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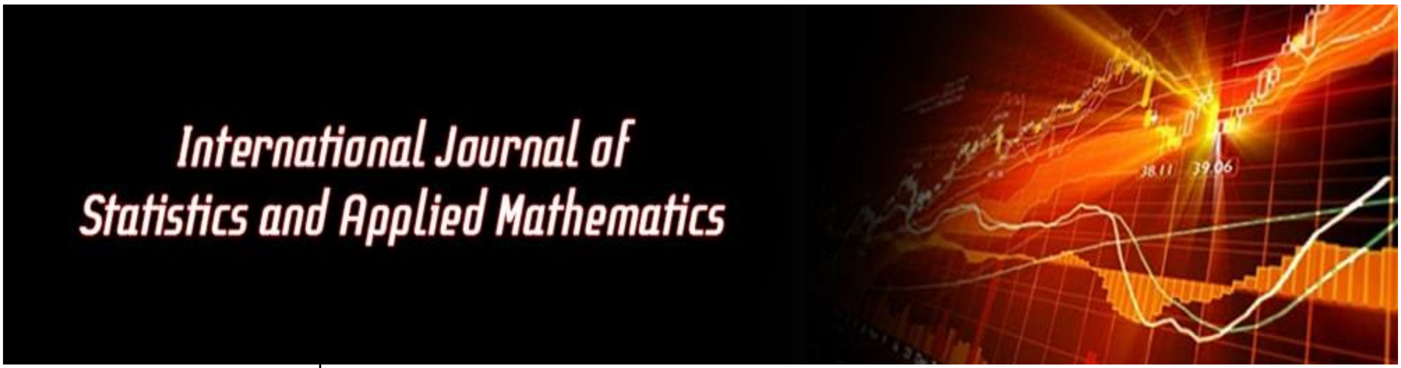

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Effect of foliar applied micronutrients on growth and production of maize-cowpea intercropping system

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Abstract
A field experiment was carried out in *kharif* season in 2018 and 2019 at Crop research farm, Department of Agronomy, Naini Agricultural Institute, SHUATS, Prayagraj (U.P). The present study assessed "Effect of foliar applied micronutrients on growth and production of maize-cowpea intercropping system". The experiment comprised of fifteen treatments consisting recommended dose of fertilizer of NPK and foliar application of micronutrients at 40 days after sowing. Foliar application of micronutrients along with Recommend dose of fertilizer recorded significantly higher grain yield of sole maize (4.92 t ha^{-1} in treatment T_4 (Maize sole crop + Foliar application of Boron 1%) and sole cowpea in treatment T_9 (Cowpea sole crop + Foliar application of Boron 1%) 1.93 t ha^{-1} as compared to other treatments. Yield attributes of maize *viz*., number of cob $plant^{-1}$, Number of grains cob^{-1}, test weight, grain yield were highest with the application of RDF + foliar application of Boron @ 1% (T_4). And Yield attributes of cowpea *viz*., number of pod^{-1}, number of grains pod^{-1}, test weight, grain yield were highest with the application of RDF + foliar application of Boron @ 1% in (T_9) was superior over recommended dose of fertilizers with other micronutrients and control. The treatment T_4 (Maize sole crop + Foliar application of Boron 1%) recorded the highest gross returns, net returns and B:C ratio.

Keywords: Intercropping, cowpea, maize, micronutrients

Introduction
Maize (*Zea mays* L.) is the third most important food grain crop next only to rice and wheat in India (L. P. Manasa *et al*., 2015) [12]. It is one of the most important cereal crop in the world's agricultural economy, both as a food and feed crop and its value added products have a good export potential. Due to its versatile characteristics of suitability and adaptability to various Agro-climates, maize is gaining popularity among the Indian farmers. It is known as the ''Queen of Cereals'' due to its high yielding potential (G. S. Adarsha *et al*., 2019) [9]. Cowpea is grown across the world on an estimated 14.5 million ha of land planted each year and the total annual production is 6.2 million metric tons. Over the last three decades, global cowpea production grew at an average rate of 5%, with 3.5% annual growth in area and 1.5% growth in yield, and the area expansion accounting for 70% of the total growth during this period (Boukar *et al*., 2016) [4]. India is the largest producer of grain legumes accounting for about 24% of the global legume production and holding 32% of the world grain legumes harvested land (Erana Kebede *et al*., 2020) [7]. Cowpea (*Vigna unguiculata* L.) plays a critical role as major source of dietary protein that produces income for farmers and traders. Besides being a rich source of protein, cowpea maintain soil fertility through biological nitrogen fixation in soil and thus play a vital role in furthering sustainable.

Growing of two or more crop species simultaneously in the same field in a definite row arrangement during a growing season. It increases total productivity per unit area through maximum utilization of land, labour and growth resources (Namatsheve *et al*., 2020) [19]. Intercropping system increases the yield and resource use efficiency due to enhanced temporal and spatial resource use efficiency, for which all the above-ground as well as belowground parts of crops play a vital role (Midega *et al*., 2014) [16]. Intercropped legume derives more of its N from the atmosphere, compared with when it is grown as sole crop. Cereal legume intercropping system is more stable than sole cropping or monoculture regarding soil fertility improvement, yields enhancement and financial returns (Machado, 2009; Himmelstein *et al*., 2017) [13, 11].

It helps to risk reduction associated with associated with growing only one crop (Snapp *et al*., 2010; Himmelstein *et al*., 2017) [22, 11].

Micronutrients are required in lower amounts compared to macronutrients (N: P: K) (Pochampally Kavya *et al*., 2020) [21]. They have a major role in cell division and development of meristematic tissues, photosynthesis, respiration and acceleration of plant maturity. In addition, iron (Fe), boron (B), zinc (Zn), copper (Cu), and manganese (Mn) are considered essential micronutrients for plants and humans and micronutrients can maintain crop-physiology balance. Foliar application is the spraying of fertilizer solutions containing one or more nutrients on the foliage of growing plants. Foliar nutrition of micronutrients has been proven to be an excellent method because foliar feeding targets the plants which shows the signs of micronutrient deficiency (Pochampally Kavya *et al*., 2020) [21].

Material and Methods

The experiment was carried out in *kharif* season in 2018 and 2019 at Crop research farm, Department of Agronomy, Naini Agricultural Institute, SHUATS, Prayagraj (U.P). The soil of the experimental field was sandy loam in texture in category of soils group, which is low in organic carbon (0.46%) and available nitrogen (118 kg ha^{-1}), medium in phosphorus (26.5 kg ha^{-1}) and high in potassium (312 kg ha^{-1}). The soil was slightly alkaline in reaction with (pH 7.7) the experiment was laid-out in Randomized block design with three replications. The details of the treatments were as T_1 Control (Maize sole crop), T_2 (Maize sole with foliar application of Magnesium 1%), T_3 (Maize sole with foliar application of Zinc 1%), T_4 (Maize sole with foliar application of Boron 1%), T_5 (Maize sole with foliar application of Iron 1%), T_6 Control (Cowpea sole crop), T_7 (Cowpea sole with foliar application of Magnesium 1%), T_8 (Cowpea sole with foliar application of Zinc 1%), T_9 (Cowpea sole with foliar application of Boron 1%), T_{10} (Cowpea sole with foliar application of Iron 1%), T_{11} control (Maize-Cowpea (1:1), T_{12} (Maize-Cowpea (1:1) with foliar application of Mg 1%), T_{13} (Maize-Cowpea (1:1) with foliar application of Zn 1%), T_{14} (Maize-Cowpea (1:1) with foliar application of Boron 1%), T_{15} (Maize-Cowpea (1:1) with foliar application of Iron 1%). Recommended dose of fertilizer used for maize and cowpea were 120:60:30 and 25:50:30 NPK kg ha^{-1} respectively according to the plant population of the crops in sole and intercropping treatments. For maize crop, half of the nitrogen and full doses of phosphorus and potash were placed below the seed in open furrows during sowing time. Remaining nitrogen was top dressed in two equal splits, immediately after first weeding corresponding to knee-height stage and second dose at tasseling stage, respectively. For cowpea full dose of nitrogen, phosphorus and potash placed below the seed in open furrows at the time of sowing. K-064 of maize and Mohini of cowpea varieties were taken for conducting research experiments. The other management operations were done as per recommended package of practises for both main and intercrops.

Results and Discussion

Growth and yield attributes

1. Effect on Maize (main crop)

The growth and yield attributes of maize indicated influence of boron application during 2018 and 2019 seasons is presented in (Table1). Maize grown under the treatment T_4 (Maize sole with foliar application of Boron 1%) resulted in the tallest plant over the other treatments during the two growing seasons. On the other hand, the shortest maize plants were produced in T_{11} (Maize-Cowpea (1:1) control) from cultivating of intercropping during the two seasons. Results in (Table.1) shows that the treatment of T_4 (Maize sole with foliar application of Boron1%) produced the greatest values of test weight (g), number of grains cob^{-1} and grain yield (t ha^{-1}) as compared to all the treatments during 2018 and 2019 seasons. Similarly, maize grown through foliar application of nutrients produced healthy seed and resulted in higher 100-grain weight compared with seed priming and soil application. Allah Wasaya *et al*. (2017) [3]. Foliar application of Boron at earlier, middle and later growth stages along with recommended dose of NPK resulted in higher maize food and fodder yield (Soomro *et al*., 2011) [23] The competition between maize and cowpea was high because of close distances between cowpea. As the number of increased cowpea sides, the competition was not too much to reduce 100-grain weight (g), number of grains cob^{-1} and grain yield (t ha^{-1}.) of maize. The pure stand maize had the greatest 100-grain weight (g), number of grains cob^{-1} and grain yield (t ha^{-1}) in both seasons. Generally, the results in (Table.1) clarify that the maize planting under the treatment of T_{11} (Maize-Cowpea (1:1) control) led to decrease the values of 100-grain weight (g), number of grain cob^{-1} and grain yield (t ha^{-1}) as compared with the pure stand or all the other treatments during in both seasons. These results are in agreement with Haruna *et al.* (2013) [10], Dube *et al*. (2014) [6] and Oyeogbe *et al.* (2015) [20].

Table 1: Effect of foliar applied micronutrients on the growth and yield of maize

Notation	Plant height (cm)		Dry weight (g)		Number of cobs plant^{-1}		Number of grains plant^{-1}		Test weight (g)		Seed yield (t ha^{-1})		Harvest index (%)	
	2018	2019	2018	2019	2018	2018	2019	2019	2018	2019	2018	2019	2018	2019
1	168.18	193.95	105.35	106.45	1.27	2.11	366.78	342.00	18.67	22.29	3.64	3.89	35.81	46.54
2	173.25	199.92	136.73	138.43	1.47	2.44	395.56	431.78	20.60	23.53	4.20	4.21	39.21	48.55
3	197.83	201.93	152.55	154.26	1.67	3.11	438.78	445.89	23.95	24.13	4.78	4.79	45.00	53.69
4	204.80	206.25	156.00	158.59	2.07	3.67	465.56	490.89	25.12	26.37	4.85	5.00	45.62	56.88
5	177.14	198.68	130.92	132.18	1.60	2.89	414.00	456.67	22.73	23.97	4.32	4.49	41.73	51.91
6	-	-	-	-	-	-	-	-	-	-	-	-	-	-
7	-	-	-	-	-	-	-	-	-	-	-	-	-	-
8	-	-	-	-	-	-	-	-	-	-	-	-	-	-
9	-	-	-	-	-	-	-	-	-	-	-	-	-	-
10	-	-	-	-	-	-	-	-	-	-	-	-	-	-
11	161.42	191.11	102.83	104.53	1.33	1.78	314.11	359.44	17.43	20.18	2.09	2.55	21.71	32.61
12	162.12	199.36	128.73	131.48	1.53	2.56	393.78	420.89	19.77	23.47	2.52	2.87	25.89	32.16
13	196.22	202.54	144.37	146.52	1.47	2.89	413.44	416.67	23.40	23.69	2.77	3.30	28.94	40.76
14	200.78	204.48	154.48	154.23	1.80	3.00	438.44	424.78	25.34	25.50	3.35	3.48	34.11	42.09
15	170.45	200.79	125.63	127.14	1.47	2.33	403.67	409.33	21.29	24.07	2.70	3.07	27.77	36.84
F-Test	S	S	S	S	S	S	S	S	S	S	S	S	S	S
S.Ed. (±)	1.632	1.831	0.563	0.569	0.091	0.216	9.926	21.186	0.860	0.731	0.194	0.228	2.205	2.150
C.D. at 0.5	3.343	3.75	1.152	1.166	0.187	0.443	20.331	43.397	1.762	1.498	0.398	0.468	4.517	4.405

2. Effect on Cowpea (secondary crop)

Foliar application of boron showed significant influence on growth and yield attributes of cowpea (Table 2.) spraying of boron at 40 days after sowing recorded maximum plant height, plant dry weight, number of pods plant^{-1}, grain yield of cowpea during 2018 and 2019 seasons. The cowpea grown under the treatment of T_9 (Cowpea sole with foliar application of B 1%), gave the tallest plants as compared with all the other treatments during in both seasons. Regarding the number of grains pod^{-1}, grain yield grains, test weight and harvest index results in (Table 2.) indicate that treatments had a significant effect on growth and yield attributes of cowpea during both seasons. Generally, it is clear that number of plant height of cowpea tended to decrease when grown under the intercropping treatments as compared with the pure stands. On the other hand, the treatment of T_{11} (Maize-Cowpea (1:1) control) resulted in the lowest growth and yield attributes viz., plant height, number of pods per plant, test weight and grain yield as compared with the other treatments. Similar results were obtained by Dahmardeh *et al. (*2010) [5], Adeniyan *et al.* (2011) [1], Akbar *et al*. (2012) [2], Ewansiha *et al*. (2015) [8], Moriri *et al*. (2015) [17], Muoneke *et al*. (2015) [18] and Mahdy and El-Said (2017) [15].

Table 2: Effect of foliar applied micronutrients on growth and yield of cowpea

Notation	Plant height (cm)		Dry weight (g)		Number of (pods plant^{-1})		Number of (grains plant^{-1})		Test weight (g)		Seed yield (t ha^{-1})		Harvest index (%)	
	2018	2019	2018	2019	2018	2019	2018	2019	2018	2019	2018	2019	2018	2019
1	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2	-	-	-	-	-	-	-	-	-	-	-	-	-	-
3	-	-	-	-	-	-	-	-	-	-	-	-	-	-
4	-	-	-	-	-	-	-	-	-	-	-	-	-	-
5	-	-	-	-	-	-	-	-	-	-	-	-	-	-
6	51.48	79.01	19.63	19.73	14.80	15.27	13.33	16.73	10.71	10.77	1.34	1.40	30.36	30.12
7	50.58	79.15	22.95	23.27	16.27	16.60	14.27	17.60	12.17	12.46	1.64	1.81	36.04	36.79
8	58.83	85.02	23.79	24.05	17.60	18.00	18.27	19.13	12.60	12.97	1.80	1.86	40.73	40.01
9	59.63	86.97	24.96	25.14	18.80	20.20	19.60	20.00	13.10	13.51	1.89	1.96	43.94	43.07
10	51.91	81.04	21.80	21.35	17.13	16.93	16.13	17.87	11.89	12.71	1.72	1.94	37.96	40.14
11	49.51	76.26	17.56	18.03	13.53	14.93	12.27	15.67	9.67	9.91	0.69	0.84	13.37	15.32
12	51.92	76.85	20.70	20.25	15.40	15.87	13.87	18.20	11.00	11.75	0.73	0.85	14.48	15.91
13	51.42	83.59	21.52	21.54	16.80	17.00	17.20	18.47	11.90	12.10	0.79	0.96	16.46	18.53
14	55.29	85.47	22.18	21.90	18.27	19.07	18.33	18.60	12.15	12.43	0.90	1.05	20.16	22.03
15	51.43	79.49	20.24	20.00	15.93	16.33	15.33	17.40	11.42	11.24	0.76	0.88	15.90	17.23
F-Test	S	S	S	S	S	S	S	S	S	S	S	S	S	S
S.Ed. (±)	0.841	0.824	0.525	0.460	0.447	0.494	0.266	0.346	0.431	0.490	0.037	0.038	0.598	0.683
C.D. at 0.5	1.723	1.687	1.075	0.942	0.916	1.011	0.546	0.709	0.884	1.004	0.075	0.078	1.225	1.400

Conclusion

In the present study, it can be concluded that the maize and cowpea crops responded positively to the foliar application of micronutrients. The treatment of sole maize that received soil application of RDF along with foliar spray of boron @ 1% once at 40 DAS showed significantly higher performance in growth and yield of maize.

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