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Response of with and without *Azotobacter* biofertilizer with different levels of nitrogen and sulphur fertilizers combination on growth, yield attributes and yield of maize (*Zea mays* L.)

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Abstract: A field experiment was conducted at crop research farm, Department of Agronomy, Allahabad School of Agriculture, Sam Higginbottom Institute of Agricultural, Technology & Sciences, Allahabad (U. P). It is on the near of the river Yamuna to study the effect of *Azotobacter,* levels of nitrogen and sulphur on growth and yield of maize (*Zea mays* L.) during *kharif* season at 2014. It was consisting of combination of twelve inorganic and organic fertilizers combination in which nitrogen sixth with *Azotobactor viz., Azotobactor* + nitrogen+ sulphur and other sixth without *Azotobactor viz.,* nitrogen + Sulphur. The field experiment was laid out in randomized block design with three replications. The results showed that application (T_6) *Azotobacter* + 140 kg N ha^{-1} + 30 kg S ha^{-1} had a significantly maximum growth yield and yield attributes, plant dry weight (3.00, 19.99 and 76.18 g at 25, 50 and 75 DAS), Crop growth rate (g m^{-2} day^{-1}) (0.66, 3.76 and 12.69 g at 0-25, 25-50 and 50-75 DAS), relative growth rate (g $g^{-1}day^{-1}$) (0.043 and 0.075 g at 0-25, and 25-50 DAS), number of leaves $plant^{-1}$, seed yield (6.16 t ha^{-1}), stover yield (8.83 t ha^{-1}), number of cobs $plant^{-1}$ (1.73), weight of cob^{-1} (184.66 g) respectively than other application of fertilizers application levels in treatments.

Keywords: *Azotobacter*, Nitrogen, Sulphur, Maize

Introduction

Maize (*Zea mays* L.) is the third most important cereal crop in the world after wheat and rice and known as "Queen of cereal". Approximately 8 to 10% of the corn crop is used as food for human consumption. It is not only a source of food, fodder and feed but also many by-products likes glucose, starch and corn oil, etc are prepared from it. Maize is extensively grown in temperate, subtropical and tropical regions of the world. Maize grain contains about 72% starch, 10% protein, 4.8 % oil, 5.8 % fiber, 3.0 % sugar and 1.7 % ash (Chaudhary, 1991). Bio fertilizers include mainly the nitrogen fixing, phosphate solubilising and plant growth promoting microorganisms. *Azotobacter* represents the main group of heterotrophic, non symbiotic, gram negative, free living nitrogen-fixing bacteria. They are capable of fixing an average 20 kg N ha^{-1} $year^{-1}$. In Nepal very limited studies were carried out on the effect of *Azotobacter* on maize growth and productivity. Therefore, a field experiment was carried out to study the effect of *Azotobacter* on maize growth and productivity. (Baral and Adhikari, 2013).

Azotobacter and *Azospirillum* increased plant growth, nutrients uptake and yield. Nitrogen is the key element in increasing productivity. It is an integral component of many compounds essential for plant growth processes including chlorophyll and many enzymes. Nitrogen also mediates the utilization of potassium, phosphorus and other elements in plants. The optimum amounts of these elements in the soil cannot be utilized efficiency if nitrogen is deficient in plants. Therefore, nitrogen deficiency or excess can result in reduced maize yields. Application of nitrogen fertilizer has also been reported to have significant effect on grain yield and quality of maize (Sharifi and Taghizadeh, 2009). In crop production, sometimes sulfur is considered to be forgotten secondary nutrient. However it is most essential for activity of proteolysis' enzymes and synthesis of amino acids. If adequate supply sulfur is ensured in the field it improves yield and quality of crops. The actual importance of sulfur has been noticed in the recent past due to exhaustive farming with high yielding varieties and the use of complex fertilizers, which led to sulfur deficiency in a lot of soils. Maize crop responds well to sulfur fertilization and it removes about 30-70 kg S ha^{-1}. Several workers have reported that uptake of major nutrients is also positively influenced by sulfur (Bharathi and Poongothai, 2008).

Sulphur is recognized as a fourth major nutrient after N, P and K. On an average maize crop absorbs as much S as it absorbs P. When S is deficient in, full yield potential of the crop cannot be realized regardless of other nutrients even under good crop husbandry practices (Tondon, 1989 and Rasheed *et al.,* 2004). The concentration of sulphur in vegetative tissue usually ranges 0.2-0.5 percent on a dry matter basis. Thus, plant requirements for available sulphur are quite low. However the sulphur is mainly responsible for nitrogen availability, hence with the increasing rate of sulphur the availability and the uptake of nitrogen is increased. usually when nitrogen and sulphur are not balanced in plants, it adversely affects the proteins, carbohydrates and oil metabolism.

Materials and Methods

Experimental site, climate and soil: The experiment was conducted during the *Kharif* season of 2014 at the Crop Research

Farm. The crop research farm is located at 25^0 24' 42" N latitude, 81^0 50' 56" E longitude and 98 m altitude above the mean sea level. This area is situated on the right side of the river *Yamuna* and by the opposite side of Allahabad Rewa road about 5 km away from Allahabad city. Allahabad has a subtropical and semi-arid climatic condition, with both extremes of temperature, *i.e.* summer and winter. The soil was sandy loam in texture, (Organic carbon 24 %, available nitrogen 237 kg ha^{-1}, available phosphorus 19.60 kg ha^{-1}, available potassium 95.00 kg ha^{-1}, soil pH 7.6) followed by warm to cool weather period from July to October.

Fertilizer application: Fertilizers were applied as side placement, for which 4-5 cm deep furrows were made along the seed rows with a hand hoe. The nutrient sources were urea, diammonium phosphate (DAP), muriate of potash (MOP) and [Plant sulf (sulphur 85 % D.P.) Mfg. by: KKD BIO PRDUCTS] to fulfill the requirement of N, P_2O_5, K_2O and S kg ha^{-1}. The recommended dose of 120:80:60:25 kg N: P: K ha^{-1} and sulphur was applied according to the treatment details. Nitrogen was applied in two split doses 1/2 nitrogen, whole of phosphorus, potash and sulphur at the time of sowing and remaining 1/2 nitrogen at 25 days after sowing. This paper deals with the objective to determine suitable level effect of *Azotobacter,* nitrogen and sulphur practices cultivation to maximize their growth attributes, yield and yield attributes of maize (*Zea mays* L.).

Experimental treatments details: Maize cultivar "Narendra 909" was sown on 4 July 2014 with a seed rate 20 kg ha^{-1} in plant to plant and row to raw spaced at 30X60 cm. There were consisting of twelve treatment combinations (T_1) *Azotobacter* + 100 kg N ha^{-1} + 20 kg S ha^{-1}, (T_2) *Azotobacter* + 120 kg N ha^{-1} + 30 kg S ha^{-1}, (T_3) *Azotobacter* + 140 kg N ha^{-1} + 20 kg S ha^{-1}, (T_4) *Azotobacter* + 100 kg N ha^{-1} + 30 kg S ha^{-1}, (T_5) *Azotobacter* + 120 kg N ha^{-1} + 20 kg S ha^{-1}, (T_6) *Azotobacter* + 140 kg N ha^{-1} + 30 kg S ha^{-1},(T_7) 100 kg N ha^{-1} + 20 kg S ha^{-1}, (T_8) 120 kg N ha^{-1} + 30 kg S ha^{-1}, (T_9) 140 kg N ha^{-1} + 20 kg S ha^{-1}, (T_{10}) 100 kg N ha^{-1} + 30 kg S ha^{-1}, (T_{11}) 120 kg N ha^{-1} + 20 kg S ha^{-1}, (T_{12}) 140 kg N ha^{-1} + 30 kg S ha^{-1} in randomized block design each replicated thrice.

Crop growth rate (CGR) (g m^{-2} day^{-1}): It represents dry weight gained by unit area of a crop in a unit time, expressed as g $m^{-2}day^{-1}$. The crop growth rate was computed with the help of dry matter production recorded for each treatment at 0-25, 25-50 and 50-75 DAS intervals. It was calculated with the help of following formula.

Crop growth rate (CGR) = W_2-W_1 / t_2-t_1

Where: W_1 = dry weight production per unit area at time t_1 ; W_2 = dry weight production per unit area at time t_2

Relative growth rate (RGR) (g g^{-1} day^{-1}): It was described by Fisher and Yates (1947) which indicates the increase in dry weight per unit dry matter over any specific time interval and it was calculated by the following equation:

$RGR = (\log_e W_2 - \log_e W_1) / (t_2 - t_1)$

Where: $\log_e W_1$ = natural log of initial (t_1) dry weight (g) of the plant; $\log_e W_2$ = natural log of dry weight (g) of the plants after an interval of time (t_2); W_1= Initial dry weight of plant (g); W_2= Final dry weight of plant (g); t_1= Initial time period; t_2= Final time period

Statistical Analysis: The value of table 'F at 5% level significance, where the treatment difference between were found significant the value of CD and CV % were also worked out to compare the treatment mean (Snedecor and Cochran 1967). At initial stage select random five plants from net plot area for further recording observations.

Results and Discussion

Effect of growth parameter on maize: Data presented in (Table-1) the plant dry weight (3.00, 19.99 and 76.18 g at 25, 50 and 75 DAS respectively under the treatment (T_6) *Azotobacter* + 140 kg N ha^{-1} + 30 kg S ha^{-1}. Whereas it treatment at par with (T_2) *Azotobacter* + 120 kg N ha^{-1} + 30 kg S ha^{-1}, in case of only 25 DAS, (T_3) *Azotobacter* + 140 kg N ha^{-1} + 20 kg S ha^{-1} at par in 25, 50 and 75 DAS and (T_{12}) 140 kg N ha^{-1} + 30 kg S ha^{-1} also at par at 25 and 50 DAS. Nitrogen uptake is closely correlated with dry matter yield which may reflect on nutrient uptake ability of N for maize growth. Rahman *et.al.* (2011). Based on these observations, sufficient supply of S is required to maintain the optimum growth and nutrient uptake ability of plants. For this purpose, the use of S fertilizer

Table-1: Effect of with and without *Azotobacter* biofertilizer with levels of nitrogen and sulphur on growth attributes of maize

Treatment combinations	Dry weight (g)			Crop growth rate (g/m²/day)			Relative growth rate (g $g^1$$day^{-1}$)			No. of leaves $plant^{-1}$		
	25 DAS	50 DAS	75 DAS	0-25 DAS	25-50 DAS	50-75 DAS	0-25 DAS	25-50 DAS	50-75 DAS	25 DAS	50 DAS	75 DAS
T_1- *Azotobacter* + 100 kg N ha^{-1} + 20 kg S ha^{-1}	2.26	12.94	68.30	0.49	2.36	12.28	0.032	0.069	0.066	6.06	9.66	11.46
T_2-*Azotobacter* + 120 kg N ha^{-1} + 30 kg S ha^{-1}	2.70	16.64	73.66	0.59	3.09	12.65	0.039	0.072	0.059	7.06	10.53	12.13
T_3- *Azotobacter* + 140 kg N ha^{-1} + 20 kg S ha^{-1}	2.93	19.26	75.22	0.64	3.62	12.42	0.042	0.074	0.054	6.46	10.86	12.73
T_4- *Azotobacter* + 100 kg N ha^{-1} + 30 kg S ha^{-1}	2.33	13.87	68.48	0.51	2.55	12.12	0.033	0.071	0.063	6.13	10.00	11.20
T_5- *Azotobacter* + 120 kg N ha^{-1} + 20 kg S ha^{-1}	2.50	15.94	70.58	0.54	2.98	12.12	0.036	0.074	0.059	5.93	10.33	11.40
T_6- *Azotobacter* + 140 kg N ha^{-1} + 30 kg S ha^{-1}	3.00	19.99	76.18	0.66	3.76	12.69	0.043	0.075	0.053	6.33	11.13	13.26
T_7-100 kg N ha^{-1} + 20 kg S ha^{-1}	2.06	10.94	66.26	0.45	1.96	11.09	0.028	0.065	0.068	5.60	9.53	11.00
T_8 - 120 kg N ha^{-1} + 30 kg S ha^{-1}	2.56	16.52	72.17	0.56	3.09	12.35	0.037	0.073	0.058	6.66	10.26	11.20
T_9 -140 kg N ha^{-1} + 20 kg S ha^{-1}	2.53	15.82	71.36	0.55	2.94	12.32	0.036	0.072	0.060	6.40	10.13	11.60
T_{10}-100 kg N ha^{-1} + 30 kg S ha^{-1}	2.23	12.25	67.26	0.49	2.21	11.98	0.031	0.067	0.067	6.06	9.60	10.53
T_{11}-120 kg N ha^{-1} + 20 kg S ha^{-1}	2.40	13.96	42.69	0.53	2.56	12.30	0.034	0.070	0.063	6.33	10.06	11.53
T_{12}-140 kg N ha^{-1} + 30 kg S ha^{-1}	2.80	18.02	74.34	0.61	3.37	12.49	0.040	0.074	0.056	7.39	11.00	12.53
F test	S	S	S	S	S	S	S	NS	S	NS	S	S
SEd (+)	0.16	088	0.60	0.04	0.20	0.26	0.0025	0.0039	0.0025	0.38	0.25	0.66
CD (0.05)	0.34	1.83	1.25	0.07	0.42	0.554	0.0052		0.0054		0.51	1.38

Table-2: Effect of with and without *Azotobacter* biofertilizer with levels of nitrogen and sulphur on yield and yield attributes of maize

Treatment combinations	Grain yield (t ha^{-1})	Stover yield (t ha^{-1})	No. of cobs plant^{-1}	Wt. of cob^{-1} (g)
T_1- *Azotobacter* + 100 kg N ha^{-1} + 20 kg S ha^{-1}	3.85	6.83	1.26	134.86
T_2-*Azotobacter* + 120 kg N ha^{-1} + 30 kg S ha^{-1}	5.18	8.26	1.53	172.33
T_3- *Azotobacter* + 140 kg N ha^{-1} + 20 kg S ha^{-1}	5.95	8.66	1.66	179
T_4- *Azotobacter* + 100 kg N ha^{-1} + 30 kg S ha^{-1}	4.18	7.16	1.20	140
T_5- *Azotobacter* + 120 kg N ha^{-1} + 20 kg S ha^{-1}	4.53	7.46	1.33	156
T_6- *Azotobacter* + 140 kg N ha^{-1} + 30 kg S ha^{-1}	6.16	8.83	1.73	184.66
T_7-100 kg N ha^{-1} + 20 kg S ha^{-1}	3.61	6.46	1.06	119.33
T_8 - 120 kg N ha^{-1} + 30 kg S ha^{-1}	4.98	7.96	1.46	166.66
T_9-140 kg N ha^{-1} + 20 kg S ha^{-1}	4.78	7.66	1.40	159.26
T_{10}-100 kg N ha^{-1} + 30 kg S ha^{-1}	3.78	6.63	1.20	122.66
T_{11}-120 kg N ha^{-1} + 20 kg S ha^{-1}	4.41	7.26	1.33	150.80
T_{12}-140 kg N ha^{-1} + 30 kg S ha^{-1}	5.58	8.36	1.60	176.66
F test	S	S	S	S
SEd (+)	1.57	2.69	0.13	04.70
CD (0.05)	3.25	5.57	0.28	09.75

is gaining importance because besides the inhibitory actions on N, it contains high S concentration.

The obtained results for leaf chlorophyll content may be attributed to the micro-organisms effect on nutrients release in soil in available form leading to the increase of nitrogen content in the plants; this in turn led to increase the chlorophyll content as reported by Ashour (1998), Awad (1998). The treatment (T_6) *Azotobacter* + 140 kg N ha^{-1} + 30 kg S ha^{-1} observed that significantly the higher crop growth rate (CGR) (0.66,3.76 and 12.69 g m^{-2} day^{-1} at 0 to 25, 25-50 and 50-75 DAS intervals. At 0 to 25 DAS interval, the significantly higher relative growth rate recorded was 0.043 g g^{-1} day^{-1} in (T_6) *Azotobacter* + 140 kg N ha^{-1} + 30 kg S ha^{-1} being at par with (T_2) *Azotobacter* + 120 kg N ha^{-1} + 30 kg S ha^{-1}, (T_{12}) 140 kg N ha^{-1} + 30 kg S ha^{-1} and (T_8) 120 kg N ha^{-1} + 30 kg S ha^{-1}. At 25 to 50 DAS interval, the non significantly higher relative growth rate recorded was 0.075 g g^{-1} day^{-1} in (T_6) *Azotobacter* + 140 kg N ha^{-1} + 30 kg S ha^{-1}. The non significantly the highest number of leaves plant^{-1} recorded (6.66 at 25 DAS), in treatment (T_8) 120 kg N ha^{-1} + 30 kg S ha^{-1} respectively. The number of leaves plant^{-1} at 50 DAS, though the significantly higher value recorded was 11.33 in (T_6) *Azotobacter* + 140 kg N ha^{-1} + 30 kg S ha^{-1} which was remained at par with (T_3) *Azotobacter* + 140 kg N ha^{-1} + 20 kg S ha^{-1} and (T_{12}) 140 kg N ha^{-1} + 30 kg S ha^{-1}. The reason for maximum growth parameters in plants received higher N may be at tributed to the most lucrative consumption of applied nitrogen and other allied environmental resources by the maize crop which resulted in maximum biomass yield. Aslam *et al*. (2011), Ullah *et al.* (2015). It might be due to higher dose of nitrogen and sulphur to more vegetative growth of plants. These results are in line with the finding of Ali *et al.,* (2013).

Yields attributes and yield of maize: The results indicated that treatment (table-2) the treatment (T_6) *Azotobacter* + 140 kg N ha^{-1} + 30 kg S ha^{-1} had significant effect (Table 1) on seed and stover yield of maize. Significantly higher seed (6.16 t ha^{-1}) and stover yield (8.83 t ha^{-1}) were recorded under (T_6) *Azotobacter* + 140 kg N ha^{-1} + 30 kg S ha^{-1} being at par with (T_3) *Azotobacter* + 140 kg N ha^{-1} + 20 kg S ha^{-1}. Whereas, significantly lower grain yield (3.61 t ha^{-1}) and lower stover yield (6.46 t ha^{-1}) were observed under treatment (T_7) 100 kg N ha^{-1} + 20 kg S ha^{-1} respectively. Intensive and excessive use of chemical fertilizer may create environmental hazard and natural imbalance. Optimum fertilization is crucial to assess nutrient status of crop and soil to avoid alarming use of chemical fertilizer. The productivity and growth of plant is directly related with sulfur uptake and assimilation. In addition S plays significant role to the acquisition of N (Malagoli, 1999).

This might be due to higher nitrogen and sulphur uptake enhances these concentrations and increases these attributes content in grain significantly. The conformity of result of present investigation was also made by Jeet *et al.,* (2012). Among the number of cobs plant^{-1} (1.73) was recorded significantly higher under the treatment (T_6) *Azotobacter* + 140 kg N ha^{-1} + 30 kg S ha^{-1} in which being at par with (T_2) *Azotobacter* + 120 kg N ha^{-1} + 30 kg S ha^{-1}, (T_3) *Azotobacter* + 140 kg N ha^{-1} + 20 kg S ha^{-1}, (T_8) 120 kg N ha^{-1} + 30 kg S ha^{-1} and (T_{12}) 140 kg N ha^{-1} + 30 kg S ha^{-1}. The significantly the higher weight of cob^{-1}(184.66 g) was recorded under the treatment (T_6) *Azotobacter* + 140 kg N ha^{-1} + 30 kg S ha^{-1} in which being at par with (T_3) *Azotobacter* + 140 kg N ha^{-1} + 20 kg S ha^{-1} and (T_{12}) 140 kg N ha^{-1} + 30 kg S ha^{-1}.

Based on the above findings in respect of the growth and yield attributes and yield, best results were achieved with *Azotobacter* inoculated seed, nitrogen 140 kg ha^{-1} applied in combination with sulphur 30 kg ha^{-1} can be recommended for sustaining and productivity of maize under of Eastern U.P.

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