Integrated Nutrient Management of Tropical Tuber Crops

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Tropical tuber crops constitute an important food crop of man from time immemorial which in turn has sustained people even during days of famine. These groups of crops compared to cereals and legumes have high biological efficiency, form cheaper source of energy especially for the weaker sections of the population.It can produce economic yields under marginal soils and environments, can withstand adverse biotic and abiotic stresses, and are rich in starch which form the raw material for many value added products. Among the tropical tuber crops, cassava belonging to the family Euphorbiaceae is the most important owing to the extensive area under cultivation globally and the better starch qualities of cassava which could help in developing many industrial products including food, feed, adhesives, pharmaceuticals, ethanol, super absorbent polymers and even bio degradable plastics.

In order to meet the rising demand of cassava tubers for both food and starch for industrial purposes, there is a need to maximize the productivity of cassava. In this regard, the nutrient management deserves special attention.

According to Henry and Gottret (1996), low soil fertility is one of the constraints in production where the management of soil fertility can increase cassava yield by 32 percent.

Integrated nutrient management (INM) practices

In general, INM practices involve the conjoint use of organic manures, chemical fertilizers and bio fertilizers. The blanket fertilizer cum organic manure recommendation being followed for tropical tuber crops is given in Table 1.

a. Green manuring in situ with cowpea as the best organic manure source for cassava

In tropical tuber crops, application of organic manures is very important from the point of view of modifying the soil physical properties for better tuberization and tuber bulking. At ICAR-CTCRI, under the long term fertilizer experiment (LTFE) in progress since 1977,used different organic manures as substitute for FYM viz., crop residue incorporation, green manuring in situ with cowpea, coir pith compost and vermicompost. Green manuring in situ was found the best in terms of tuber yield, monetary benefit,

Table 1. Fertilizer recommendation for tropical tuber crops

Crop	FYM* (t ha-1)	(kg ha-1)		
		N	P2O5	K2O
Cassava	12.5	100	50	100
Sweet potato	5.0	50	25	50
Taro	12.5	80	25	100
Lesser yam	10.0	80	60	80
Greater yam	10.0	80	60	80
Elephant foot yam	25.0	100	50	150
Chinese potato	10.0	60	60	100
Arrowroot	10.0	50	25	75
Tannia	25.0	80	50	150

* Farm Yard Manure

improvement in soil properties and controlling weeds. The cowpea seeds can be sown @ 25 kg/ha after ploughing the field with application of full P, half N and half K of the recommended dose for cassava during the second week of April. If there is sufficient rain, there will be enough vegetative growth within 45-60 days to the tune of 15-25 t/ha which can be ploughed and incorporated into the soil while taking mounds for planting cassava.

b. Avoiding the use of P in high P soils

As regards to the nutrient uptake by cassava, it is found that, compared to N and K, the uptake of P is one tenth to the range of 15-25 kg/ha for a tuber production of 30 t/ha. Moreover, over N and K, there is no loss of P due to its immobile nature in soil, resulting its building up to several manifold on continuous application. under the LTFE, since 2005, based on soil test data which was found very high to the tune 100-125 kg/ha due to continuous application from an initiation status of 30-40 kg/ha, P was omitted and the tuber yield data did not show any significant difference with P applied at the recommended dose of 50 kg/ha. Hence, if the soil test is far above high or very high, application of P can be skipped at least for 5 years till the level comes to the high (around 25 kg/ha).

c. Soil test based application of fertilizers and manures

Under the LTFE since 2005, with a treatment based on soil test data of the post harvest soil analysis, for the last 12 years, the mean NPK during these years was 82:0:73 kg/ha resulting a tuber yield of 22.81 t/ha on par with a tuber yield of 25 t/ha under POP where NPK @100:50:100 kg/ha was applied. This implicates the need to adopt soil test based crop management in cassava especially with the omission of P when the level of soil available P is high to very high.

d. Soil test based application of secondary and micronutrients in cassava

The experience under LTFE since 1990 clearly revealed that, when the status of nutrients especially Zn, Mg and B in the soil due to continuous application becomes high, crossing the soil critical level of these nutrients, the response is not positive in accordance with the level of application. Since, Mg, Zn and B were found very

Soil Mg status (meq 100/g)	Rate of application of MgSO4 (kg/ha)	Soil Zn status (ppm)	Rate of application of ZnSO4 (kg/ha)	Soil B Status (ppm)	Rate of application of borax(kg/ha)
0–0.25	20	<0.2	12.5	<0.2	10
0.25–0.50	15	0.2–0.3	10	0.2–0.5	7.5
0.50–0.75	10	0.3–0.4	7.5	0.5–1.0	5 .0
0.75–1.00	5	0.4–0.6	5	1–2	2.5
>1.00	2.5	>0.6	2.5	>2	0

essential for cassava, we have standardised the rate of application of these nutrients based on soil available level of these nutrients and is given below:

e. Nutritional disorders due to deficiency of K, Ca, Mg, and B in cassava and its correction

In the acidic laterite soils of Kerala, the deficiency of these nutrients are rampant if proper nutrient management involving these nutrients are not done. K deficiency is characterized by drying and necrosis of the tip and margins of lower leaves which can be prevented by balanced application of MOP. If symptoms are initiated, either apply MOP as per POP to soil and in severe cases, foliar application of sulphate of potash 0.5-1% can be resorted to. Ca and B deficiency usually seen in upper younger leaves due to the immobility of these nutrients in plant system.Ca deficiency is manifested as round appearance of the tip of the leaves instead of pointed tip. It can be prevented by either regular soil application of lime or dolomite @ 1 t/ha especially in the case of Ca sensitive varieties. After appearance, foliar spraying of calcium nitrate @ 0.5-1% is advised. Mg deficiency usually appear as interveinal chlorosis of mature lower leaves and is prevented by either soil application of dolomite @ 1-2 t/ha or magnesium sulphate @ 20 kg/ha.

In severe cases, foliar application of magnesium sulphate @0.5-1% can be done. B deficiency usually appear as rosette look at the plant apex with small sprouts in clusters or bunches with reduced / crinkled leaves / distorted appearance affecting the growth of the plant. Soil application of either borax or boric acid @ 10 kg/ha to prevent the symptom and once appeared, foliar application of CaNO3 (0.5%) along with solubor (0.05-0.1%) (Combined) at fortnightly intervals till the plant recoup can be done. However, Ca, Mg and B deficiencies are variety specific.

f. Low input management strategy in cassava

A low input management strategy for cassava was developed involving NUE genotypes viz., CI 905 and CI 906, soil test based application of fertilizers including secondary and micronutrients as N:P:K:MgSO4:ZnSO4 @106:0:89:15:2.5kg/ha, green manuring in situ with cowpea as organic manure source and nutrient use efficient bio fertilizers viz., N fixer (Bacillus cereus),

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P solubilizer (Bacillus megaterium) and K solubilizer (Bacillus subtilis). This strategy resulted in a tuber yield of 33.68 and 34.72 t ha-1 with CI 905 and CI 906 respectively having a BC ratio of 4.43 and 4.57 respectively. It also saved P, K, Mg and Zn to the tune of 100, 11.5, 62.5 and 80% respectively with reduction in input cost up to 55%.

g. Nutrient use efficient genotypes in cassava

The objective of identifying nutrient use efficient (NUE) varieties is to reduce the dependence on chemical fertilizers as these genotypes because of its unique root system or leaf architecture can scavenge the soil nutrients or harness the sunlight effectively. The experiments conducted at ICAR-CTCRI since 2007 in this line resulted in releasing the first K efficient variety by name' Sree Pavithra' in 2015 which was an elite landrace (Aniyoor). Further experiments conducted could identify two N efficient genotypes viz., W-19 and CR 43-8 which require 50% of the recommended dose of N which are yet to release. Three NPK efficient genotypes viz., CI 905, CI 906 and 7 III E3-5 having good cooking quality was in pipeline which can reduce/ substitute for chemical NPK fertilizers up to 75%. The three NPK efficient genotypes are under field trials in different districts of Kerala now.

h. Nutrient recycling in cassava through cassava starch factory solid waste (thippi) composting

In Tamil Nadu, cassava is used for the production of industrial starch and sago and there is large scale generation of starch factory solid waste (thippi) causing enormous environmental pollution. We explored the possibility of making some value added organic manures from thippi and among the various protocols tried, the cheap and traditional way of composting using earthworms gave better result in making it in to a nutrient rich organic manure. It had the highest plant nutrient content with low C:N ratio (8:1). The mean N, P, K, Ca and Mg, Fe, Mn, Cu and Zn content in thippi compost was 1.32, 3.82, 0.40, 2.18, 0.96, 1.11, 0.08%, 11.23 and 89.93 ppm respectively which is 3.5, 49,7, 32.5, 8, 185, 100, 2.5 and 12 times compared to raw thippi which is having a C:N ratio of 82:1. The mineralization pattern of nutrients from thippi compost indicated the maximum release of almost all nutrients during 5-7th month. Field experiments conducted for two seasons indicated thippi compost as an alternative to FYM, green manuring in situ with cowpea, crop residue incorporation, vermicompost and coir pith compost and even NPK fertilizers up to 50% of the recommended dose, $MgSO_4$ @ 2.5 kg/ha and $ZnSO_4$ @ 2.5 kg/ ha.

Envisaging New Dimensions in Research of Ethnic Crops

Dr. K. Susan John, Principal Scientist (Soil Science) was the proud recipient of International Potash Institute (IPI)-Fertilizer Association of India (FAI) award in 2014, International Plant Nutrition Institute (IPNI) award in 2016 and International Zinc Association (IZA)- FAI award in 2018 for her outstanding, sustained and continuous research for more than 25 years on balanced nutrition of tropical tuber crops through integrated nutrient management (INM) practices involving major, secondary and micronutrients to achieve enhanced crop productivity in addition to maintaining soil health. Her area of research include soil test based fertilizer recommendations, secondary and micronutrient management, diagnosis and correction of nutritional disorders, screening nutrient use efficient genotypes for low input management, nutrient use efficient microbial isolates as substitutes to chemical fertilizers, cassava starch factory solid waste (thippi) management for nutrient recycling, development of customized fertilizers for tropical tuber crops under intercropping in coconut and role of plant nutrition in cassava mosaic disease management. She has developed many technologies like INM strategy for tannia, soil test based recommendation for Mg, Zn, B, thippi composting and customized fertilizer formulation technology etc. Her enthusiasm towards research is a motivation for women scientists and academicians across the country.

i. Customized fertilizer mixtures for elephant foot yam (EFY) intercropped in coconut gardens

Customized fertilizer formulations contain the required plant nutrients together in one mixture can facilitate easy and timely application in one shot. Based on a series of experiments conducted for EFY under AEU 3 and AEU 9, which covers the major tuber crops growing tracts of Kerala, three grades of the mixtures were evolved viz., N: P_2O_5:K_2O:Mg:Zn:B@8:11:21:3.5:1:0.3(CF1), 7:12:24:2.5:1.25:0.4 (CF2) and 7:3:25:3:1.25:0.4 (CF3). Usually the CF is applied basally which contains N and K@ 20 and 70% respectively and the remaining N and K will be applied as top dressing. Experiments conducted with these three formulations at two rates viz., 500 and 625 kg/ha indicated CF2 @625 kg/ha is best for EFY. For cassava under intercropping with coconut, CF1 and CF2 @ 500 kg/ha was found good. This is yet to popularise among farmers.

j. Cassava mosaic disease (CMD) management through crop nutrition

Preliminary studies conducted to screen nutrients viz., P, Zn, Si, Ca and B in managing CMD with soil application @2g/plant basally within one week of planting setts followed by top dressing at 2 and half months after planting and at 5MAP and foliar application of 0.1% (except solubor @0.01%) concentration of the salts containing the above nutrients from one week of sprouting at monthly intervals till 6MAP indicated the degree of disease control in the order as B > Zn > Ca > Si > Devirus (to control vector) > POP (Package of Practices recommendation) > P > AC (absolute control without any soil and foliar application) in managing the disease. Detailed studies are in progress.

k. Integrated nutrient management in Tannia (Xanthosama sagittifolium L. Schott)

Tannia is an important tuberous vegetable grown extensively as intercrop mostly in coconut and banana plantations. Though the crop fetches high price among the different tropical tuber crops, its growth and yield is affected by some nutritional disorders. Subsoil acidity due to Al^{3+} ions resulting Mg deficiency was diagnosed as the problem. Application of dolomite @1 t/ha was found as the suitable soil ameliorant to rectify this problem. Since the crop was not having a nutrient recommendation, the INM strategy also was evolved as NPK @ 80:50:150 kg ha-1 + 25 t ha-1 farm yard manure (FYM).

The strategy was standardised as application of dolomite as soil amendment @ 1 t ha-1 (80 g/ plant) during ploughing. Then can keep the land as such for 2 weeks. Then,apply FYM @ 25 t ha-1 in pits and P @ 50 kg ha-1 as basal. Plant the Pseudomonas treated cormel/corm, sow green manure cowpea immediately after planting tannia. Apply N fixer within 1 month of planting , neem cake in pits after 1 month of N fixer application and apply 1/3 fertilizer N and 1/3 fertilizer K within 2 months after planting (MAP). Apply 1/3 fertilizer N and 1/3 fertilizer K within 4 MAP and the rest of 1/3 fertilizer N and 1/3 fertilizer K within 6 MAP.

l. NUE bio fertilizers in reducing chemical fertilizers in EFY

As in the case of NUE cultivars, NUE microbes viz., N fixers, P and K solubilizers also form a component of INM practices where in by using these microbes, we can reduce the use of chemical fertilizers. In this line also, the research work conducted at ICAR-CTCRI since 2007 resulted in the isolation, identification and characterization of Bacillus cereus, Bacillus megaterium and Bacillus subtilis respectively as N fixer, P and K solubilizers and experiments conducted using these microbes to substitute for chemical fertilizers in elephant foot yam and sweet potato resulted in saving 25% each of N and K and P up to 50-75%.

These studies carried out at ICAR-CTCRI for the last 25 years clearly revealed the need to apply inorganic chemical fertilizers including secondary and micronutrients especially Mg, Zn and B in tropical tuber crops along with organic manures emphasis to profitable and farmer friendly practices like green manuring in situ with cow pea. Bio fertilizers also increase tuber yield, improve tuber quality, enhance farmer profit and sustain soil health in addition to saving the crop from nutritional disorders affecting its growth and yield.