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Thulasi V
Associate Professor, Regional Agricultural Research Station, Kerala Agricultural University, Mele Pattambi, Palakkad, Kerala, India

Moossa PP
Professor, Regional Agricultural Research Station, Pattambi, Kerala, India

Sureshkumar P
Professor (Retd) Kerala Agricultural University, Mele Pattambi, Palakkad, Kerala, India

Narayanankutty MC
Professor (Retd) Kerala Agricultural University, Mele Pattambi, Palakkad, Kerala, India

Corresponding Author
Thulasi V
Associate Professor, Regional Agricultural Research Station, Kerala Agricultural University, Mele Pattambi, Palakkad, Kerala, India

Standardisation of the package of application of Sampoorna KAU multimix (vegetables) in vegetables

Thulasi V, Moossa PP, Sureshkumar P and Narayanankutty MC

Abstract
Multi-nutrient mixture was developed for foliar application in vegetables to address the wide spread deficiency of secondary and micronutrients evidenced in the composite samples collected from the fields all over the Kerala state. The multi-nutrient mixture prepared contain micronutrients such as zinc, copper, boron and molybdenum. The mixture released as Sampoorna KAU Multimix, was evaluated for standardising the schedule of application for improving yield in cowpea, okra, brinjal, and chilli through pot culture and field experiments. Pot culture experiments in cowpea, okra, brinjal and chilli indicated that foliar application of the mixture @ 0.5 per cent could improve vegetable yield by more than 30 per cent over control. Foliar application of Sampoorna KAU multimix @ 5 g per litre at 30, 45 and 60 DAS in direct sown vegetables and at 15, 30 and 45 DAP in transplanted vegetables recorded significantly higher yield than control in the field experiments conducted.

Keywords: Sampoorna KAU multimix, vegetables, micronutrient management, foliar application

Introduction

Management of agricultural systems should revolve around the capacity of soil to feed the plant. Crop yields in acid laterite soils of Kerala, are very low due to inherent soil characteristics. Most parts of the Kerala state experiences hot humid tropical climate and the major soil forming process is laterization which involves loss of basic cations and silica and residual enrichment of oxides of aluminium and iron. Laterite soils are acidic, having kaolinitc clay with low cation exchange capacity (CEC), often gravelly with low water and nutrient retention capacity. Low availability of nutrients, especially micronutrients, is one of the reason for the low productivity in Kerala soils. A state wide study on soil fertility by Rajasekharan and co-workers (2018) indicated that nearly 60 percent of the soil samples collected from the fields all over the Kerala state were deficient in boron and magnesium was deficient in three fourth of the samples analysed. Deficiency of zinc, copper and potassium were also reported from the study.

Micronutrients are required by the crops in lower quantities than macronutrients but are equally significant in plant nutrition. Hence deficiency symptoms and reduction in productivity are commonly exhibited by plants grown in micronutrient-deficient soils (Havlin *et al*. 2005, Kumar *et al*. 2016) [3, 6]. Singh and Kalloo (2000) [12] reported that micronutrients play a catalytic role in absorption and balancing other nutrients. Micronutrients are important essential elements with specific physiological functions; though required in small quantities for normal growth and development of plants. Zinc is an essential component of a number of enzymes such as proteinase, phosphohydrolase, dehydrogenase, isomerase, aldolase and peptidase (Mousavi, 2011) [8]. Boron is very much essential for water absorption carbohydrate metabolism and translocation in plants, DNA synthesis in meristematic tissue, cell division and elongation, fertilization, water relation and photosynthesis, and involves indirectly in the metabolism of primary nutrients, fat and hormones (Haque *et al*. 2011) [2]. Boron has an important role in flowering and fruit formation (Nonnecke, 1989) [9]. Hence in order to have healthy crops providing healthy produce there is urgent need to correct the deficiency of nutrients through different methods.

Vegetables constitute high protective food of dietary complex of human beings. Plant nutrition is an important aspect resulting in healthy and productive crop as far as vegetable crops are concerned. Micronutrients The chemical composition and general condition of vegetable crops are improved by micronutrients as they act as various catalysts in many metabolic reactions (Karthick *et al*. 2018) [5]. Multi-nutrient deficiencies are commonly occurring in vegetable crops cultivated throughout the state.

Recently, foliar application of nutrients in vegetables is gaining importance as an effective practice for micronutrient management as nutrient use efficiency can be increased by adopting this mode of application and it reduces nutrient load on soil and crop. Multi-nutrient mixture, Sampoorna KAU multimix was developed for specific crops to address the deficiency problems reported throughout Kerala state (Thulasi *et al*. 2015) [14] and the present study was conducted to evaluate the foliar application of Sampoorna KAU Multimix in vegetables for imrpoving growth and yield.

Materials and Methods

A state wide study on soil fertility by Rajasekharan and co-workers (2018) indicated that micronutrients *viz* boron, zinc, copper were deficient in the soils of Kerala. Considering the extent of deficiencies and impaired availability of essential nutrients, multi-nutrient mixture was developed at RARS Pattambi for foliar application in vegetables, and released as Sampoorna KAU multimix. The standardisation of the schedule of application of the mixture was attempted through a set of Pot culture and field experiments conducted at the research station to analyse the effectiveness of foliar application. The details of the experiments are given below:

1. Pot culture experiment- The experiment was conducted at RARS pattambi during rabi season, 2015 with two direct sown vegetable crops - Cowpea, and okra and two transplanted vegetable crops- brinjal and chilli. The experiment was laid out in CRD (completely random design) with 5 treatments and 5 replications. The treatments included of 4 different levels of concentration of Sampoorna KAU multimix for foliar application viz., 0.2, 0.3, 0.5 and 1.0 per cent applied twice at 40 and 60 DAS/P and a control. The varieties adopted for the experiment were anaswara in cowpea, arka anamika in okra, keerthy in chilli and haritha in brinjal. The cultivation and nutrient management was followed as per package of practices of KAU of the respective crops in all treatments. The experimental site experiences warm humid climate. The experimental soil was deficient in boron and magnesium. The vegetable yield of all the crops were recorded and analysed statistically.

2. Field experiment a - A field experiment was conducted with chilli and okra as test crops during summer season in 2016 at RARS Pattambi with treatments comprised of varying levels of concentration of the Sampoorna KAU multimix and different schedules of application. The seedlings of the chilli variety Keerthy were transplanted at the age of 30 DAS while the okra variety arka anamika was seeded directly. The experiment was laid out in a factorial RBD (Randomised Block Design) with two factors. The first factor comprised of 3 levels of concentration of the mixture Sampoorna KAU multimix viz., 0.5 per cent, 1.0 per cent and 2.0 per cent solutions in water. Second factor consisted of two schedules of application which were different for direct sown and transplanted vegetable crops. In chilli, the two tested schedules were foliar application i) twice at 20 and 40 days after planting and ii) thrice at 15, 30 and 45 days after planting. In okra, the two tested schedules were foliar application i) twice at 40 and 60 days after sowing and ii) thrice at 30, 45 and 60 days after sowing.

The experimental site experiences a warm humid climate, the soil was acidic in reaction and deficient in boron and zinc. The vegetable yield of both the crops was recorded.

3. Field experiment b- Another field experiment was conducted at RARS Pattambi (with selected treatments from field experiment a) with chilli and okra as test crops during rabi season in 2017. The varieties adopted for the experiment were keerthi in chilli and arka anamika in okra. The experiment was laid out in randomised block design with four treatments *viz*., foliar application of Sampoorna KAU multimix @0.5 per cent, 1.0 per cent, water spray and control. The mixture was applied in different concentration as per the treatments thrice at 15, 30 and 45 days after planting in chilli and 30, 45 and 60 days after sowing in okra The experimental soil was deficient in boron and zinc. Vegetable yield and growth parameters were recorded. The plant samples were analysed for different nutrients.

All data were subjected to analysis of variance and the treatment means were compared at 5 per cent probability level

Results and Discussion

The multi-nutrient mixture Sampoorna KAU Multimix developed at RARS Pattambi contained zinc, copper, boron, traces of iron, manganese, molybdenum and secondary nutrients such as magnesium and sulphur. The composition of the prepared mixture used in the study is given in table 1.

Table 1. Pot culture experiments and field experiments were conducted in different vegetables for standardisation of the schedule of application of the mixture. The results of the pot culture with respect to vegetable yield in different crops are presented in Table 2. The mixture was applied in different concentration of the spray solution varying from 0.2 to 1.0 per cent

In cowpea, the foliar application of the mixture at a concentration of 0.2 per cent (2 g per litre) improved the yield by 31.68 per cent over control. When the concentration of the spray solution increased from 0.2 to 0.50 per cent, there was a gradual and significant improvement in yield upto 65.65 per cent over control. The crop responded positively up to 1.0 per cent spray concentration resulting in more than double the yield over that in control.

In brinjal, though the foliar application of the mixture at a spray concentration of 0.20 per cent improved yield over control by 15.28 per cent, the increase in spray concentration from 0.20 to 0.30 per cent did not improve the yield significantly. However, when the mixture was applied at a concentration of 0.50 per cent, yield improved over control by 30.83 per cent and further increase in spray concentration did not improve the vegetable yield significantly.

In chilli, the foliar application of Sampoorna KAU multimix at a concentration of 0.2 per cent increased the vegetable yield by 24.05 per cent over control. When the spray concentration was increased to 0.3 per cent, the increase in yield was not statistically significant. Significantly higher vegetable yield was obtained with foliar spray concentration of 0.50 per cent, while the increase in spray concentration up to 1.0 per cent did not change the yield significantly.

In okra, the foliar application of the mixture at a concentration of 0.2 per cent (2 g per ltre) improved the yield by 45.24 per cent over control. The increase in spray concentration up to 0.50 per cent did not bring significant improvement in yield. However, the yield recorded on foliar application of 1.0 per cent concentration of the mixture was significantly higher to that on 0.20 per cent concentration.

From these observations, in general, we can infer that foliar application of 0.5% mixture was effective in all vegetables though there existed varying levels of response in tested vegetable crops. Moreover, an increase in concentration of spray solution from 0.5 to 1.0 per cent did not result in significant improvement in yield in vegetable crops tested except cowpea.

Many researchers have reported that foliar application of individual micronutrient fertilizers also improved vegetable yields owing to the physiological functions of the specific nutrients in plants. In bell pepper, highest number of fruits and fruit yield per plant was observed when borax was applied foliar @0.5% (Kumar and Malabasari, 2011) A combined application of zinc, manganese, iron and boron (each at 0.2%) resulted in an increase in the number of flower clusters per plant, number of flowers per cluster and number of fruits per plant (Bose and Tripathi, 1996). Sivaiah *et al*. (2013) [13] reported a positive role of the combined foliar application of zinc, molybdenum, boron, copper, manganese and iron (each at 100 ppm except manganese at 50 ppm) on fruit yield per plant in tomato.

Field experiments were conducted in a transplanted crop, chilli and a direct sown vegetable, okra and the fruit yield were recorded. The foliar application of the multi-nutrient mixture Sampoorna KAU multimix in different concentrations (0.5, 1.0 and 2.0%) in different schedules (Chilli: i. twice at 20 and 40 days after planting and ii. thrice at 15, 30, 45 days after planting and Okra: i. twice at 40 and 60 days after sowing and ii. thrice 30,45 and 60 days after sowing) were tested in chilli and okra and the results are presented in table 3 and 5. The spray concentration of the mixture had significant effect on vegetable yield of both the crops. Among the different concentration levels tested, the spray concentration of 1.0 per cent resulted in highest fruit yield in chilli. However in case of okra, the spray concentration above 0.5 per cent did not change the vegetable yield significantly. Different schedules of application of the mixture also significantly affected the vegetable yield in chilli and okra. The schedule with three sprays had resulted in significantly higher vegetable yield in both the crops.

Table 3 and table 4

The interaction effect of spray concentration and schedule of foliar application on fruit yield of chilli and okra is given in table 4. Among the treatment combinations, C3S2, foliar application of the 2.0 per cent mixture thrice registered higher yield in both the crops; but it was on par with the yield in C1S2, foliar application of 0.5 per cent mixture thrice. The data clearly revealed that foliar application of 0.50 per cent mixture, applied three times is the best package of application of Sampoorna KAU multimix in both the crops with 43.3 and 23.71 per cent improvement in vegetable yield over control in chilli and okra respectively.

A confirmatory field experiment (field experiment b) was conducted at RARS Pattambi in chilli and okra during rabi season in 2016. The experiment was conducted with foliar application of Sampoorna KAU multimix in different concentrations applied thrice at 15, 30 and 45 days after planting in chilli and 30,45 and 60 days after sowing in okra. The results are presented in table 5. The foliar application of 1.0 percent mixture registered highest yield, but it was on par with that registered by plants which received foliar application of 0.50 per cent mixture. The foliar application of the mixture @ 0.5% increased the fruit yield in chilli and okra by 52 and 168g per plant respectively over control. The increase in concentration of the mixture over 0.5% did not produce significant increase in fruit yield.

Table 5. The analysis of the growth parameters indicated an improvement in fruit length in chilli and number of fruits in Okra due to the foliar application of the multi-nutrient mixture which might have contributed to the improvement in vegetable yield. Hazara *et al.* 1987 has also reported productivity of okra crop is improved by the application of a micronutrient mixture containing boron and copper. They could attribute the yield increase to the increase in number of inflorescence/plant, total number of flowers, fruit size and number of fruits per plant.

Similar results of the effect of multi-nutrient mixtures were also reported in many studies. Sharma *et al*., 2000 [11] had reported that foliar application of a liquid fertilizer containing most of macro and micronutrients along with NPK significantly improved the growth and growth attributes in chilli (Sharma *et al*., 2000) [11]. The commercial foliar fertilizer, HiGrow, containing various macro (N, P, K, Ca and Mg) and micronutrients (Fe, Mn, B, Cu and Mo), when applied foliar at the concentration of 8 ml/l in chilli improved the number of fruits per plant (118.8), fruit size and weight and total fresh fruit yield (14977 kg/ha) (Baloch *et al*., 2008) [1].

The hidden deficiencies of micronutrients were overcome due to their supplementation during growth period, which resulted in better crop growth and thereby yield. The results of the present study indicated that multi nutrient mixture Sampoorna KAU multimix (vegetables) can be used as an immediate remedy for addressing the multi-nutrient deficiencies prevalent throughout the state. The nutrient uptake values in okra as affected by spray concentration in field experiment b (table 6) indicated the positive effect of the foliar application of the mixture on individual nutrient uptake.

Table 6. Initial status of the micronutrients in the experimental field (field experiment a) before the experiment indicated that the soil was deficient in zinc and boron. The soil was deficient in these nutrients even after the experiment. Similar results were observed in the field experiment b also. Hence the foliar application could not bring about changes in sol status of available nutrients.

The study proved that foliar application of the multi-nutrient mixture ensure increased yield in vegetables. The multi-nutrient mixture containing Zn B, Cu and traces of Fe, Mn and Mo and other nutrients as fillers (K, Mg, S and N) was developed for foliar application in vegetables. Effect of the micronutrient mixture was assessed in pot culture and field experiments conducted at RARS Pattambi. Growth and yield of vegetables improved significantly due to the foliar application of the multi micronutrient mixture, Sampoorna KAU Multimix (vegetables). Application of soil test based NPK and foliar application of Sampoorna KAU multimix @ 5 g per litre at 30, 45 and 60 DAS in direct sown vegetables and at 15, 30 and 45 DAP in transplanted vegetables yielded significantly higher than control.

Table 1: Percent nutrient content of different micronutrients in the multi-nutrient mixture Sampoorna KAU multimix (vegetables) developed for foliar application in vegetables

Nutrients	Content (%)
Zinc	4.2
Copper	0.4
Boron	3.0
Molybdenum	0.015
Iron	0.15
Manganese	0.14

Table 2: Effect of foliar application of Sampoorna KAU multimix (vegetables) on fruit yield (g/pot) in pot culture experiments

Treatment (Spray concentration)	Cowpea	Brinjal	Chilli	Okra
0.2%	92.45	717.3	169.2	544.8
0.3%	93.78	718.9	179.7	576.2
0.5%	116.3	814.0	214.6	592.0
1%	149.1	834.1	223.1	617.1
Control	70.21	622.2	136.4	375.1
CD (0.05)	24.61	59.21	21.12	58.20

Table 3: Effect of spray concentration and schedule of foliar application of Sampoorna KAU multimix on fruit yield in chilli and okra (field experiment a)

Treatments	Chilli	Okra
Spray concentration-levels		
C1 (0.5 per cent)	181.4	464.7
C2 (1.0 percent)	229.8	472.7
C3 (2.0 per cent)	238.5	476.2
C4 (Water spray)	158.4	411.3
C D (0.05)	26.26	21.14
Schedule of application-levels		
S1 spraying twice	194.2	426.2
S2 Spraying thrice	209.4	486.6
CD (0.05)	13.76	14.95

Table 4: Interaction effect of concentration and stages of application of the mixture Sampoorna KAU Multimix on fruit yield (g per plant) in chilli and okra in field experiment a.

Treatments		Chilli Variety Keerthi	Okra Variety Arka Anamika
C1S1	Sampoorna 0.5% twice	158.5	423.5
C1S2	Sampoorna 0.5% Thrice	204.2	505.1
C2S1	Sampoorna 1% twice	224.5	433.8
C2S2	Sampoorna 1% Thrice	235.1	511.5
C3S1	Sampoorna 2% Twice	237.9	437.6
C3S2	Sampoorna 2% Thrice	239.1	518.8
C4S1	Water spray twice	157.5	410.0
C4S2	Water spray thrice	159.2	412.6
	Control	142.5	408.3
	CD(0.05)	35.70	29.91

Table 5: Growth and yield in okra and chilli in response to foliar application of Sampoorna KAU multimix (vegetables) in field experiment b

Treatments (Spray concentration)	Chilli			Okra		
	Fruit yield (g per plant)	No of fruits per plant	Fruit length (cm)	Fruit yield (g per plant)	No of fruits per plant	Fruit length (cm)
0.50 per cent	201.4	54.2	9.54	589.5	20.5	21.9
1.0 per cent	256.5	54.18	9.55	592.3	20.6	21.8
Water spray	152.6	52.1	8.31	436.9	18.7	21.3
Control	149.2	52.0	8.28	421.2	18.5	21.1
CD (0.05)	58.89	NS	0.785	72.65	1.531	NS

Table 6: Nutrient uptake (mg per g plant dry matter yield) in okra as affected by spray concentration of Sampoorna KAU multimix in field experiment b

Treatments (Spray concentration)	N	P	K	Ca	Mg	S	Zn	Cu	B
0.50 per cent	1645	352	2895	2147	425.1	245.1	6.35	1.01	0.628
1.0 per cent	1689	365	2947	2085	485.6	251.4	6.41	0.95	0.639
Water spray	1504	348	2645	1986	374.1	154.8	5.84	0.62	0.429
Control	1495	351	2684	2147	371.5	155.9	5.86	0.61	0.432
CD (0.05)	91.8	25.67	164.2	327.3	24.2	18.7	0.49	0.085	0.047

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