Indian J.Sci.Res. 19(1): 06-09, 2018

ISSN: 0976-2876 (Print)
ISSN: 2250-0138(Online)

DEVELOPMENT OF CUSTOMIZED FERTILIZER FORMULATIONS FOR ELEPHANT FOOT YAM UNDER INTERCROPPING IN COCONUT FOR TWO AGRO ECOLOGICAL UNITS OF KERALA

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ABSTRACT

Among the tropical tuber crops, elephant foot yam (EFY) (Amorphophallus paeoniifolius (Dennst.) Nicolson) is a highly potential and ideal intercrop for the coconut gardens of Kerala. Being a high nutrient demanding crop, for efficient fertilizer management, we have developed a customized fertilizer mixture containing primary, secondary and micronutrients based on soil nutrient status and crop requirement. This paper narrates the protocols designed for the development of the customized fertilizer mixture which in turn consisted of arriving at the weighted average of the nutrient status of the two AEU's, nutrient omission/nutrient level experiments off station and arriving at some basic parameters to arrive at the fertilizer grades.

KEYWORDS: Tropical Tuber Crops, Elephant Foot Yam, Fertilizer Management Practices, Customized Fertilizer

It is a common fact that, the cultivable land resources are shrinking day by day and to meet the food, fiber, fodder and other needs of the growing population, the productivity of the agricultural land need to be increased. Inorder to increase the agricultural productivity from limited land resources, efficient use of agricultural inputs like seeds, fertilizers, water and agrochemicals are necessary. Elephant foot yam (EFY) is one of the most important tropical tuber crops and is regarded as the ‘king of tuber crops’ having high nutrient demand. The present nutrient recommendations for EFY under sole cropping system comprised of only major nutrients resulting in widespread deficiency of secondary and micronutrients especially in tropical soils. Hence, studies were initiated to develop multi nutrient mixtures known as ‘custom made fertilizers’ containing primary, secondary and micronutrients specific to crops and soils considering the crop requirement, limiting nutrients in that particular soil and the present farmers’ nutrient management schedule. The protocol for the development of these fertilizer mixtures involved the optimization of all required nutrients based on the weighted average of the soil data of the two agro ecological units (AEU) of which in turn consisted of 43 panchayats in AEU 3 and 161 in AEU 9 followed by validation of the optimum fixed through nutrient omission and nutrient level plot experiments in farmers' fields and on station. Information on farmers’ nutrient application rate, tuber yield, plant uptake, pre and post soil test data were used to arrive at parameters like nutrient uptake, nutrient requirement, percentage contribution from soil, fertilizer use efficiency and hence the nutrient to be applied through fertilizers. The grades of component nutrients and their levels of application for the two AEU's were designed by fitting these parameters using STCR (for an yield target of 45 t ha^{-1}) and response curve (RC) approaches based on the data generated from farmers' field trials conducted in these AEU's.

STUDY AREA

The study was confined to the two agro ecological units (AEU) of Kerala viz., AEU 3 (Onattukara sandy plain) and AEU 9 (South central laterites) where EFY is an important commercial tuberous vegetable as intercrop in coconut gardens. The Onattukkara sandy plain (AEU 3) extends mainly in two districts such as Alappuzha and Kollam covering 43 panchayats and AEU 9 covers the major six districts such as Thiruvananthapuram, Kollam, Alappuzha, Pathanamthitta, Kottayam and Ernakulam having 161 panchayats.

MATERIALS AND METHODS

The weighted average was computed taking into account the average chemical parameters of each panchayat with respect to its area where the primary soil data base was taken from the Kerala State Planning Board coordinated project on 'Soil based plant nutrient management plans for agro ecosystems of Kerala'. From the weighted average, STBF rate was evolved as per Aiyer and Nair (1985) for major nutrients and soil critical level for secondary and micronutrients (KAU, 2012). This was followed by conduct of nutrient omission (nitrogen, phosphorus, potassium) and nutrient level (calcium, magnesium, boron, zinc) plot experiments to arrive at the optimum rate of application of nutrients for the two AEU’s. Here, different levels of the nutrients in question were tested in three locations viz., two in AEU 9 and one

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in AEU 3 during 2014-16. These trials were conducted with EFY variety Gajendra and were laid out in randomized block design (RBD) with 15 treatments replicated twice. Each plot consisted of 25 plants and the plot size was 4.5 × 4.5 m.

In the nutrient omission plot experiment, as regards to N and K, five levels viz., -N/K, 0.75, opt, 1.5 and 2 times of the recommended dose (optimum) of N/K as per soil test was taken. In the case of P, based on the soil test, as the recommended rate was zero, a maintenance dose of 25% of PoP (Package of Practices) was taken as the optimum (P) and the super optimal 1 and 2 were 0.5P and P. Here, the levels of nutrients viz., Mg, Zn, B and dolomite were kept optimum in both AEU's. As regards to the nutrient level experiments, the limiting nutrients viz., Ca, Mg, Zn and B as per KSPB (2013) for these two AEU's was taken care of. For Ca and Mg, dolomite was chosen as the amendment as Susan John *et al*., (2013) already reported dolomite as the best soil amendment for tuber crops in the Ultisols of Kerala. Hence, for standardization of dolomite, Zn and B, four levels as 0.5, Opt, 1.5 and 2 and for Mg, 0.25, 0.5, opt and 1.5 times of the recommended dose (optimum) was taken.

Destructive sampling was done at peak vegetative growth stage of the crop (around 6 MAP) from inner plants. The fresh weight of the entire lamina and pseudostem of two plants per plot was recorded and 100g fresh weight of these samples was oven dried for dry matter and other chemical analyses. Harvesting was done at 10 MAP and tuber yield was recorded. The pre and post harvest soil samples and plant samples also were analyzed for the tested nutrients as per routine analytical procedures. Based on the tuber yield data, the optimum nutrient rate of the tested nutrients was standardized. A total of 72 farmers belonging to the different places of the two AEU's were interviewed to get an overview of the type of organic manures, chemical fertilizers, their rate and mode of application for EFY intercropping in coconut garden which in turn will help to decide on the rate of application of the CF developed in parity with farmers' application rate. From the recorded observations, parameters like nutrient requirement (NR) (kg nutrient taken up per ton of tuber), soil available nutrient supply, percentage nutrient contribution from soil (-N, P, K plots, CS %), total plant nutrient uptake (kg ha^{-1}), nutrient to be taken from the fertilizer (kg ha^{-1}), fertilizer use efficiency (%) and fertilizer nutrient application requirement were computed. These parameters along with the survey results were used to design the fertilizer mixture grade which in turn contains nutrients viz., N and K @ 20 and 70% respectively and other nutrients in full. The grades were designed based on soil test crop response (STCR) (for an yield target of 45 t ha^{-1}) and response curve (RC) approach.

RESULTS AND DISCUSSION

The STBF rate evolved based on the above data of the two AEU's as per Aiyer and Nair (1985) and KAU (2012) were as N, P, K, Mg, Zn, B, Dolomite @71:12.5:106.5:16: 5.25: 1.31:1000 kg ha^{-1} and 78:12.5:90:16:5.25:1.31:1000 kg ha^{-1} for AEU 3 and AEU 9 respectively. In the nutrient omission plot experiment, the tuber yield data indicated 2N as significantly highest in AEU 3 and AEU 9 (average data of the two locations), so 2N @142 and 156 kg ha^{-1}, were taken as the optimum for AEU 3 and AEU 9 respectively. In AEU 3, 1.5 P recorded significantly the highest tuber yield and in AEU 9, in both locations, minus P (-P) recorded yield on par with the other higher levels. But the mean data over these two locations revealed optimum P (P @ 12.5 kg ha^{-1}) on par with other higher levels and hence in AEU 3, P @ 18.75 kg ha^{-1} and in AEU 9, optimum P @ 12.5 kg ha^{-1} was taken (. In the case of K, in both AEU' s, 2K @ 212 kg ha^{-1} (AEU 3) and 180 kg ha^{-1} (AEU 9) gave significantly the highest tuber yield and hence were taken as the optimum.

In the second experiment, the constraint nutrients typical for these two AEU's viz., Ca, Mg, B and Zn were standardized through nutrient level experiment as in the previous experiment using different levels of the nutrients in question. Since Ca and Mg are deficient in these two AEU's, dolomite was recommended as the best soil amendment (Susan John *et al., 2013*). As regards to the tuber yield under dolomite, in AEU 3 and 9, 2D was on par with 1.5D from the recorded tuber data and hence in both AEU's, dolomite @ 1.5 t ha^{-1} was recommended as the optimum. In the case of Mg, in both AEU's, 1.5 Mg was on par with optimum Mg, and hence, 1.5 Mg (Mg @ 24 kg ha^{-1}) was taken as the optimum. In AEU 3, 2Zn was on par with 1.5 Zn and in AEU 9, the mean data over the two locations indicated optimum Zn as on par with the other higher levels. Hence, in AEU 3, 1.5 Zn as Zn @ 7.88 kg ha^{-1} and in AEU 9, Zn @ 2.63 kg ha^{-1} has been taken as the optimum. In AEU 3 and 9, optimum B was on par with the other two higher levels, so, optimum B (B @ 1.31 kg ha^{-1}) was taken as the optimum rate. Based on the tuber yield data of the two AEU's, the optimum nutrient rate of primary (N,P, K), secondary (Mg), micronutrients (Zn, B) and dolomite were standardized for the two AEU's as N: P: K: Mg: B: Zn: Dolomite @ 150: 20: 225: 24: 8: 1.31:

1500 kg ha^{-1} for AEU 3 and 120 :12.5: 200: 24: 1.31: 3: 1500 kg ha^{-1} for AEU 9.

The farmers survey indicated the general application rate was as factomphos containing N:P:K:S (20:20:0:15) @ 200 kg ha^{-1}, MOP @ 500 kg ha^{-1} and urea @ 200 kg ha^{-1} along with farm yard manure @ 25 t ha^{-1}. It is also known that, progressive farmers are applying 14 (900 kg) bags of chemical fertilizers and normal farmers are going for 8 (400 kg) bags of chemical fertilizers. Hence, the rate of application of the designed custom made fertilizer was fixed as 10- 15 bags ha^{-1} (500-750 kg ha^{-1}).

The grades of the fertilizer mixture for the two AEU's were arrived at using soil test crop response (STCR) and response curve (RC) approaches. In the STCR approach, for an yield target of 45 t ha^{-1}, the NR (kg nutrient taken up for every ton of tuber), nutrient uptake, total soil nutrient availability (inclusive of soil percent, manures and fertilizers), percentage contribution from soil and fertilizer use efficiency as in terms of N, P, K for AEU 3 and 9 were arrived. The technical and scientific expertise of Tata Chemicals (Centre for Agri solutions), Aligarh, Uttar Pradesh who are the pioneers in the development of customized fertilizer was utilized for arriving at the grades of the CF for the present study.

In the case of secondary and micronutrients, based on the optimum evolved as Mg, Zn and B @19.2, 4.2, 1.575 and 19.2, 6.3, 1.969 kg ha^{-1} respectively for AEU 3 and AEU 9, the grades of Mg, Zn and B for the CF for the AEU 3 and AEU 9 were fixed as 3.84, 0.84, 0.3 and 2.5, 1.25, 0.4% respectively taking into account the CF developed has to be applied @500 kg ha^{-1}. The final grade of CF (application rate of 500 kg ha^{-1}) for EFY intercropped in coconut gardens based on STCR approach for an yield target of 45 t ha^{-1} was N:P_2O_5:K_2O: Mg: Zn: B as 8:11:21:3.5:1:0.3 for AEU 3 and 7:12:24:2.5:1.3:0.4 for AEU 9. The response curve (levels of each nutrient versus tuber yield) plotted indicated the optimum for N, P_2O_5, K, Mg, Zn and B for AEU 3 was as 142,12.5,213,19.2,4.2,1.6 kg ha^{-1} and 156, 12.5, 180, 19.2, 6.3 and 2 kg ha^{-1} for AEU 9 respectively. Based on these, the grades of the component nutrients in the CF was evolved with 20% N, full P and 70% K and other nutrients full for an application rate of 500 kg ha^{-1} as N, P_2O_5, K_2O, Mg, Zn, B @ 6: 3: 30: 3.5: 0.8: 0.3% respectively for AEU 3 and for AEU 9, the grades were 7: 3: 25: 4: 1.25: 0.4%. In arriving at the four different grades of the CF for AEU 3 and AEU 9 based on STCR and RC approach, the manufacturing tips for better granulation of the product like N:P ratio, percentage of steam and filler, type of P fertilizer, DAP: TSP ratio, percentage share of K fertilizer are taken into consideration. As the CF contained 20%N and 70% K, the rest of 80% N and 30% K needs to be applied as top dressing in the form of urea and MOP. Among the three grades viz., CF1, CF2 and CF3 tried at two rates viz., 500 kg ha^{-1} and 625 kg ha^{-1} in five locations of the two AEU's with eight treatments including POP and farmers' practice replicated thrice in RBD indicated the three grades of CF @ 625 kg ha^{-1} are significantly superior to other treatments with a high BC ratio (mean of CF's @ 625 kg ha^{-1}) of 26.95. To find out the best among the three CF's, trials were in progress with the three CF's @ 625 kg ha^{-1} in five districts of Kerala belonging to these two AEU's.

Table 1: Tuber yield (t ha^{-1}) of EFY under different treatments by three CF rates

Treat	Description	AEU3	AEU 9		AEU's
		Site 1	Site 1	Site 2	Mean
T1	CF 1 @ 500 kg/ha	14.250	41.392	26.296	27.313
T2	CF 2 @ 500 kg/ha	13.391	47.000	29.444	29.945
T3	CF 3 @ 500 kg/ha	15.447	47.825	30.088	31.120
T4	CF 1 @ 625 kg/ha	19.026	46.695	31.543	32.421
T5	CF 2 @ 625 kg/ha	18.127	53.875	35.802	35.935
T6	CF 3 @ 625 kg/ha	20.217	53.310	35.500	36.342
T7	POP	15.237	35.274	26.177	25.563
T8	FP	16.209	33.752	24.879	24.947
Mean (Locations)		16.488	44.890	29.966	
CD (Treat)		3.139	5.511	3.376	2.295
CD (Locations)		-	-	-	1.405
CD (Treat X Locations)		-	-	-	3.975

CONCLUSION

Though the concept of designer fertilizers /customized fertilizers specific to crops and soils is a new concept, the. As the basic philosophy in the development of custom made fertilizers involve pro active soil and plant tissue testing, inclusion of all the required nutrients specific to soil and crop in the required proportion and involvement of advanced scientific principle in the development of the fertilizer, it will definitely improve crop and soil productivity, produce quality, increase profit with better nutrient use efficiency. Hence, the present effort in the development of the designer fertilizer for EFY intercropped in coconut gardens of Kerala can help in meeting the above crop management benefits compared to the existing nutrient management practices.

ACKNOWLEDGEMENT

The authors gratefully acknowledge the 27th Swadeshi science congress for giving an opportunity for oral presentation held at Amrita University and Kerala State Council for Science, Technology and Environment (KSCSTE) for the financial support and Kerala State Planning board for introducing the concept of customized delivery of plant nutrients as an objective of their project.

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