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Effect of nitrogen and sulphur levels on growth and yield of maize (*Zea mays* L.) under Poplar (*Populus deltoides*) based agroforestry system

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Abstract
A field experiment was conducted during *kharif* season 2017 at the Forest Nursery and Research Centre, College of Forestry, Sam Higginbottom University of Agriculture, Technology and Sciences, Allahabad to study the "Effect of Nitrogen and Sulphur levels on growth and yield of Maize (*Zea mays* L.) Under Poplar (*Populus deltoides*) based Agroforestry system". The soil of experimental plot was sandy loam in texture, nearly neutral in soil reaction (pH 6.7), low in organic carbon (0.35%), available N (230 kg ha^{-1}), available P (20 kg ha^{-1}) and available K (189 kg ha^{-1}). Experiment was laid out in Factorial Randomized Block Design with three levels of Nitrogen [(100 kg ha^{-1}), (120 kg ha^{-1}) and (140kg ha^{-1})] and three levels of Sulphur [(20kg ha^{-1}), (30kg ha^{-1}) and (40kg ha^{-1})].There were 9 treatments each replicated thrice. The result showed that growth attributes *viz.*, Plant height (153.43 cm) at 90 DAS, No. of leaves per plant (11.50) at 90 DAS and plant dry weight (128.56g) at 90 DAS where as yield attributes and yield *viz.*, Number of cobs / plant (1.83), Number of grains/cob (419.55), Test weight (233.00g) and grain yield (54.16q/ha) was recorded highest with the application of 140 kg N ha $^{-1}$ and 40 kg S ha $^{-1}$.

Keywords: Nitrogen, Sulphur, Poplar Agroforestry and maize

Introduction
Agroforestry is useful because it offers an array of environmental services both on a macro and micro scale. On a macro scale it mitigates land degradation through the means of controlling water erosion, sheet and rill erosion (soil erosion), reclaiming marginalized land, and increasing irrigation and agricultural productivity (Wu and Zhu, 1997) [16]. Additionally, the change of macroclimate includes the increase of rainfall through the means of increasing evapotranspiration which in turn increases water vapor available in the atmosphere. Concurrently there is also the possibility of modification of microclimates. This includes reducing wind speed, stabilizing daily mean temperature, modification of solar radiation, increasing air humidity, and decreasing evaporation (Lu and Zhao, 1991) [13].
The term maize, which has been derived from an arawik-exils word "mahiz", also known as Indian corn maize *(Zea mays* L.) is one of the important cereal crops grown all over the world. It is grown in various agro climatic conditions ranging from temperate to tropical regions from sea level to an altitude of 2500 meters thought out the world. Maize ranks third both in terms of area (127.38 million hectares) and production (470.57 million tonnes). In India, it is grown in an area of 6.25 million hectares with a production of 10.6 million tonnes. The average global productivity of crop is 3.78 tonnes/ha against the average productivity of 1.7 tonnes/ha in India. (Rai and Mouria, 1998) [15]. About 66 percent of the global maize production is used as feed, 25 percent as food and industrial products, and the remaining as seed etc. Maize serves as staple food for several 100 million people in Latin America, Asia and Africa.
It is high calorie cereal, rich in carbohydrate and proteins. It is a fairly good source of minerals viz. calcium, phosphorus and iron vitamin A, nicotinic acid and riboflavin, maize grain provides more calories on an equivalent basis than that of wheat and rice, several dishes including chapaties are prepared out of maize flour, roasted green cobs are considered to be a delicacy among common people.
Poplars are known as 'short-rotation woody crops' because of their ability to grow fast thus mature quickly. In areas lacking natural forests, especially in the northern hemisphere, poplars have proved to be very valuable in satiating demand for timber. Even though they are considered a minor contributor to the world's timber supply, the areas in Nitrogen plays a vital role for the activity of every living cell. An adequate supply of Nitrogen is associated with dark green colour, high photosynthetic activity and vigrous growth. An excess of nitrogen can delay the crop maturity and the optimum use of nitrogen in conjunction with other nutrients

i.e. N,P,K, and S cause timely maturity of crops such as corn. When N supplies are sufficient, carbohydrates will be deposited in vegetative cells causing them to thicken. When N supply are adequate and conditions are favorable for growth, proteins are formed from the manufactured carbohydrate which is thus deposited in the vegetative portion, more protoplasm is hydrated which result in succulent plant tissues production in the United States, South Korea, and China are increasing (Heilman, 1999) [10]. Commercial scale plantations of poplar have been expanding since the WIMCO-sponsored Farm Forestry Project was launched in 1984. Because of its deciduous nature, poplar can support the growth of agricultural crops beneath it without adversely affecting yield. During the winter season, wheat can be grown. Ten million trees used to be planted annually in 0.02 million ha with an average density of 400-500 trees per hectare. The advantages of integrating poplar trees in farms are having faster biomass & growth, more compatible with agricultural crops. The leaves decompose and help to maintain soil nutrients. It can be easily sold and fetches better price.

Sulphur nutrition helps the plants to perform many physiological functions like synthesis of sulphur containing amino acids namely, cytein, cystine, methionine, chlorophyll etc. Synthesis of proteins occurs in leaves; hence sulphur deficiency leads to chlorosis of younger leaves. It is also responsible for synthesis of certain vitamins, metabolism of carbohydrates and oils. The concentrations of sulphur in vegetative tissue usually range 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.

Material and methods

The materials, methodology and technique adopted during the course of investigation are described under the following heads.

Experimental site

The experiment was carried out during *kharif* season 2017-18 at Forest Nursery and Research Center, COF, Sam Higginbottom University of Agriculture, Technology and Sciences (SHUATS), Allahabad. U.P., which is, located at 25.57° N latitude. de 81.50° E longitude and 98 m altitude above the mean sea level. All the facilities, which are required for crop cultivation met out from the Department.

Soil of the experimental field

To ascertain physico-chemical characteristics of the soil, before sowing, soil sample were collected randomly from 0-30 cm depth from different spots of experimental field just before layout of experiment. A representative homogenous composite sample was drawn by mixing all these soil sample together. This composite soil sample was analyzed to determine the physico-chemical properties of the soil.

Design and Treatment

The experiment was carried out in 3×3 factorial randomized block design with three levels of Nitrogen three levels of Sulphur. The treatments were replicated three times and were allocated at random in each replication.

Variety of crop (Maize)

The crop variety used for experimental area is “Sweet Heart”.

Fertilizer application

The fertilizers were applied in each plot according to treatment combinations. The nitrogen requirement meets with urea 46%. The Nitrogen and Sulphur was applied three different levels *i.e.* [(100 kg ha^{-1}), (120 kg ha^{-1}) and (140kg ha^{-1})] and three levels of Sulphur [(20kg ha^{-1}), (30kg ha^{-1}) and (40kg ha^{-1})]respectively was given in equal quantity to each plot which was calculated on the basis of general recommendation for maize was supplied.

Results and discussion

Pre-harvest observation

Perusal of table reveals the highest plant height(cm), number of leaves per plant and plant dry weight (g) was recorded with the application of 140 kg N/ha (167.20 cm, 11.30 and 121.56(g) respectively) and minimum was recorded with the application of 100 kg N/ha i.e. (159.23 cm, 10.60 and 112.77(g) respectively).

The data also reveals that by increasing the levels of Sulphur the plant height (cm), number of leaves/plant and plant dry weight (g) increased. The maximum plant height (cm), number of leaves/plant and plant dry weight (g) was recorded (171.33 cm, 11.42 and 122.17 g respectively) with the application of 40-kg sulphur/ha. The minimum (155.71 cm, 10.55 and 110.55g) was recorded with for the no sulphur respectively.

Interaction effect of nitrogen and sulphur levels on

Similarly irrespective of the levels of nitrogen, the increasing levels of sulphur significantly increased the plant height (cm), number of leaves/plant and plant dry weight (g). The application of 140 kg nitrogen + 40 kg sulphur/ha has given significant result.

Table 1a: Effect of Nitrogen and Sulphur levels on Pre-harvest observation of *kharif* Maize *(Zea mays* L.)

Treatment	Growth parameters		
	Plant height (cm) (90DAS)	**No of leaves/plant (90DAS)**	**Plant Dry weight/plant (90DAS)**
Nitrogen (kg ha^{-1})			
100	159.23	10.59	112.77
120	161.98	11.07	117.90
140	167.20	11.30	121.56
F-test (5%)	S	S	S
S. Ed. ±	0.56	0.11	0.12
CD at 5%	1.17	0.24	0.27
Sulphur (kg ha^{-1})			
20	157.94	10.79	116.64
30	166.23	11.19	120.29

40	171.33	11.42	122.17
F-test (5%)	S	S	S
S. Ed. ±	0.65	0.13	0.14
CD at 5%	1.36	0.27	0.31

Table 1b: Interaction effect of Nitrogen and Sulphur levels on Pre-harvest observation of *kharif* Maize (*Zea mays* L.).

Levels of S (kg/ha)	Plant height (cm) (90DAS)			No of leaves/ plant (90DAS)			Plant Dry weight/plant (90DAS)		
	Levels of Nitrogen kg/ha								
	100	120	140	100	120	140	100	120	140
20	153.16	157.63	163.04	10.523	10.91	10.93	111.62	117.63	120.67
30	167.20	163.79	167.71	10.80	11.26	11.52	116.32	121.99	122.55
40	167.04	171.28	175.68	10.59	11.65	12.06	115.83	122.33	128.34
F-test at 5%	S			S			S		
SE±	1.13			0.22			0.25		
CD at 5%	2.36			0.48			0.53		

Post- harvest observations

Perusal of table reveals the highest No of Cobs/ plant, Test weight (g) and Grain yield (q/ha) was recorded with the application of 140 kg N/ha (1.19, 252.51(g) and 48.04(q/ha) respectively) and minimum was recorded with the application of 100 kg N/ha i.e. (1.10, 235.50(g) and 46.51(q/ha) respectively).

The data also reveals that by increasing the levels of sulphur increased the No of Cobs/ plant, Test weight (g) and Grain yield (q/ha). The maximum plant No of Cobs/ plant, Test weight (g) and Grain yield (q/ha) was recorded (1.20, 255.05(g) and 51.45(q/ha) respectively) with the application of 40-kg sulphur/ha. The minimum (1.13, 245.68(g) and 45.47(q/ha)) was recorded with the no sulphur respectively.

The above findings might be due to higher content of proteins, hormones, enzymes, vitamins alcoholised and chlorophyll in plants leaves, which might have resulted in increased nitrogen metabolismgreater utilization of absorbed nitrogen better photosynthesis and higher photosynthetic accumulation which ultimately led to better growth development of plants. Similar findings were also obtained by

Interaction effect of nitrogen and sulphur levels on

Similarly irrespective of the levels of Nitrogen, the increasing level of Sulphur increased the No of Cobs/ plant, Test weight (g) and Grain yield (q/ha) significantly. The application of 140 kg nitrogen + 40 kg sulphur/ha has given significant result.

Table 2a: Effect of Nitrogen and Sulphur levels on yield characters of *kharif* Maize (*Zea mays* L.).

Treatment	Yield parameters		
	No of Cobs/plant	Test weight (g)	Grain yield (q/ha)
Nitrogen (kg ha^{-1})			
100	1.10	235.50	46.51
120	1.16	245.70	47.64
140	1.19	252.51	48.04
F-test (5%)	S	S	S
S. Ed. ±	0.06	0.12	0.11
CD at 5%	0.14	0.27	0.24
Sulphur (kg ha^{-1})			
20	1.13	245.68	45.47
30	1.19	252.70	49.60
40	1.20	255.05	51.45
F-test (5%)	S	S	S
S. Ed. ±	0.07	0.14	0.13
CD at 5%	0.16	0.31	0.28

Table 2b: Interaction effect of Nitrogen and Sulphur levels on yield parameters of *kharif* Maize (*Zea mays* L.).

Levels of S (kg/ha)	No of Cobs/plant			Test weight (g)			Grain yield (q/ha)		
	Levels of Nitrogen kg/ha								
	100	120	140	100	120	140	100	120	140
20	1.07	1.15	1.17	240.20	247.93	248.92	43.29	48.75	49.05
30	1.15	1.20	1.21	242.17	256.02	256.27	45.41	51.31	52.32
40	1.12	1.23	1.25	245.83	259.41	263.60	45.19	52.50	53.00
F-test at 5%	S			S			S		
SE±	0.13			0.25			0.23		
CD at 5%	0.28			0.53			0.49		

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