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GROWTH AND YIELD OF OKRA UNDER FOLIAR APPLICATION OF SOME NEW MULTINUTRIENT FERTILIZER PRODUCTS

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ABSTRACT

Foliar fertilization successfully supplements plant nutrition, in integration with soil applied chemical fertilizers, under adverse soil, plant and environmental conditions. A field study was conducted to evaluate the growth and yield response of okra to three newly introduced foliar fertilizer products, viz. Super-dawn, Agri-power and Unigrow-C, either alone or integrated with soil applied recommended nitrogen and phosphorus. The results endorsed the benefits of foliar fertilization of crops by witnessing the improved growth traits of okra plants, viz. days to flowering, plant height, number of branches plant^{-1}, number of fruits plant^{-1} and fruit length, coupled with the better crop yield of okra by the integration of all three foliar fertilizers with the recommended soil applied chemical fertilizers. Okra yield was significantly ($p < 0.01$) correlated with all the above stated plant growth traits of okra. The regular testing of such effective foliar fertilizers and their use, after extensive controlled condition and field scale studies, is recommended for sustainable okra production.

Keywords: Okra, growth, yield, foliar fertilization.

INTRODUCTION

In Pakistan, okra (*Hibiscus/Abelmoschus esculentus* L. Moench) is commonly cultivated in the plain areas of Punjab and Sindh provinces (Anwar *et al*., 2011). The area under okra cultivation is about 2.2×105 ha, that yields ~2.9×106 tons of green pods (Kashif *et al*., 2008). Multinutrient foliar fertilization, in relation to balanced plant nutrition, appeared to be the part and parcel of modern sustainable vegetable production during recent past. This mode of applying fertilizers to the crops has been considered a precious supplement to the application of nutrients to soil system (Fageria *et al*., 2009). A number of studies

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highlighted the benefits of foliar fertilization in improving plant growth, crop yield, nutrient uptake and product quality (Naruka and Singh, 1998; Tumbare *et al*., 1999; Naruka *et al*., 2000; Alkaff and Hassan, 2003; Chattopadhyay *et al*., 2003; El-Aal *et al*., 2010; Zodape *et al*., 2011). This technique ensures immediate translocation of nutrients to various plant organs via leaf tissues under various nutrient deficiencies (Fageria *et al*., 2009). Hence, under the situations of low soil nutrients bioavailability, hard top soil, and decreased root activity during the reproductive growth stage of plants, foliar fertilization is most effective (Naruka *et al*., 2000; Chattopadhyay *et al*., 2003; Fageria *et al*., 2009; Zodape *et al*., 2011). Foliar fertilization has been recommended as a treatment in the integrated plant production due to its being environmentally safe and since it increases the crop yield and quality (Tumbare *et al*., 1999; Fageria *et al*., 2009; El-Aal *et al*., 2010; Zodape *et al*., 2011). Recently, Maitlo *et al*. (2006) documented the positive effects of foliar application of urea to the plant growth traits of wheat and its yield. Moreover, nutrient uptake by wheat also increased by the foliar application of urea. Earlier, it has been reported that the foliar fertilization improves nutrient use efficiency and hence it is an environmentally friendly technique. Foliar fertilization also improves the use efficiency of applied nutrients (Fageria *et al*., 2009; El-Aal *et al*., 2010; Zodape *et al*., 2011). Despite the fact that the subject of foliar fertilization of various nutrients to supplement crop production under stresses is adequately studied (Naruka *et al*., 2000; Chattopadhyay *et al*., 2003; Fageria *et al*., 2009), many aspects of the nutrient uptake and translocation within a plant in relation to newly introduced foliar fertilizers are still unrevealed. This study aimed at evaluating the growth and yield of okra in relation to the foliar fertilization of three newly introduced foliar fertilizers.

MATERIALS AND METHODS

A field study was conducted at Sindh Agriculture University Tandojam to evaluate the growth and yield response of okra to three newly introduced foliar fertilizer products against the soil application of recommended nitrogen and phosphorus fertilizers. The detailed nutrient content of these fertilizer products were: 1. Agri-power (mg L^{-1}): nitrogen 180,000, potash 1000, magnesium 100, zinc 100, boron 100, iron 1000, copper 20, manganese 100, 2. Super-dawn (mg L^{-1}): nitrogen 180,000, potash 1500, magnesium 300, zinc 900, boron 300, iron 1500, copper 10, manganese 100, molybdenum 0.002, cobalt, 0.002, 3. Unigrow-C (mg L^{-1}): nitrogen 2,00,000, magnesium 100, zinc 50, boron 100, iron 1000, copper 10, manganese 100. The nutrient contents of these foliar fertilizers were homogenized by adding the required amounts of various nutrients before foliar application to crop at one-liter ha^{-1}. For instance, 435 g urea was dissolved to one-liter Agri-power and Super-dawn each to provide the deficit amount of 200 g nitrogen. The treatments included T1: soil application of 150-75 kg nitrogen (N) and phosphorus (P) ha^{-1}, T2: soil application of 150-75 kg NP ha^{-1} + foliar spray of 1.0 L Super-dawn ha^{-1}, T3 = foliar spray of 1.0 L Super dawn ha^{-1} , T4: soil application of 150-75 kg NP ha^{-1} + foliar spray of 1.0 L Agri-power ha^{-1}, T5: foliar spray of 1.0 L Agri-power ha^{-1} , T6: soil application of 150-75 kg NP ha^{-1} + foliar spray of 1.0 L UniGrow-C ha^{-1} and T7: foliar spray of 1.0 L UniGrow-C ha^{-1} . The

soil under study (analyzed following Ryan *et al.*, 2001) was clay loam in texture, free from salinity hazards (EC: 0.42 dS m^{-1}), alkaline in reaction (pH: 8.1), low in organic matter (5.1 g kg^{-1}) and total N (0.43 g kg^{-1}), while deficient in $NaHCO_3$-extractable P (5.4 mg kg^{-1}) and NH4OAc-extractable potassium (105 mg kg^{-1}). The land was given two dry ploughings, followed by clod crushing and leveling for the homogenous irrigation of 60 cm wide ridges. The experiment was conducted following randomized complete block design having three replications. The individual plot size was 5m × 3m = 15m^2.

The seeds of okra cv. Subzpari were dibbled on both sides of ridges. The distance between two rows was 50 cm. Thinning was done 15 days after sowing, to maintain the plant to plant distance of 20 cm. The seeds were treated with Benlate fungicide before planting. The crop was irrigated at 10-15 days interval. All the recommended management practices were performed throughout the growth period of crop. Nitrogen and phosphorus fertilizers were applied as urea (46% N) and diammonium phosphate, DAP (18% N and 46% P_2O_5), respectively. The recommended dose of nitrogen (150 kg ha^{-1}) was applied in three equal splits, i.e. at the time of furrow preparation by broadcasting and soil incorporation and at second and third irrigation by top dressing. The recommended dose of phosphorus (75 kg ha^{-1} each) was applied at the time of furrow preparation by broadcasting and soil incorporation. The foliar fertilization was done by spraying the recommended dose of liquid fertilizers in four equal splits at 30, 45, 60 and 75 days after plant emergence. The observations recorded from plants were: days taken to flowering, plant height, number of branches $plant^{-1}$, number of fruits $plant^{-1}$, fruit length and fruit yield. The collected data were statistically analyzed for analysis of variance by using the statistical package Statistix ver. 8.1. The treatment means were separated by using Tukey's honestly significant difference (HSD) test at 5% level of probability. The relationship of various parameters with okra yield was also determined through correlation analysis using Statistix ver. 8.1.

RESULTS

The okra yield and its contributing growth traits were significantly affected by various foliar fertilizer treatments as against soil application of recommended nitrogen and phosphorus fertilizers, as depicted by the significance of F-values from the analysis of variance (Table 1). The flowering of okra delayed more in case of application of fertilizers either by soil application or foliar fertilization alone. However, integrating these two methods of fertilization enhanced the rate of flowering in okra and reduced the number of days to flowering. Accordingly, maximum days to flowering (55.1) were observed in case of foliar fertilization of Unigrow-C alone followed by the foliar fertilization of Agri-power (52.2) and Super-dawn (49.0) alone, and soil application of chemical fertilizers (46.5) alone. Moreover, number of days to flowering reduced when okra was fertilized with chemical fertilizers along with foliar fertilizers. Minimum numbers of days to flowering were observed in case of integrated application of chemical fertilizers

with Super-dawn (40.2) and Agri-power (42.0), both treatments were statistically alike, followed by Unigrow-C (45.0). Hence, foliar fertilization alone delayed flowering, however, when integrated with recommended chemical fertilizers it enhanced flowering in okra as against the use of chemical fertilization alone. Almost similar trend was observed in case of height of okra plants under the influence of type and method of fertilizer application.

The soil application of chemical fertilizers alone was more effective than the application of foliar fertilizers alone. However, the integration of soil application and foliar fertilization was most promising in enhancing the plant height of okra. The plant height was minimum (61.9 cm) where Unigrow-C was applied to okra foliage alone, followed by the foliar application of Agri-power alone (64.9 cm) and Super-dawn alone (69.0 cm). The soil application of recommended chemical fertilizers alone further enhanced height of okra (75.5 cm) plants. The integration of recommended chemical fertilizers with foliar fertilizers further increased plant height, in order of Super-dawn (98.4 cm), Agri-power (89.1 cm) and Unigrow-C (85.2 cm). Similarly, maximum branches on okra plants were observed where recommended chemical fertilizer was applied to soil and then the plants were supplemented with foliar fertilization of Super-dawn (4.8), followed by Agri-power and Unigrow-C (4.6 each and statistically alike). The soil application of recommended chemical fertilizer alone remained more effective in producing number of branches of okra (3.9) than the single application of three foliar fertilizer products, i.e. Super-dawn (3.7), Agri-power (3.5) and Unigrow-C (3.2). However, all these four treatments were statistically alike. Interestingly, number of fruits plant^{-1} did not affect by the type and method of application of recommended chemical fertilizer and foliar fertilization. Nonetheless, exactly similar numerical trend was observed for all the treatments as was noted for other parameters of okra. The fruit length of okra was maximum in case of integrated nutrition by recommended chemical fertilizers and Super-dawn (9.1 cm), followed by Agri-power (8.5 cm) and Unigrow-C (7.7 cm). This was followed by the fruit length of okra recorded in case of single use of soil applied recommended chemical fertilizers (7.0 cm), and foliar applied Super-dawn (6.9 cm), Agri-power (6.1) and Unigrow-C (5.1 cm). These four treatments were statistically alike. In case of fruit yield of okra, the integrated application of recommended chemical fertilizer and foliar fertilization of Super-dawn was the most effective treatment producing about 13.0 t ha^{-1} fruit yield of okra. Other two treatments where recommended soil applied chemical fertilizer was integrated with foliar fertilization of Agri-power and Unigrow-C were statistically similar in producing fruit yield of okra, i.e. 11.2 and 10.4 t ha^{-1}, respectively. The single application of recommended chemical fertilizers to the soil produced more fruit yield of okra (10.1 t ha^{-1}) than the single application of Super-dawn to okra foliage (8.6 t ha^{-1}). Moreover, the foliar fertilization of Agri-power and Unigrow-C alone produced lowest, statistically alike fruit yield of okra, i.e. 7.5 and 6.8 t ha^{-1}, respectively.

Highly significant positive correlations were observed between okra yield and other plant growth traits of okra, viz. plant height (r = 0.97***), number of branches plant^{-1} (r = 92**), number of fruits plant^{-1} (0.98***) and fruit length (r = 0.96***). The relationship of okra yield with number of days to flowering was also highly significant, but negative in nature (r = −0.98***).

Table 1. Significance of F-values from analysis of variance (ANOVA) of yield and yield components of okra as affected by some foliar fertilizer products.

Parameter	**F-value**	**P-value**	**CV**
Days to flowering	164.8	0.0000	1.77
Plant height (cm)	359.5	0.0000	1.85
Number of branches plant^{-1}	5.8	0.0017	12.92
Number of fruits plant^{-1}	2.8	0.0424	5.49
Fruit length (cm)	10.2	0.0001	11.92
Fruit yield (t ha^{-1})	38.1	0.0000	7.17

Table 2. Yield and yield components of okra as affected by some foliar fertilizer products.

Fertilizer Treatments						Days to flowering	Plant height (cm)	Number of branches plant^{-1}	Number of fruits plant^{-1}	Fruit length (cm)	Fruit yield (t ha^{-1})
	N	P	SD	AP	UG						
T_1	+	+	−	−	−	46.5	75.5	3.9	14.0	7.0	10.1
T_2	+	+	+	−	−	40.2	98.4	4.8	15.0	9.1	12.9
T_3	−	−	+	−	−	49.0	69.0	3.7	13.8	6.9	8.6
T_4	+	+	−	+	−	42.0	89.1	4.6	14.7	8.5	11.2
T_5	−	−	−	+	−	52.2	64.9	3.6	13.5	6.1	7.5
T_6	+	+	−	−	+	45.0	85.2	4.6	14.4	7.7	10.4
T_7	−	−	−	−	+	55.1	61.9	3.2	13.2	5.1	6.8
Tukey's HSD 0.05						1.95	3.35	1.23	1.81	2.01	1.62

N (nitrogen) and P (phosphorus) at 150 and 75 kg ha^{-1}, respectively. SD (Super-dawn), AP (Agri-power) and UG (Unigrow-C) at one-liter ha^{-1} each. For details about time and method of application, see materials and methods. The '+' and '−' signs denote fertilizer application and vice versa, respectively.

DISCUSSION

This study envisaged the growth and yield of okra as affected by the application of three newly introduced foliar fertilizers, as against soil application of recommended chemical fertilizers. Foliar fertilization of crops has been considered a precious supplement to the application of nutrients under adverse soil and environmental situations, viz. low soil nutrients bioavailability, hard top soil, and decreased root activity during the reproductive growth stage of plants (Naruka *et al.,* 2000; Alkaff and Hassan, 2003). It facilitates timely translocation of deficient nutrients to plant system through leaf tissues (Chattopadhyay *et al.,* 2003; Fageria *et al.*, 2009). Foliar fertilization not only improves plant growth traits, crop yields and nutrient uptake by crops (Maitlo *et al.*, 2006) but also enhances nutrient use efficiency of crops (Fageria *et al.*, 2009). Hence, foliar fertilization is considered as an environmentally friendly fertilization technique. The results of this study also endorsed the benefits of foliar fertilization of crops. The growth traits of okra plants and crop yield were more better when soil applied recommended chemical fertilizers were integrated with foliar fertilizers (Table 2). These benefits of foliar fertilizers under study might be related to their multi-nutrient contents, which upon absorption by the leaf tissues improved the growth traits of okra plants and resultantly increased okra yield. This notion is further supported by the highly significant correlations of various plant traits with okra yield, as stated in the results section. These results are frequently supported by the findings of many previous studies. Earlier, Maitlo *et al*. (2006) also reported enhanced growth traits, increased yield and better nutrient uptake by wheat crop under foliar fertilization of urea. Alkaff and Hassan (2003) reported improved growth and yield traits of okra in relation to foliar fertilization. Early fruit set and fruit maturity was noted by the foliar application of micronutrients in kinnow mandarin (Mishra *et al.*, 2003). Significant improvement in plant height of sunflower was reported as a result of foliar fertilization (Tuncay *et al.*, 2004). The results of Paliwal *et al*. (1999) elucidated maximum number of branches in okra plants in response to foliar fertilization. Many other studies also reported the benefits of foliar fertilization in improving growth, yield, nutrient uptake and product quality (Naruka and Singh, 1998; Tumbare *et al*., 1999; Naruka *et al*., 2000; Alkaff and Hassan, 2003; Chattopadhyay *et al*., 2003; El-Aal *et al*., 2010; Zodape *et al*., 2011).

CONCLUSION AND RECOMMENDATIONS

The integrated use of foliar fertilizers and soil applied recommended chemical fertilizers improved the growth traits of okra plants and enhanced okra yield. The regular testing of such effective foliar fertilizers and their use, after extensive controlled condition and field scale studies, is recommended for sustainable okra production.

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