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https://doi.org/10.29321/MAJ.10.A02369

Madras Agric. J. 72 (4) : 206-212 April, 1985

EFFECT OF FOLIAR APPLICATION OF N, P, K AND S ON GRAIN YIELD AND YIELD COMPONENTS OF CORN (*Zea mays* L.)*

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The effect of foliar application of N, P, K and S on the grain yield and yield components of corn was investigated. The results showed that neither the fifteen factorial treatments alone nor all the twenty-eight treatments used had a significant effect, ($P < 0.05$) on the grain yield and yield components. However, the grain yield of the factorial treatments was positively and significantly correlated with seed size, ($P < 0.01$) and ear length, ($P < 0.05$), but both yield components did not significantly influence grain yield. Based upon these results, foliar application of micro-nutrients on corn to increase grain yields may not be worthwhile.

Although foliar fertilization constitutes one of the many important milestones in the progress of agricultural crop production, it has been used principally in cases requiring quick recovery from a micro-nutrient deficiency. Foliar application of macro-nutrients either in single or complete formulations, generally, has not been widely investigated as a method of fertilizing grain crops to increase grain yields. Results from limited studies of foliar application of N and or P on corn have been conflicting. Some workers have reported yield increases (Thomas, 1960; Singh and Sarolia, 1970; Barel, 1975) while some reported on yield increase (Schumacher and Welch, 1970).

Forms a part of Ph. D. Thesis submitted by the author to the Department of Agronomy, Iowa State University, Ames, Iowa-50011, U. S.A.

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With continuous cropping, particularly of grain crops on the same soils nutrient deficiency disorders with their concomitant yield reductions are becoming more frequent. Foliar nutrient sprays are often the most effective and at times the only practical means of correcting and controlling such deficiencies. Moreover, the soil imposed problems of dilution penetration and fixation of nutrients applied directly on the soil are circumvented through foliar fertilization. Based upon the above, foliar fertilization has a great potential in crop production and should be reconsidered as a means of increasing crop yields. This study was conducted to investigate the effect of foliar application of N, P, K and S on the grain yield and yield comprising seed size, ear length and ear weight of corn.

MATERIALS AND METHODS

The experiment was conducted on the Bruner University farm located

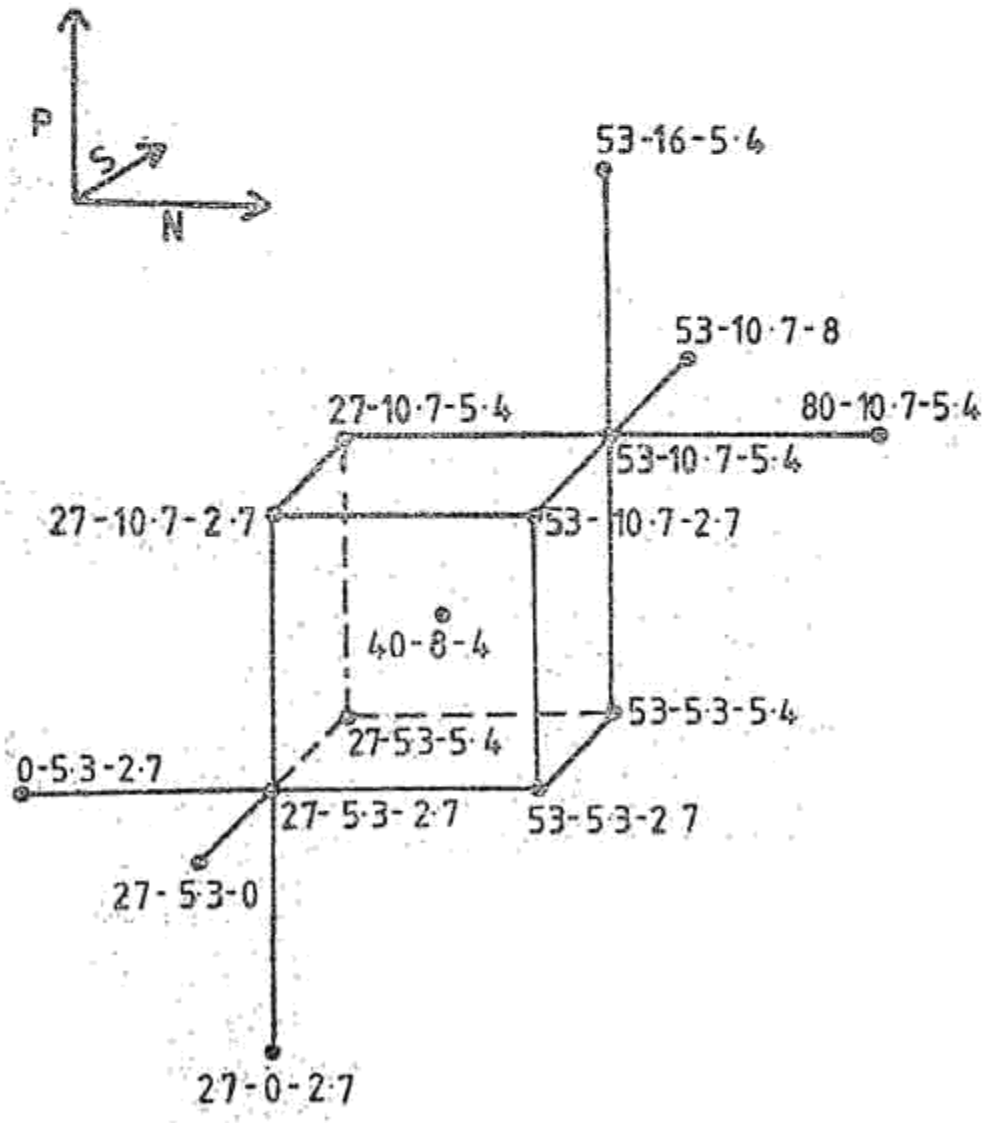

Figure : An incomplete 4^3 factorial design with a midpoint treatment of 40-8-4 kg/ha of elemental N, P and S respectively.

Table 1 : Treatments applied and sources of nutrients used

Treatment No.	Total nutrients applied (kg/ha) N	P	K	S[a]	Sources of nutrients[b]
1.	40	8.0	8.0	4.0	1, 2, 3, 5, 8
2.	27	5.3	8.0	2.7	1, 2, 3, 4, 5
3.	27	5.3	8.0	5.4	1, 2, 3, 4, 5
4.	27	10.7	8.0	2.7	1, 2, 3, 4, 5
5.	27	10.7	8.0	5.4	1, 2, 3, 4, 5
6.	53	5.3	8.0	2.7	1, 2, 3, 4, 5
7.	53	5.3	8.0	5.4	1, 2, 3, 4, 5
8.	53	10.7	8.0	2.7	1, 2, 3, 4, 5
9.	53	10.7	8.0	5.4	1, 2, 3, 4, 5
10.	0	5.3	8.0	2.7	2, 3, 5, 9,
11.	80	10.7	8.0	5.4	1, 2, 3, 4, 5
12.	27	0.0	8.0	2.7	1, 5, 6, 7,
13.	53	16.0	8.0	5.4	1, 2, 3, 4, 5
14.	27	5.3	8.0	0.0	1, 2, 3, 5,
15.	53	10.7	8.0	8.0	1, 2, 3, 4, 5
16.	40	5.3	8.0	2.7	1, 2, 3, 4, 5
17.	80	5.3	8.0	2.7	1, 2, 3, 4, 5
18.	53	0.0	8.0	2.7	1, 5, 6, 7,
19.	53	8.0	8.0	2.7	1, 2, 3, 4, 5
20.	53	16.0	8.0	2.7	1, 2, 3, 4, 5
21.	53	5.3	8.0	0.0	1, 2, 3, 5
22.	53	5.3	8.0	8.0	1, 2, 3, 4, 5
23.	53	5.3	0.0	2.7	1, 3, 4, 5
24.	53	5.3	4.0	2.7	1, 2, 3, 4, 5
25.	53	5.3	16.0	2.7	1, 2, 4, 5, 6
26.	0.0	0.0	0.0	0.0	5,
27.[c]	0.0	0.0	0.0	0.0	—
28.	53	5.3	8.0	2.7	1, 2, 3, 4

[a] The primary but not the sole sources of N, P, K and S were urea, ammonium polyphosphate, potassium polyphosphate and ammonium sulfate respectively. Different combinations of different fertilizer compounds were used to obtain the required treatments.

[b] 1 = Urea, 2 = potassium polyphosphate, 3 = ammonium polyphosphate, 4 = ammonium sulfate, 5 = 0.1% Tween 80, 6 = potassium sulfate, 7 = potassium chloride, 8 = ammonium thiosulfate, 9 = sodium sulfate.

[c] Absolute control.

about 13km West of Ames, Iowa. The soil at the site is a Nicollet-Webster complex, but is primarily webster silty clay loam; which is classfied as Typic Haplaquoll. The Nicollet soil is classified as Aquic Hapludoll. The plowlayer (0-15cm) of the site was analysed for chemical properties before the beginning of the experiment. The soil PH and soil buffer PH were 7.1 and 7.2 respectively. The available phosphorus and potassium contents were 36 and 127 ppm respectively, the former being medium and the latter being low-medium. The available nitrogen and sulfur contents of the site were not determined but they had been repoited to be of low-medium range.

A widely grown corn variety in Iowa, Pioneer 3780 was used as the test plant and it was machine planted in rows spaced 0.76m apart between the rows and at the planting rate of 49,400 kernels/ha. An incomplete 4^4 factorial arrangement of treatments in a randomized complete block design of three replications was used. The core treatments were designed as a cube with extended edges as shown in Figure 1, and they included the first fifteen treatments, (Table 1). Treatments 16-28 (Table 1) were added to test both the effects of each nutrient at fixed levels of the other three nutrients and effect of the surfactant (Tween 80). This incomplete factorial design has the advantages of permitting (a) the use of fewer treatments, (mainly fifteen in this case), as compared to the sixty-four treatments of the 4^4 complete factorial, (b) the estimation of both the quadratic responses and the interactions with good precision, and (c) the graphic presentation of the results (Laird and Turrent 1974, Ramon and Hanway, 1976).

Each experimental plot was 3.05m wide and 12.2m long. The fertilizer solutions (Table 1) were first sprayed on the corn plants at four weeks after 75% silking. Spraying was performed in the morning between 7 and 10 a.m. and at the rate of 150 l/ha of fertilizer solutions were made at the rate of 150 l/ha of fertilizer solution per application. Two foliar applications of the solution were made at one-half of the total nutrients applied per application at two-week interval. The aerial plant parts, particularly the leaves were sprayed to give as much a uniform coverage as possible. The corn grain yield components comprising ear length, ear weight and seed size or seed weight were recorded.

Because of the nature of the exprimental design in which the first fifteen treatments were in a factorial arrangement and the rest of them were not, the statistical analyses of the results were divided into two parts. In the first part the first fifteen treatments were analysed, and in the second part all of the twenty-eight treatments were analysed.

RESULTS AND DISCUSSION

Analyses of the first fifteen treatments, including linear and quadratic components and all possible interactions showed no significant effect on grain yield but the P x S interaction had a significant effect on seed size, ($P<0.07$) (Table 2). Analyses of all twenty-eight treatments also revealed that the treatments had no significant

effect on any of the parameters investigated. The effects on mean grain yield of the rates of each given nutrient with the rates of the other three nutrients held constant are shown in Table 3. Although, all the nutrients, except S, appeared to have a slight positive effect on grain yield at all rates except the highest rates, the analyses of variance of these non-orthogonal sets showed no significant effect on grain yield which was the only parameter tested in this case. Comparisons of the two levels (0 and 3.0 l/ha) of the surfactant, (Tween 80), treatments 27 and 26 respectively, showed that the surfactant had no significant effect on all the parameters investigated may be due to several reasons, paramount amongst which are the following :- (a) the nutrient contribution of the soil may have been high, thus limiting crop response to foliar fertilization, (b) the foliar-applied nutrients may not have been fully absorbed to enhance crop response, and (c) substantial grain-filling may have occurred before foliar application of the nutrients.

The lack of significant effects of foliar fertilization on the parameters investigated, particularly grain yield, was in disagreement with the findings of some authors (Singh and Sarolia, 1970; Barel, 1975). They reported grain yield increases resulting from foliar fertilization of corn using single fertilizer formulations and these were applied at a much earlier developmental stage of the corn plants for instance, (Barel, 1975) did not only apply different phosphatic compounds singly, but the foliar fertilized corn plants at three different physiological stages, namely at knee-high, just before tasseling and after silking. The correlation co-efficients between grain yield and seed size, ear weight and ear length were 0.48, 0.74 and 0.28 respectively. Although these yield components were correlated with grain yield, they did not significantly influence the grain yield *per se*. These correlations, however, were probably due to random variations in yield of which seed size, ear weight and ear length are positively correlated components.

The study indicated that foliar application of N, P, K and S on corn during the grain-filling period to increase grain yields may not be worthwhile.

The author is grateful to Professor J. J. Hanway for providing the funds to conduct this research and for his assistance throughout the conduction of this research. Special thanks are also extended to Dr. L. C. Dumenil and my colleagues for helping in the statistical analyses of the data and for their invaluable suggestions in the preparation of the manuscript.

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Table 2. Effect of foliar fertilization on means ± S. E. for grain yield (q/ha), Seed size (g), Ear weight (g) and Ear length (cm)

Treatment No.	Grain yield	Seed size	Ear weight	Ear length
1.	80.4±2.57	28.2±0.80	204.1±9.10	80.7±1.59
2.	89.2±4.36	29.7±1.10	220.8±6.57	80.2±1.97
3.	82.2±3.30	28.1±0.86	211.7±8.44	79.0±1.53
4.	86.8±2.95	28.7±0.75	228.3±6.35	76.8±2.42
5.	87.6±5.41	30.3±1.16	217.8±9.07	78.3±0.88
6.	87.0±3.30	29.1±0.28	228.3±1.50	80.0±2.31
7.	87.3±1.60	28.6±0.87	220.8±6.03	80.0±2.08
8.	87.7±3.13	28.4±1.06	219.3±12.10	79.3±2.19
9.	83.9±0.80	30.9±0.38	229.8±3.99	80.8±1.19
10	84.3±3.72	29.0±1.13	217.7±6.91	79.0±1.53
11	86.8±2.64	29.4±2.06	220.7±8.40	82.3±4.49
12.	93.0±3.52	29.1±2.13	223.8±8.42	78.0±1.53
13.	83.6±8.83	28.2±0.94	222.3±24.99	73.7±2.67
14.	88.6±2.77	29.5±1.24	217.7±4.53	70.7±4.98
15.	90.3±2.12	30.6±0.99	211.7±3.00	78.8±0.44
16.	85.8±2.18	30.6±0.87	225.2±3.98	83.3±2.76
17.	82.0±1.88	27.1±0.01	204.1±2.63	75.0±3.51
18.	84.9±1.57	27.0±0.50	210.2±3.99	78.8±2.75
19.	86.9±3.40	28.2±0.82	219.2±9.21	80.2±0.17
20.	84.3±3.67	28.5±0.09	211.7±6.60	82.3±0.67
21.	87.1±3.28	28.4±0.28	225.3±17.36	81.8±2.73
22.	83.2±3.64	28.6±1.24	213.2±2.60	82.2±2.09
23.	83.8±4.85	28.4±0.41	216.2±3.99	77.7±0.20
24.	84.6±3.19	27.4±0.37	222.3±13.08	78.3±0.41
25.	82.0±4.61	28.8±0.47	211.7±5.67	84.0±4.04
26.	84.6±6.48	28.2±1.28	213.2±18.13	75.7±3.52
27.	73.7±4.68	26.3±0.59	199.6±6.93	77.3±2.03
28.	77.5±4.85	27.4±2.13	199.6±14.17	77.7±0.67

Table-3. Effect of selected treatments involving different rates of N, P, K and S on Mean ± S.E for grain yield

Treatment No.	Rate (kg/ha)[d]				Mean ± S.E. grain yield (q/ha)
	N	P	K	S	
10	0.0				84.3±3.72
2	27.0				89.2±4.36
16	40.0				85.8±2.18
6	53.0				87.0±3.30
17	80.0				82.0±1.88
18		0.0			84.9±1.57
6		5.3			87.0±3.30
19		8.0			86.9±3.40
8		10.7			87.7±3.13
20		16.0			84.3±3.67
23			0.0		83.8±4.85
24			4.0		84.6±3.19
6			8.0		87.0±3.30
25			16.0		82.0±4.61
21				0.0	87.1±3.28
6				2.7	87.0±3.30
7				5.4	87.3±1.60
22				8.0	83.2±3.64

[d] The rates of the other nutrients not shown in each treatment are the same as in Table 1.

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