ISSN: 0974 - 0376

The Ecoscan : Special issue, Vol. VII: 467-472: 2015
AN INTERNATIONAL QUARTERLY JOURNAL OF ENVIRONMENTAL SCIENCES
www.theecoscan.in

EVALUATION OF THE EFFICACY OF FOLIAR APPLICATION OF WATER SOLUBLE FERTILIZERS IN OKRA

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KEYWORDS

Efficacy
Foliar application
Nutrient uptake
Water soluble fertilizers

Proceedings of National Conference on Harmony with Nature in Context of Bioresources and Environmental Health
(HORMONY - 2015)
November 23 - 25, 2015, Aurangabad,
organized by
Department of Zoology,
Dr. Babasaheb Ambedkar Marathwada University
Aurangabad (Maharashtra) 431 004
in association with
National Environmentalists Association, India
www.neaindia.org

The Ecoscan
AN INTERNATIONAL QUARTERLY JOURNAL OF ENVIRONMENTAL SCIENCES

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ABSTRACT

The field experiment comprised of seven treatments of spraying of water soluble fertilizers; *viz*., Mixed fertilizer 19:19:19 @ 0.5%, Urea @ 1%, MCP @ 0.5%, MOP @ 0.5, DAP @ 2%, Banana pseudostem enriched sap @ 1% and Water spray as control was conducted to study the foliar application of fertilizers in okra. Three sprays of banana pseudostem enriched sap @ 1 % resulted in achieving the highest commercial green fruit yield (15.18 t/ha), maximum N, P and K content and uptake by fruit and plant, protein content (17.98 %) and total N (67.62 kg/ha), P (10.83 kg/ha) and K (52.42 kg/ha) uptake by okra and was found at par with three sprays of mixed fertilizer 19:19:19 @ 0.5% in all cases. whereas, maximum absorption of N through leaves was noted with spraying of urea @ 1% (T_2) while P and K with spraying of mixed fertilizer 19-19-19 @0.5% (T_1) and in most of the cases, treatment (T_6) receiving enriched sap @ 1% remained statistically at par during all the sprays. Hence, 3 sprays of enriched sap (T_6) or mixed fertilizer (19:19:19) is recommended for okra.

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INTRODUCTION

okra (*Abelmoschus esculentus* L. Moench), is an important vegetable crop, also known as lady's finger or *bhendi* belongs to family Malvaceae. Though okra finds its origin in South Africa, India stands top in area and production. It is grown practically in all agro-ecological zones of India mainly for its immature fruits which are eaten as cooked vegetable. Dried seeds are nutritious food. It contains upto 20% protein and the fibre from okra canes is a possible paper pulp source, while the dried canes are a fuel source (Lyngdoh *et al*., 2013). The major okra growing states includes Assam, Uttar Pradesh, Bihar, Orissa, West Bengal, Maharashtra, Andhra Pradesh and Karnataka. In Gujarat okra is grown in summer season (May-August) but adoption of high tech farming system (such as green house technology); farmers are growing okra throughout the year. The area under okra cultivation in Gujarat is about 65990 hectares with the production of 75904 MT per year and productivity of 11.5 MT/ha (Anonymous, 2014).

Nutrient management is the most basic factor and is found to exert a great influence not only on growth and yield attributes of vegetables but also for obtaining sustained productivity. Among all nutrients; N, P and K are most important nutrients which contribute to proper growth and yield of plants and it also has direct effect on metabolism of plants (Abusaleha and Shanmugavelu, 1988). Method of fertilization also plays an important role in supplying the nutrient to the plants because the efficacy of fertilizers applied in soil being low due to various losses and fixation, mainly in area of problematic soil. Under this condition, foliar application seems to be promising for ensuring use efficiency of applied nutrients. Foliar spray enables plants to absorb the applied nutrients from the solution through their leaf surface and thus, may result in the economic use of fertilizer (Manasa *et al.,* 2015). The high effectiveness, rapid plant responses, convenience and elimination or reduction of toxicity symptoms brought by excessive soil accumulation of given element due to foliar nutrition makes it more reliable (Jules, 1984). Recently specialty fertilizers with different ratios of N, P and K having high solubility had been introduced and is highly amenable for foliar nutrition (Jeyabal *et al*., 1998). The importance of foliar feeding of water soluble fertilizers in horticultural crops is immensely felt among the scientists and farmers, since macro and micro nutritional deficiencies in Indian soils have been on the increase due to adoption of high input agriculture (Garhwal *et al*., 2007).

The farmers of South Gujarat are using different water soluble macro nutrient fertilizers as foliar sprays to increase the productivity of vegetables besides to reduce the cost of cultivation. The information available on the use of these water soluble fertilizers in vegetables is meager and hence the present investigation was carried out under South Gujarat condition.

MATERIALS AND METHODS

A field experiment was conducted during the summer season of 2014 at the Regional Horticultural Research Station (RHRS) of Navsari Agricultural University, Navsari,

Gujarat. The soil of the experimental field was silty clay in texture with a pH of 8.1 and EC of 0.36 dS/m. The experimental soil was low in available nitrogen (243 kg/ha), medium in available phosphorus (42.8 kg/ha) and available potash (280 kg/ha). The famous okra variety "Gujarat okra- 5" was used for the study. The seed were sown in plat bed with spacing of 45 x 30 cm and plot size of 3.6m x 2.1m. The experiment comprised of seven treatments with spraying of water soluble fertilizers; *viz.*, T_1 (Mixed fertilizer 19:19:19 @ 0.5%), T_2 (Urea @ 1%), T_3 (MCP @ 0.5%), T_4 (MOP @ 0.5), T_5 (DAP @ 2%), T_6 (Banana pseudostem enriched sap @ 1%), T_7 (Water spray) were evaluated in a Randomized Block Design with three replications. Water soluble fertilizers were applied thrice at 30, 45 and 60 DAS of okra. Enriched sap of banana pseudostem (T_6) is novel organic liquid fertilizer prepared by the team of National Innovative Project on "A Value Chain on Utilization of Banana Pseudostem for Fiber and Other Value added Products". This enriched sap is a very good source of essential plant nutrients (Table 1) could be applied through fertigation or by foliar method of application.

All the treatments received soil application of fertilizers as recommended dose (100:50:50 kg/ha). The entire quantity of common dose of organic manure (10 t/ha) *i.e.* FYM was well mixed in all the experimental plots at the time of field preparation. Methods followed in present study are described below:

Commercial green fruit yield

The picking of green pods was done separately from net plot and after each picking, fruit yield per net plot area were recorded. The total commercial pod yield was obtained by summing up the yields of all the pickings.

Leave nutrient content

To determine the efficacy of nutrients through leaves after 24 hours of each spray, fully matured and expanded leaves were selected from net plot and picked up. These leaves were brought to the laboratory and first washed with tap water followed by distilled water. After washing of the leaves, they were kept in laboratory to dry for some time and then two composite samples were withdrawn each for determining dry weight and nutrient content, respectively.

Fruit and Plant analysis

Periodical collected fruit and plant samples (at harvest) were oven dried and ground in mixture having stainless steel blade. These ground samples were used for chemical analysis by set procedures (Table 2). The protein content was determined from fruit samples by describe formula:

Protein content = Nitrogen content in fruits X 6.25

And, the uptake of different nutrients by aerial biomass was computed on dry weight basis by using the following formula:

$$\text{Uptake of nutrient (kg/ha)} = \frac{\text{Nutrient content (\%) X Yield (kg/ha)}}{100}$$

Total uptake (kg/ha) = Nutrient uptake by fruit (kg/ha) + Nutrient uptake by plant (kg/ha)

Soil analysis

To know the effect of foliar fertilization on soil chemical properties, soil samples were collected (0-22.5cm depth) after harvesting and analyzed as per the set procedure (Table 2).

Statistical Analysis

Data pertaining to growth and yield attributes were subjected to statistical analysis as per the methods described by Panse and Sukhatme (1967).

RESULTS AND DISCUSSION

Commercial fruit yield

Spraying of water soluble fertilizers significantly enhanced the commercial fruit yield of okra (Table 3). Foliar spray of pseudostem banana enriched sap @ 1% (T_6) recorded significantly the highest fruit yield (15.18 t/ha) which was found statistically at par with the treatment T_1 (14.22 t/ha), receiving foliar spray of mixed fertilizer (19-19-19) @ 0.5 %. Foliar spray of Urea @ 1 % (T_2) recorded the third highest green fruit yield (12.82 t/ha) and was at par with the treatments T_4 and T_5. Moreover, significantly lowest green fruit yield (9.93 t/ha) was noted with water spray (T_7). The spraying of water soluble fertilizers increases uptake of nutrients and water, resulting in

Table 1: Chemical composition of banana pseudostem enriched sap

Plant nutrient	Macro-nutrient							GA_3	Cytokinin
	N	P	K	Fe	Mn	Zn	Cu		
concentration (mg/l)	119	50.4	1289	124	6.73	6.73	0.97	110-205	137-244

Table 2: Method followed for soil and plant analysis

Parameters		Methods
A.	Soil chemical analysis	
(1)	pH	Potentiometric (Jackson, 1973)
(2)	EC	Conductometric (Jackson, 1973)
(3)	Organic carbon	Wet oxidation (Walkley and Black, 1934)
(4)	Available N	Alkaline permanganate oxidation (Subbhiah and Asija, 1956)
(5)	Available P_2O_5	Spectrometric (0.5 M $NaHCO_3$, pH 8.5, blue color) (Olsen *et al.*, 1954)
(6)	Available K_2O	Flame photometric (neutral N NH_4OAc) (Jackson, 1973)
B.	Plant analysis	
(1)	Total N	Wet digestion (Chromic acid) (Trivedi *et al.*, 1999)
(2)	Total P, K	Wet digestion (Jackson,1973)P: Vanadomolybdo yellow color methodK: Flame photometry

Table 3: Effect of different treatments on commercial fruit yield, NPK content in okra leaves, fruits and plants as well as protein content in fruit

Treatments	Commercial fruit yield(t/ha)	Nutrient content in leaves After 1st spray (31 DAS) N (%)	P (%)	K (%)	After 2nd spray(46 DAS) N (%)	P (%)	K (%)	After 3rd spray(61 DAS) N (%)	P (%)	K (%)	Nutrient content in fruits N (%)	P (%)	K (%)	Nutrient content in plant N (%)	P (%)	K (%)	Protein content(%)
T_1	14.22	2.85	0.61	1.40	2.68	0.59	1.37	2.51	0.53	1.34	2.84	0.51	2.70	2.41	0.31	1.27	17.77
T_2	12.82	3.02	0.45	1.28	2.80	0.41	1.26	2.69	0.37	1.22	2.63	0.40	2.53	2.27	0.26	1.18	16.46
T_3	11.01	2.25	0.48	1.21	2.12	0.46	1.18	1.93	0.40	1.15	2.36	0.43	2.38	2.11	0.27	1.12	14.77
T_4	12.41	2.32	0.42	1.37	2.18	0.38	1.34	2.05	0.35	1.31	2.38	0.40	2.67	2.12	0.25	1.25	14.88
T_5	12.59	2.65	0.58	1.22	2.42	0.52	1.21	2.30	0.49	1.17	2.59	0.44	2.45	2.26	0.29	1.16	16.21
T_6	15.18	2.75	0.55	1.31	2.49	0.51	1.27	2.43	0.47	1.25	2.88	0.52	2.74	2.44	0.32	1.32	17.98
T_7	9.93	1.97	0.38	1.10	1.89	0.37	1.08	1.84	0.35	1.06	2.01	0.37	2.18	1.99	0.22	1.10	12.56
S. Em. ±	0.51	0.11	0.03	0.05	0.10	0.03	0.05	0.09	0.02	0.05	0.11	0.02	0.10	0.07	0.02	0.03	0.70
CD at 5%	1.58	0.33	0.09	0.16	0.30	0.08	0.15	0.28	0.07	0.14	0.34	0.06	0.30	0.22	0.05	0.09	2.14
CV %	7.03	7.26	10.43	7.15	7.14	9.84	7.09	6.92	9.35	6.57	7.62	8.57	6.94	5.53	8.42	4.41	7.62

T_1 (Mixed fertilizer 19:19:19 @ 0.5%), T_2 (Urea @ 1%), T_3 (MCP @ 0.5%), T_4 (MOP @ 0.5), T_5 (DAP @ 2%), T_6 (Banana pseudostem enriched sap @ 1%), T_7 (Water spray as control)

more photosynthesis and enhanced food accumulation in edible parts. The probable reason for increase in yield might be due to easy assimilation of nutrients and balance in NPK ratio which affects the crop productivity (Batra *et al.,* 2002). The present findings are found in agreement with Chaurasia *et al.* (2005); Narayanamma *et al.* (2006); Premsekhar and Rajashree (2009).

Nutrient content in leaves after each spray

Fully matured and expanded okra leaves were collected after 24 hours of each spray (31, 46 and 61 DAS) and analyzed for N, P and K content. It was observed that application of water soluble fertilizers significantly increased the N, P and K contents in okra leaves (Table 3). The trend of increase in nutrient content of leaf was found similar after all sprays but the values of nutrient content continuously decreases from first to third spray. Nutrient absorption through leaves changes with leaf cuticle composition changed with leaf maturity and varies with species and the environment. The changes in leaf cuticle composition correspond with changes in efficacy of foliar-applied fertilizers (Fernandez and Eichert, 2009).

N content

The data on N content in okra leaves revealed that spraying of urea @ 1% (T_2) registered significantly higher N (3.02, 2.80 and 2.69 per cent at 31, 46 and 61 DAS, respectively) content and remained at par with treatments T_1 and T_6 at 31 and 61 DAS and only T_1 at 46 DAS. While, significantly lower values of N content (1.97, 1.89 and 1.84 per cent at 31, 46 and 61 DAS, respectively) were recorded in water spray treatment (T_7). Wojcik (2004) stated that the absorption of urea by the leaves of most crops is greater and faster than that of inorganic nitrogen forms. This phenomenon is related to the fact that the cuticular membrane is 10 to 20 times more permeable to urea than to inorganic ions. Similar result was also reported by Yildirm *et al.* (2007).

P content

In case of P content, foliar application of mixed fertilizer 19-19-19 @ 0.5% (T_1) recorded significantly higher values of P content (0.61, 0.59 and 0.53 per cent at 31, 46 and 61 DAS, respectively) in okra leaves and was found statistically at par with the treatments T_5 and T_6 after each spray. Significantly lower values of P content (0.38, 0.37 and 0.35 per cent at 31, 46 and 61 DAS, respectively) were recorded with the treatment receiving only water spray (T_7). NaH_2PO_4, $NH_4H_2PO_4$ and H_3PO_4 are rapidly absorbed by the leaves; although, their utilization is considerably dependent on plant species (Yogaratnam *et al.,* 1981).

K content

And in case of K content also, same treatment receiving spray of mixed fertilizer 19-19-19 @ 0.5% (T_1) registered higher K (1.40, 1.37 and 1.34 per cent at 31, 46 and 61 DAS, respectively) in leaves and remained at par with the treatments T_2, T_4 and T_6 after each spray Furthermore, minimum values of K content (1.10, 1.08 and 1.06 per cent at 31, 46 and 61 DAS, respectively) were recorded with the treatment T_7 (water spray). Umar *et al.* (1999) reported that higher leaf K concentration with 1% KCl application due to the fact that groundnut plants tented to accumulate more potassium when given through KCl as compared to foliar spray of other forms of K

Table 4: Effect of different treatments on nutrient uptake by okra

Treatments	Fruit (kg/ha)			Plant (kg/ha)			Total (kg/ha)		
	N	P	K	N	P	K	N	P	K
T_1	34.71	6.49	34.10	27.80	3.65	14.59	62.51	10.15	48.69
T_2	29.33	4.60	28.87	25.16	2.99	13.10	54.49	7.59	41.97
T_3	25.78	4.69	25.96	22.25	2.87	11.87	48.03	7.56	37.83
T_4	26.35	4.51	30.00	22.32	2.76	13.12	48.66	7.27	43.12
T_5	29.19	5.26	28.21	23.99	3.13	12.38	53.18	8.39	40.59
T_6	36.73	6.79	35.71	30.89	4.04	16.72	67.62	10.83	52.42
T_7	21.93	3.97	23.10	19.73	2.23	10.86	41.97	6.20	33.96
S. Em. ±	1.14	0.16	1.34	0.80	0.20	0.60	1.44	0.31	1.45
CD at 5%	3.50	0.50	4.13	2.45	0.61	1.83	4.44	0.95	4.47
CV %	6.76	5.39	7.89	5.61	11.08	7.77	4.64	6.44	5.89

T_1 (Mixed fertilizer 19:19:19 @ 0.5%), T_2 (Urea @ 1%), T_3 (MCP @ 0.5%), T_4 (MOP @ 0.5), T_5 (DAP @ 2%), T_6 (Banana pseudostem enriched sap @ 1%), T_7 (Water spray as control)

Table 5: Effect of different treatments on soil chemical properties after harvesting

Treatments	pH	EC(dS/m)	OC(%)	N(kg/ha)	P_2O_5(kg/ha)	K_20(kg/ha)
T_1	7.6	0.36	0.54	224	39	247
T_2	7.7	0.37	0.56	224	40	252
T_3	7.8	0.37	0.53	238	40	255
T_4	7.8	0.36	0.53	229	41	252
T_5	7.9	0.37	0.51	236	43	248
T_6	7.7	0.36	0.54	222	38	247
T_7	7.8	0.37	0.52	242	42	262
S.Em. ±	0.20	0.01	0.02	8	2	8
CD at 5%	NS	NS	NS	NS	NS	NS
CV %	4.54	5.17	6.91	5.97	9.81	5.34

T_1 (Mixed fertilizer 19:19:19 @ 0.5%), T_2 (Urea @ 1%), T_3 (MCP @ 0.5%), T_4 (MOP @ 0.5), T_5 (DAP @ 2%), T_6 (Banana pseudostem enriched sap @ 1%), T_7 (Water spray as control)

The nutrient content in leaves is increases because concentration of a nutrient present in a foliar spray will always be significantly higher than the concentration found within the plant organ. Therefore, a concentration gradient will be established when a nutrient solution is sprayed on the plant (leaf) surface and this will potentially lead to the diffusion of the nutrient across the surface. Higher penetration rates in association with increased concentrations of several applied mineral elements have been reported in many studies performed with isolated cuticles and intact leaves (Chapagain and Wiesman 2004; Borowski and Michalek 2009).

Nutrient content in fruit and plant

Spraying of water soluble fertilizers registered a significant effect on N, P and K content in fruit and plant of okra (Table 3). Application of enriched sap @ 1% recorded significantly higher values of N (2.88% in fruit and 2.44% in plant), P (0.52% in fruit and 0.32% in plant) and K (2.74% in fruit and 1.32% in plant) content and was at par with the treatments T_1, T_2 and T_5 in case of N for both fruit and plant; only T_1 for fruit and T_1, T_3 and T_5 for plant in case of P and T_1, T_2, $T_4$and T_5 for fruit and T_1, and T_4 for plant in case of K content. While, the lowest values of N (2.01% in fruit and 1.99% in plant), P (0.37% in fruit and 0.22% in plant) and K (2.18% in fruit and 1.10% in plant) content were recorded in treatment T_7. The increase in N, P and K content in plant may be attributed due to their higher content in water soluble fertilizers which plant have absorbed directly through leaves and hence increased the content. The results are found with the agreement with Tohamy *et al.* (2011).

Protein content

The protein content in okra fruit varied from 12.56 to 17.98 per cent (Table 3). Significantly higher value of protein content (17.98 %) was recorded with treatment T_6 consisting enriched sap @1% which was found at par with treatments T_1, T_2 and T_5. And lowest value of protein content (12.56%) was obtained with treatment T_7 (water spray). The improvement in protein content might be attributed to higher uptake of nitrogen during growth period which increased photosynthesis, synthesis of protoplasm and protein for higher rate of mitosis. The higher protein content was found with application of enriched sap which might be due to foliar nutrition of macro elements with hormones, could improve the photosynthetic activity and enzymes carbohydrate transformation (Doss *et al.* (2013).

Nutrient uptake

The results on N, P and K uptake by okra fruit revealed that application of enriched sap @1% (T_6) recorded significantly higher value of N (36.73 kg/ha), P (6.79 kg/ha) and K uptake (35.71 kg/ha) and was found statistically at par with treatment T_1. Similarly, in case of nutrient uptake by okra plant, treatment T_6 receiving enriched sap @ 1% out classed all the experimental treatments and registered significantly the highest N (30.89 kg/ha) and K (16.72 kg/ha) uptake, while same treatment (T_6) recorded also significantly higher uptake of P (4.04 kg/ha) but found at par with the treatment T_1.

Total uptake of N, P and K was significantly affected due to foliar fertilization through water soluble fertilizers (Table 4). The results revealed that in case of total uptake of N, application of enriched sap @ 1% (T_6) out classed all the experimental treatments and recorded significantly maximum total uptake of N (67.62 kg/ha) while, the same treatment (T_6) recorded significantly higher total uptake of P (10.83 kg/ha) and K (52.42 kg/ha) but found at par with the treatment T_1. In addition, the second highest total uptake of N (62.51 kg/ha)

was found in treatment T_1 and third highest total uptake of P (8.39 kg/ha) and K (43.12 kg/ha) were noticed in treatments T_5 and T_4, respectively. Frizts (1978) pointed out that a repeated application of small units of foliar fertilizers stimulates plant metabolism and increased nutrient uptake *via*. the roots can be observed. Found result is corroborated by Yadav *et al*. (2004) and Yadav and Choudhary (2012).

Soil status after harvesting

The results presented in table 5 revealed that spraying of water soluble fertilizers was failed to exert any significant effect on soil reaction (pH), electrical conductivity (EC) organic carbon content as well as available N, P_2O_5 and K_2O in the soil. The values of available N, P_2O_5 and K_2O varied from 220 to 240, 35 to 41 and 242 to 268 kg/ha, respectively in soil after harvest of okra. Higher status of N, P_2O_5 and K_2O in soil was found with treatment receiving water spray. Similar results of soil chemical properties were reported by Gundrashiya, (2013). Incorporation of FYM along with fertilizers favored the conversion of organically bound nutrient to inorganic form (Panwar, 2008). Similar increase in available nutrient in soil due to addition of organics was reported by Sharma *et al.*, (2013).

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