-1}+ *Azotobacter*), T_3(75% RDF + 0.2% Zn + *Azotobacter*), T_4(75% RDF + 0.5% Zn + *Azotobacter*), T_5(90% RDF + 5 kg Zn ha^{-1}+ *Azotobacter*), T_6 (90% RDF + 0.2% Zn + *Azotobacter*), T_7(90% RDF + 0.5% Zn + *Azotobacter*), T_8(75% RDF + 5 kg Zn ha^{-1}+ *Azospirillum*), T_9(75% RDF + 0.2% Zn + *Azospirillum*), T_{10}(75% RDF + 0.5% Zn + *Azospirillum*), T_{11}(90% RDF + 5 kg Zn ha^{-1}+ *Azospirillum*), T_{12}(90% RDF + 0.2% Zn + *Azospirillum*) and T_{13}(90% RDF + 0.5% Zn + *Azospirillum*) in three replications. In general, application of different levels of NPK, basal and foliar application of zinc along with seed treatment of babycorn with *Azatobacter* and *Azospirillum* significantly influenced the growth and growth attributes of babycorn. Statistically significantly higher average plant height (82.19cm), number of leaves per plant (8.45), dry matter production per plant (57.01g) and leaf area (1903.05 cm^2) were recorded in treatment T_{11} due to application of 90% RDF + 5kg Zn ha^{-1} + *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 of 90% RDF + 5kg Zn ha^{-1} + *Azospirillum* registered significantly higher chlorophyll concentration before tasselling (92.93%) and after tasselling (48.61%) as compared to other treatments. However, application of 90% RDF + 5kg Zn ha^{-1} along with *Azospirillum* recorded less number of days to tasselling (47.67) as compared to other treatments. While, the lowest value for growth and growth attributes were recorded in control treatment.

Keywords: Baby corn, biofertilizers, growth & growth attributes, nitrogen, phosphorus, potassium, zinc

Introduction
Baby corn is an important crop of Thailand, Taiwan and India; recently, baby corn has gained popularity in Delhi, Uttar Pradesh, Haryana, Maharashtra, Telangana, 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 (Government of India, 2014). Baby corn is a delicious, decorative and nutritious vegetable, without cholesterol. It is low calorie vegetable which helps in weight management, it is also a low carb, high fiber, fat free vegetable, and has rich source of vitamins and minerals. Babycorn has low glycemic index than regular corn, hence good for controlling blood sugar levels. One Baby corn can be compared with an ‘egg’ in terms of minerals. It also has nutritive value similar to that of non-legume vegetables such as cauliflower, cabbage, tomato, cucumber. Hundred gram of baby corn contained 89.1% moisture, 0.2 g fat, 1.9 g protein, 8.2 mg carbohydrate, 0.06 g ash, 28.0 mg calcium, 86.0 mg phosphorus, and 11.0 mg of ascorbic acid (Rakesh *et al.*, 2017) [16]. Baby corn is a high value crop which gives good returns in short period of time (About 55-60 days) with bonus of 50-60 tons ha^{-1} green fodder. Hence, it is best suited for multiple cropping. It also acts as a contingent crop at the time of crop failure. Baby corn is not only a cash crop but also a catch crop. Towards diversification and value addition through cultivation of baby corn for vegetable purpose is emerging as a highly profitable activity.In addition baby corn is an ideal forage crop having quick growth with high yielding ability, which can be fed to cattle at any stage of growth. The crop can easily be raised as a dual purpose crop- vegetable and fodder. Raising baby corn both for food and forage can be encouraged in peri urban areas as their demand is high throughout the year. 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. Although baby corn cultivation is popular world- wide, for Afghanistan, it is a completely new crop, people and farmers of Afghanistan are not aware of this crop.

Foliar feeding was stimulated by Tukey and Wittwer during 1950's at Michigan State University, using radioactive isotopes of known plant nutrients which were absorbed by plant foliage and translocated throughout the plant (Dorneanu *et al*., 2011) [6]. According to the recent survey, zinc deficiency in human nutrition is the most wide spread nutritional disorder, next to iron, vitamin 'A' and iodine. Nearly, 49% of the global population does not meet their daily-recommended intake of 15 mg day-1 of zinc for an adult and is one of the leading risk factors associated with diseases such as diarrhoea and retarded growth contributing to the death of 8,00,000 people each year. One third of the world population is reported at the risk of malnutrition due to inadequate dietary intake of zinc (Cakmak, 2009) [4]. About 50% of Indian soils are deficient in zinc causing low level of zinc and yield losses in fodder crops and affecting the health of the livestock (Singh, 2011))[17]. Zinc fertilization is used to increase micronutrient in edible parts to reduce the micro nutrient deficiency in human populations. Zinc fertilization is essential for keeping sufficient amount of available zinc in soil solution (by soil application of zinc) and in leaf tissue (by foliar application of zinc) which contributes to the maintenance of adequate root zinc uptake.

Azotobacter and Azospirillum is a beneficial free living (non-symbiosis) nitrogen fixing bacteria which is reported to fix 20-60 kg ha^{-1} nitrogen in soil annually. *Azotobacter* was the first and is the most common biofertilizer for some plants such as maize, wheat, sorghum and rice which produces some plant growth promoting metabolites, enzymes and hormones (auxin, cytokinin and gibberelin) in addition to fixing air nitrogen (Kumar and Ahlawat 2004) [10].

Nitrogen is an essential element for both fodder quantity and quality as it is a component of protein and chlorophyll. It is thus, essential for photosynthesis, vegetative and reproductive growth and it often determines yield of maize. Both the yield and quality of maize are strongly influence by the availability of nitrogen. Phosphorus being the constituents of sugar, phosphatases, ADP and ATP plays an important role in energy transformations and it is also involved in the basic reactions of photosynthesis. Review regarding this nutrient has been cited in this section. Potassium activates number of enzymes, including those involved in the synthesis of carbohydrates and resistance to diseases and adverse environmental conditions. It also improves the utilization of nitrogen and phosphorous and plays an important role in growth and reproductive development of plants. Potassium is the cation most abundantly available in the cytoplasm that regulates osmotic potential of cells and tissues of glycophytic plant species (Marschner 1995) [12].

At the end Baby corn is an extremely short duration fascinating cereal vegetable preferred in the elite group of society with advantage of planting round the year. Income and employment both can be enhanced through production of baby corn.

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. Babycorn G-5414 variety was chosen for the study. The treatments were consisting of thirteen combinations of different levels of NPK and Zinc basal and foliar application with Biofertilizers viz. T_1(Control), T_2(75% RDF + 5 kg Zn ha^{-1}+ *Azotobacter*),T_3(75% RDF + 0.2% Zn + *Azotobacter*), T_4(75% RDF + 0.5% Zn + *Azotobacter*), T_5(90% RDF + 5 kg Zn ha^{-1}+ *Azotobacter*), T_6 (90% RDF + 0.2% Zn + *Azotobacter*), T_7(90% RDF + 0.5% Zn + *Azotobacter*), T_8(75% RDF + 5 kg Zn ha^{-1}+ *Azospirillum*), T_9(75% RDF + 0.2% Zn + *Azospirillum*), T_{10}(75% RDF + 0.5% Zn + *Azospirillum*), T_{11}(90% RDF + 5 kg Zn ha^{-1}+ *Azospirillum*), T_{12}(90% RDF + 0.2% Zn + *Azospirillum*) and T_{13}(90% RDF + 0.5% Zn + *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) and zinc sulfate at the rate of 5kg Zn ha^{-1} was applied at the time of sowing. The entire quantity of P and half the recommended doses of N and full does K and Zinc were applied as basal and remaining quantity of N were top dressed at knee high stage (25 DAS) of Baby corn. Foliar spray of Zinc was applied at 25 and 45 days after sowing. Standard cultural Practices were followed and irrigation was given as per requirement. Plant height of five randomly selected babycorn plants were recorded at 10, 20, 30, 40 & 50 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 babycorn were counted from five tagged plants in each plot and the mean value was calculated. Leaf area of babycorn 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 babycorn 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 g plant^{-1}. Tasseling was done as soon as the tassels appeared. When the plants were in full bloom, readings were performed using the portable meter of chlorophyll SPAD-502 (Soil- Plant Analysis Development (SPAD) Section, Minolta Camera Co., Ltd, Japan). Measurements with the SPAD were performed at the fifth corn leaf downwards. Evaluations were carried out in five plants per plot, being three readings by leaves. (Araújo *et al*. 2017) [1]. Data were analyzed statistically for test of significance following the Fisher's method of "Analysis of variance".

Result and Discussion

In general, growth and growth attributes of babycorn were significantly influenced by NPK, Zinc and biofertilizers at different crop growth stages. Among the treatments statistically significantly higher plant height (12.09, 33.27, 73.07, 121.87 and 170.67 cm), number of leaves per plant (3.87, 6.80, 89.60, 10.60 and 11.40 cm), dry matter production per plant (1.37, 9.09, 44.00, 92.51 and 138.14g) and leaf area (420.07, 817.20, 1754.73, 2409.47 and 4113.80 cm^2) were recorded in treatment T_{11} with application of 90%

RDF + 5kg Zn ha^{-1} + *Azospirillum* at 10, 20, 30, 40 and 50 days after sowing 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 90% RDF + 5kg Zn ha^{-1} + *Azospirillum* registered significantly higher chlorophyll concentration before tasselling (92.93%) and after tasselling (48.61%) as compared to other treatments. However, application of 90% RDF + 5kg Zn ha^{-1} along with *Azospirillum* recorded less number of days to tasselling (47.67) as compared to rest of the treatments. Whereas, no zinc treatment resulted lower growth attributes. Increase might be due to rapid division and elongation of cells with balanced and adequate NPK and Zinc supply, which seemed to be the reason behind the favorable influence on all the growth attributes of baby corn (Rakesh kumar and Bohra, 2014) [16].

Significant variation in the plant height is due to in time availability of the needed nutrients to the plant at the important growth stages and application of zinc has led to production of IAA resulting in increased plant height (Manasa and Devaranavadagi, 2015) [11]. Nitrogen and zinc also helped in more leaf area as a consequence more assimilates were produced and increased the plant height (Jasim Iqbal *et al.*, 2016) [7]. The synergistic effect of both nitrogen and zinc helps in rapid growth and development of plants as they help in photosynthesis and various plant biochemical processes which responds towards growth (Jasim Iqbal *et al.*, 2016) [7]. These results are in conformity with Asghar *et al*., (2011) [2] and Parasuraman (2008) [14]. Generally, P has positive significant interaction with N absorption and plant growth. The higher leaf area was due to the increased plant height resulted into more number of nodes per plant leading to more number of leaves per plant. The formation of optimum photosynthetic stage for longer period was through timely supply of nutrients by foliar nutrition. On the other side, the improved photosynthetic capacity was highly influenced by the foliar fertilization of micronutrients (Watson, 1952) [19]. Increased dry matter production is due to balanced amount of macro and micro nutrients through foliar fertilization which resulted in better crop growth and photosynthetic activity which led to better supply of photosynthates ultimately resulted in higher dry matter production per plant. Inoculation of *Azospirillum* showed significantly higher growth and growth attributes 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) [3], Kumar *et al*. (2007) [9], Kole (2010) [8] and (Rafiq *et al*. (2010) [15].

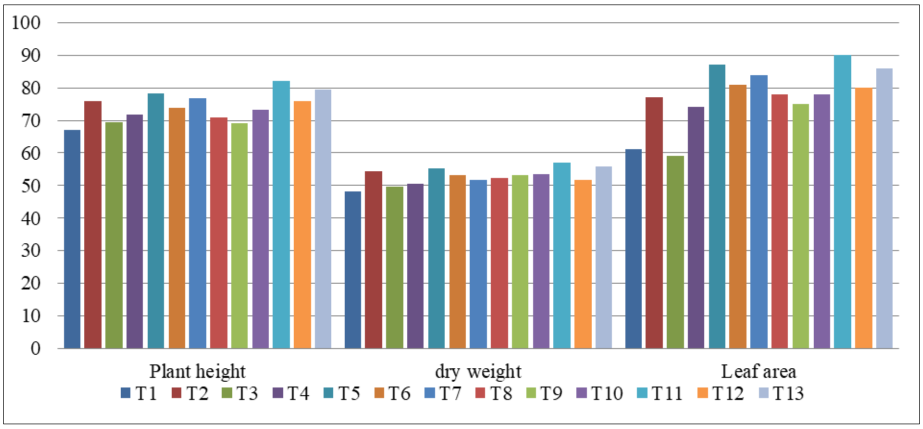

Fig 1: Effect of different levels of NPK and Zinc along with seed inoculation with *Azotobacter* and *Azospirillum* on growth attributes of babycorn

Table 1: Effect of different levels of NPK and Zinc along with seed inoculation with *Azotobacter* and *Azospirillum* on plant height, number of leaves per plant, dry weight and leaf area at different crop growth stages in babycorn

Treatments	Average of plant height, number of leaves per plant, dry weight and leaf area at 10, 20, 30, 40 and 50 DAS			
	Plant height (cm)	Number of leaves $plant^{-1}$	Dry weight (g $plant^{-1}$)	Leaf area (cm^2)
T_1: Control	66.97	7.51	48.16	1613.79
T_2: 75% RDF + 5 kg Zn ha^{-1}+ *Azotobacter*	75.87	7.89	54.34	1773.17
T_3: 75% RDF + 0.2% Zn + *Azotobacter*	69.27	7.68	49.50	1593.13
T_4: 75% RDF + 0.5% Zn + *Azotobacter*	71.87	7.93	50.62	1744.33
T_5: 90% RDF + 5 kg Zn ha^{-1}+ *Azotobacter*	78.13	8.11	55.20	1873.05
T_6: 90% RDF + 0.2% Zn + *Azotobacter*	73.90	7.95	53.14	1817.25
T_7: 90% RDF + 0.5% Zn + *Azotobacter*	76.78	7.97	51.66	1848.92
T_8: 75% RDF + 5 kg Zn ha^{-1}+ *Azospirillum*	70.80	7.85	52.26	1779.37
T_9: 75% RDF + 0.2% Zn + *Azospirillum*	68.99	7.84	53.30	1759.57
T_{10}: 75% RDF + 0.5% Zn + *Azospirillum*	72.72	8.07	53.48	1786.96
T_{11}: 90% RDF + 5 kg Zn ha^{-1}+ *Azospirillum*	82.19	8.45	57.02	1903.05
T_{12}: 90% RDF + 0.2% Zn + *Azospirillum*	76.01	7.93	51.70	1809.52
T_{13}: 90% RDF + 0.5% Zn + *Azospirillum*	79.38	8.17	55.88	1867.39
S.Em.±	1.74	0.08	0.94	38.52
C.D. at 5%	5.09	0.24	2.75	112.44

Table 2: Effect of different levels of NPK and Zinc along with seed inoculation with *Azotobacter* and *Azospirillum* on days to tasselling and days to cob emergence in babycorn

Treatments	Days to tasselling	Days to cob emergence
T_1: Control	51.67	55.33
T_2: 75% RDF + 5 kg Zn ha^{-1}+ *Azotobacter*	48.67	51.33
T_3: 75% RDF + 0.2% Zn + *Azotobacter*	49.33	53.00
T_4: 75% RDF + 0.5% Zn + *Azotobacter*	50.33	53.67
T_5: 90% RDF + 5 kg Zn ha^{-1}+ *Azotobacter*	48.00	51.33
T_6: 90% RDF + 0.2% Zn + *Azotobacter*	47.67	50.67
T_7: 90% RDF + 0.5% Zn + *Azotobacter*	48.33	52.33
T_8: 75% RDF + 5 kg Zn ha^{-1}+ *Azospirillum*	48.33	51.33
T_9: 75% RDF + 0.2% Zn + *Azospirillum*	49.33	51.67
T_{10}: 75% RDF + 0.5% Zn + *Azospirillum*	50.00	52.33
T_{11}: 90% RDF + 5 kg Zn ha^{-1}+ *Azospirillum*	47.67	51.00
T_{12}: 90% RDF + 0.2% Zn + *Azospirillum*	48.00	50.67
T_{13}: 90% RDF + 0.5% Zn + *Azospirillum*	49.33	52.33
S.Em.±	0.76	0.68
C.D. at 5%	2.22	1.19

Table 3: Effect of different levels of NPK and Zinc along with seed inoculation with *Azotobacter* and *Azospirillum* on chlorophyll concentration in babycorn

Treatments	Chlorophyll concentration (SPAD value)	
	Before tasselling	After tasselling
T_1: Control	45.11	34.20
T_2: 75% RDF + 5 kg Zn ha^{-1}+ *Azotobacter*	79.69	43.13
T_3: 75% RDF + 0.2% Zn + *Azotobacter*	51.47	31.49
T_4: 75% RDF + 0.5% Zn + *Azotobacter*	49.05	31.09
T_5: 90% RDF + 5 kg Zn ha^{-1}+ *Azotobacter*	47.73	43.95
T_6: 90% RDF + 0.2% Zn + *Azotobacter*	89.73	36.20
T_7: 90% RDF + 0.5% Zn + *Azotobacter*	47.13	37.42
T_8: 75% RDF + 5 kg Zn ha^{-1}+ *Azospirillum*	44.97	37.44
T_9: 75% RDF + 0.2% Zn + *Azospirillum*	84.65	33.25
T_{10}: 75% RDF + 0.5% Zn + *Azospirillum*	59.27	35.17
T_{11}: 90% RDF + 5 kg Zn ha^{-1}+ *Azospirillum*	92.93	48.61
T_{12}: 90% RDF + 0.2% Zn + *Azospirillum*	73.41	40.39
T_{13}: 90% RDF + 0.5% Zn + *Azospirillum*	72.47	44.25
S.Em.±	3.10	1.64
C.D. at 5%	9.04	4.77

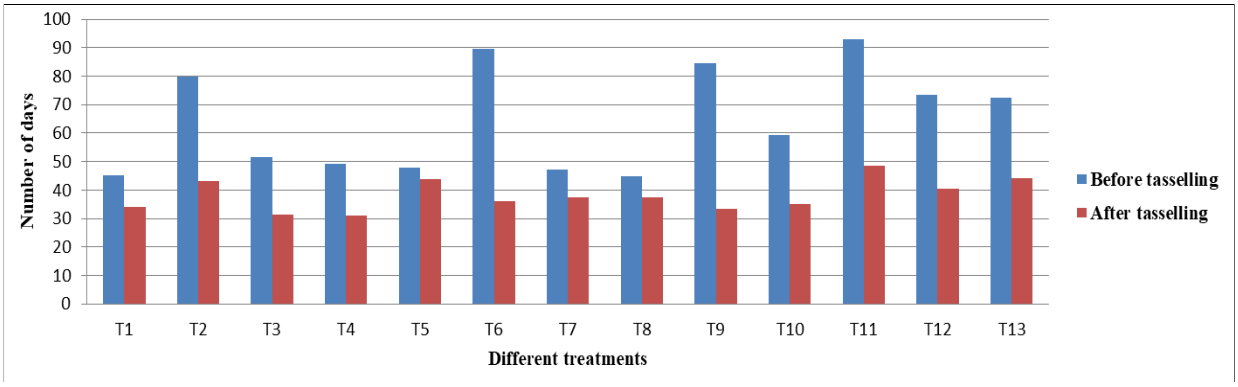

Fig 2: Effect of different levels of NPK and Zinc along with seed inoculation with Azotobacter and Azospirillum on chlorophyll concentration in babycorn

Conclusion

Fertility management plays a key role in baby corn production and it exhibit full potential only when supplied with adequate quantities of nutrients in proper way at proper time. This is particularly important in achieving the higher growth and yield as well as for maintaining the soil fertility. On the basis of above findings, It is concluded that among different treatments studied in baby corn, soil application NPK @ 90 kg ha^{-1} + $ZnSO_4$ @ 5 kg ha^{-1} + foliar spray of $ZnSO_4$ @ 0.5% at 25 DAS and at 40 DAS recorded significantly higher growth and growth parameters as compared to rest of the treatments.

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