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Integrated nutrient management in tannia (*Xanthosoma sagittifolium* L. Schott): yield, plant nutrient concentration, plant uptake and soil chemical properties in an ultisol, Kerala

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Abstract

Tannia (*Xanthosoma sagittifolium* L. Schott) is an important tropical tuber crop under aroids usually grown as an intercrop in plantations fetching good income. The leaves, corm and cormels are edible with good nuetraceutical properties and high content of minerals especially K, Ca and Mg in leaves. An Integrated Nutrient Management (INM) package was evolved for this crop involving dolomite as soil amendment (@1 t ha^{-1}) to correct sub soil acidity which usually hinders the growth and yield of the crop along with FYM @ 25 t ha^{-1} as organic manure source and NPK @ 80:50:150 kg ha^{-1}. By virtue of the organic nature of the crop, the N requirement was substituted with green manuring *in situ* with cowpea, neem cake and N efficient bio fertilizer to the extent of 75% and the remaining through urea. The INM strategy developed could rectify the nutrient disorder with increased corm and cormel yields to 12.821 and 12.863 t ha^{-1} over the existing adhoc recommendation of taro (FYM @ 12.5 t ha^{-1}+ NPK @80:50:100 kg ha^{-1}) where the cormel and corm yields were 6.37 and 5.86 t ha^{-1} respectively. Though the plant dry weight percentages and plant nutrient contents were not affected, the leaf, corm and cormel dry matter production as well as total plant uptake of nutrients were affected either by levels of dolomite, levels of K or their interaction effect. However, drastic variation was noticed in the plant nutrient contents and, in the corm, cormels and leaves, the N content was 1.446, 2.334, 2.40 %, P content was0.493, 0.333, 0.333 %, K content was 0.226, 0.419, 2.368 %, Ca content was 0.356, 1.141, 1.029 %, Mg content was 0.079, 0.565, 2.492% and Mn content was 31.92, 40.83 and 147.5 ppm respectively. Levels of dolomite significantly affected the post harvest soil pH, soil available Ca and Mg and levels of K affected soil pH and K and the interaction effect was significant in the case of pH and K.

Keywords: Tannia, Cormel, Corm, PoP, INM, Nutrients

Introduction

Among the tropical tuber crops, aroids *viz.,* elephant foot yam, taro and tannia are valued as nutritious as well as therapeutically valuable tuberous vegetables grown mainly as intercrops in coconut as well as banana and rubber plantations. Since coconut is a major crop grown both on plantation scale and as a component crop in the homesteads of Kerala, raising intercrops like aroids is a common practice by farmers. Among

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the aroids, tannia known as new cocoyam (*Xanthosoma sagittifolium* L. Schott) is the most remunerative as its cormels fetches better price (₹ 30-100 kg^{-1}) in the local markets and is having good export potential. Tannia is cultivated for edible tubers (corms and cormels) and young leaves. The tubers and young leaves are highly nutritious having substantial quantities of protein, vitamins, and minerals in addition to starch/ energy. Compared to taro, tannia is preferred by people due to the absence of itching and lack of too much of mucilage in the tubers, good cooking quality as well as better taste. Since the starch granules in tannia tubers are relatively large, they are mainly used to produce industrial starch. In some places, flesh scrapings of corm and cormels are pulped and used as anti-coagulants, anti-tetanus, and anti-venom agents against tarantula, scorpion and even snake bites (Ramesh et al., 2007).

Tannia is grown mostly in southeast Asia, west Africa, and central America. In India, it is grown in Maharashtra, Kerala, Tamil Nadu, Karnataka, West Bengal and northeastern states in area of around one lakh hectares. Being one of the nutritious tuberous vegetables grown locally and regionally, many experiments were undertaken at ICAR-Central Tuber Crops Research Institute, Sreekariyam, Thiruvananthapuram, Kerala to standardize the nutritional requirement of this crop. But these were hindered due to some soil and plant nutritional problems affecting the growth and yield of the crop especially in laterite soils (Ultisols) (Susan John et al., 2006). Studies conducted at CTCRI resulted in evolving an integrated nutrient management (INM) strategy for the crop (KAU, 2016). During these studies, some crop and soil attributes too were studied and this research paper narrates the parameters like yield of corm, cormels, plant (leaves, corm, cormels) dry weight percentage, nutrient (N, P, K, Ca, Mg and Mn) concentration in the different plant parts, total plant uptake of the above nutrients as well as the effect of growing tannia on soil chemical properties (pH, organic carbon, available N, P, K, Ca and Mn).

Materials and Methods

The study was conducted for a period of three years. During the first year, the major objective was to rectify the subsoil acidity which was found critical in the manifestation of the foliar symptom and associated problems in tannia. In this regard, experiments were conducted both under field as well as controlled conditions using five different liming materials *viz.,* calcite, dolomite, gypsum, calcium silicate and calcium oxalate at different rates ranging from 100 to 1000 g. Soil samples were taken at one month interval for a period of six months from 4 different depths *viz.,* 0-15, 15-30, 30-45 and 45-60cm and were analyzed for pH, CEC and exchangeable Ca.

The second-year experiment involved the standardization of different components of INM *viz.,* FYM, different combinations of organic and inorganic sources of N and level of P by keeping the adhoc recommendation of taro (N: P_2O_5: K_2O @80:50:100 kg ha^{-1} + FYM @ 12. 5 t ha^{-1}) as the basic treatment. This experiment was conducted in a split plot design with 20 treatments. The main plot treatments were different INM components (FYM, N sources and P) including their mode and time of application. The subplot treatments were two soil ameliorants *viz.,* gypsum and dolomite. Observations were taken mainly on the occurrence of nutritional disorders, yield and yield attributes, plant nutrient contents and total plant uptake.

As the INM components with respect to soil ameliorant, organic manure, rate of N and P, its mode and time of application were standardised from the previous experiments, during the third year, an experiment was undertaken to standardise the rate of application of dolomite and K. Hence, the third-year experiment consisted of the full INM package comprising of soil ameliorant (rate of dolomite application will be standardised through third year experiment), FYM, N application rate, P (sources of N, mode and time of application already standardised during second year experiment), and K (rate of K application will be standardised through third year experiment). This experiment too was undertaken in split plot design with 13 treatments replicated twice where the control was the adhoc recommendation of taro. The main plot treatments included four levels of dolomite @ 0.5, 1.0, 1.5 and 2.0 t ha^{-1} and sub plot treatments were three levels of K @ 50, 100 and 150 kg ha^{-1}.

Hence, the results presented here in this paper is on the combined INM strategy which involved the results of the first two year studies as the basic component along with levels of dolomite and K levels on corm and cormel yield, plant (leaf, corm and cormel) dry matter production, pre and post harvest soil nutrient status (pH, organic carbon, available N, P, K, exchangeable Ca, Mg and Mn), plant (leaf, corm and cormel) nutrient (N,P, K, Ca, Mg, Mn) contents and total plant uptake of nutrients (N,P, K, Ca, Mg, Mn).

With regards to corm and cormel yield, after 9 months of planting, when the entire plant get dried up, they were uprooted, separated the cormels from the mother corm and the weight of cormels and corm was recorded. The plant dry matter production was determined for arriving at the total plant nutrient uptake. Since tannia starts drying up from sixth month of planting onwards depending upon the weather condition, for dry matter production, the plant fresh weight were usually taken at the peak vegetative growth stage, i.e., 5 months after planting (5MAP). During this time, the sample plants were uprooted and separated into leaves, corm and cormels. While calculating the total leaf dry matter, the total number of leaves formed from beginning till the end of crop growth period was taken. At 5-6 MAP, the total fresh weight of the leaves in a plant including the petiole was taken and from this a representative sample of 50 g was taken and kept for determining the dry weight percentage of the leaf. From the number of total leaves formed in the plant (by counting the number of rings in the mother corm), fresh weight of one leaf in the plant and dry weight percentage of leaf and the total leaf dry weight was determined. Similarly, from the fresh corm weight, and its dry weight percentage, the total dry weight of the corm per plant was obtained. The fresh weight of the cormels separated from the corm was taken and based on the cormel dry weight percentage, the total dry weight of the cormel per plant was calculated. By adding the dry weight of leaf, corm and cormels of the plant, the total plant dry weight per plant was computed and converted on per hectare basis.

The samples of leaf, corm and cormels kept for drying after determining the dry weight percentage was ground thoroughly in a mill (IKA A11 B S022) and was used for the determination of nutrient contents in the different plant parts. In the case of N in the different plant parts, diacid digestion (9:4 perchloric: sulfuric acid) (Tulin KjeLTRON KD1GB 20M) followed by distillation (KjeLDIST AF DD) was done in N analyser and titration was done using automatic burette (MICROLIT E- burette). In the case of other nutrients, *viz.,* P, K, Ca, Mg and Mn, triacid digestion (9:3:1 nitric: perchloric: sulphuric acid) followed by estimation in the respective instruments like colorimetry for P in spectrophotometer (VIS Double Beam), flame emission photometry for K and Ca in flame photometer (Systronics MC 128) and atomic absorption spectrometry for Mg and Mn in atomic absorption spectrophotometer (PinAAcle 900H) was done (Piper, 1966). The uptake of each nutrient with respect to each plant part was determined by multiplying the dry weight of the plant parts per hectare with percentage nutrient concentration. From the independent uptake of leaves, corm and cormels on per hectare basis, the total plant uptake for each of these nutrients was computed. The pre and post harvest soil samples were analysed for pH, organic carbon, available N, P, K, Ca, Mg and Mn (Jackson, 1973) to determine the effect of INM on soil chemical characters. The data generated were analysed using Genstat Discovery Edition.

Results and Discussion

The first year results revealed that dolomite is the best liming material for tannia (Susan John et al., 2013b., Susan John and Remya, 2022). The second year studies standardized the components of INM strategy with respect to FYM, N and P with an application rate of FYM @ 25 t ha^{-1} along with N @ 80 kg ha^{-1} and P @ 50 kg ha^{-1} and the mode of application of N as 75% through organic sources *viz.,* raising green manure cowpea, use of N fixer and neem cake and 25% through chemical fertilizer, urea (Susan John et al., 2013a; Susan John et al., 2013b). The results presented in this paper are mainly those of the third year experiment (2011) which comprised of the independent and interaction effect of levels of dolomite and levels of K on corm and cormel yield, plant (leaf, corm and cormel) dry matter percentage, plant dry matter production, plant nutrient contents (N, P, K, Ca, Mg, Mn), total plant uptake of these nutrients as well as the post-harvest soil chemical properties which are described below.

Corm and cormel yield

Levels of dolomite significantly influenced the corm and cormel yields. In both cases, dolomite @ 2.0 t ha^{-1} recorded the highest corm yield (10.989 t ha^{-1}), which was on par with 1.5 (10.085 t ha^{-1}) and 1.0 t ha^{-1} (9.523 t ha^{-1}). But significantly low yield of both corm (7.217 t ha^{-1}) and cormels (8.667 t ha^{-1}) were seen with dolomite @ 0.5 t ha^{-1}. Hence, it was inferred that dolomite @ 1.0 t ha^{-1} is sufficient to maintain good corm and cormel yield in tannia. The effect of higher levels of dolomite in sustaining and maintaining both corm and cormel yield could be attributed to the favourable effect of Mg in dolomite which solubilizes at low pH and moves to the lower layers replacing the exchangeable Al which in turn would be a threat to the crop through hindering the water and nutrient uptake with a concomitant decrease in Ca uptake as reported by Merino-Gergichevich et al., (2010). Rodriguz et al., (1982) also reported that dolomitic limestone can reduce the exchange acidity and improve the subsoil acidity and hence the yield in tannia.

The 3 levels of K significantly affected the corm and cormel yields. Corm yield was highest with K @ 150 kg ha^{-1} (11.550 t ha^{-1}). An increase in corm yield with an increase in the level of K from 50 to 150 kg ha^{-1} K_2O was observed. There was also significant difference between the 3 levels in affecting the corm yield. In the case of cormel yield, it was significantly higher (11.634 t ha^{-1}) with K @ 150 kg ha^{-1}. There was a significant difference between the K levels, with K @ 50 kg ha^{-1} recording the lowest (8.401 t ha^{-1}). An increase in cormel yield also was noticed with increase in K levels. The increase in tuber yield observed with increase in K application further confirms the role of K as the key nutrient in tuber crop production both in terms of tuber formation, tuber development and tuber bulking as reported by many workers (Nair and

Table 1. Interaction effect of Dolomite and K on corm and cormel yield

Level of Dolomite (t ha^{-1})	Corm yield (t ha^{-1})				Cormel yield (t ha^{-1})			
	Level of K (kg ha^{-1})			Mean	Level of K (kg ha^{-1})			Mean
	50	100	150		50	100	150	
0.5	5.234	8.332	8.085	7.217	6.901	9.571	9.530	8.667
1.0	6.111	9.923	12.535	9.523	8.382	9.925	11.703	10.003
1.5	7.191	10.308	12.757	10.085	8.715	9.365	12.438	10.173
2.0	8.783	11.364	12.821	10.989	9.604	11.941	12.863	11.469
Mean (K)	6.830	9.982	11.550		8.401	10.201	11.634	
CD (0.05) (K)	1.421				1.253			
CD (0.05) (D)	1.296				1.496			
CD (0.05) (D × K)	1.320				1.208			

Sadanandan, 1987; Susan John et al., 2013a; Nayar and Sadanandan, 1992; Imas and Susan John, 2013.

The interaction effect of K and dolomite was found to be significant in corm as well as cormel yields. Application of dolomite @ 2 t ha^{-1} along with K @ 150 kg ha^{-1} resulted in maximum corm yield of 12.82 t ha^{-1} which in turn was on par with the corm yield obtained with application of K @ 150 kg ha^{-1} along with dolomite @ 1.5 and 1.0 t ha^{-1}. This indicated that application of K @ 150 kg ha^{-1} along with dolomite @ 1.0 t ha^{-1} is sufficient for obtaining good corm yield in tannia. Wilken (1987) reported dolomite as the best liming material for tannia in soils having pH below 6.0, especially when Mg deficiency is reported. The interaction effect of levels of dolomite and K indicated that the highest cormel yield was obtained with K @ 150 kg ha^{-1} along with dolomite @ 2.0 t ha^{-1} (12.86 t ha^{-1}). This was found on par with the cormel yield obtained with K @ 150 kg ha^{-1} along with dolomite @ 1.5 t ha^{-1}(10.17 t ha^{-1}) and @ 1 t ha^{-1} (10.00 t ha^{-1}). Hence, it can be concluded that the dose of dolomite and K can be fixed as 1.0 t ha^{-1} and 150 kg ha^{-1} respectively for obtaining higher tuber yield of tannia (Table 1) (Susan John et al., 2013b).

Dry matter production

The total plant dry matter production comprised of the dry weight of the different plant parts of the crop *viz.,* leaf, corm and cormels. For lhe leaf dry matter production the parameters taken were single leaf fresh weight, number of leaves per plant and leaf dry weight percentage during three intervals *viz.,* 3MAP, 6MAP and at harvest. The corm and cormel fresh weight were taken at harvest and their dry matter percentage was determined. The leaf, corm and cormel dry weight percentages were not significantly influenced by either the levels of dolomite, levels of K or their interaction. Though there was not much variation in leaf, corm and cormel dry weight percentages under the influence of different levels of dolomite as well as different levels of K, substantial difference among leaf, corm and cormel dry matter percentage was observed. The mean leaf, corm and cormel dry matter percentage under different levels of dolomite and K were 13.78, 21.93 and 24.59%, respectively (Fig. 1). In tannia, Jayapal et al., (2021) reported a cormel dry matter percentage of 28.11% in the Alfisols of Kerala.

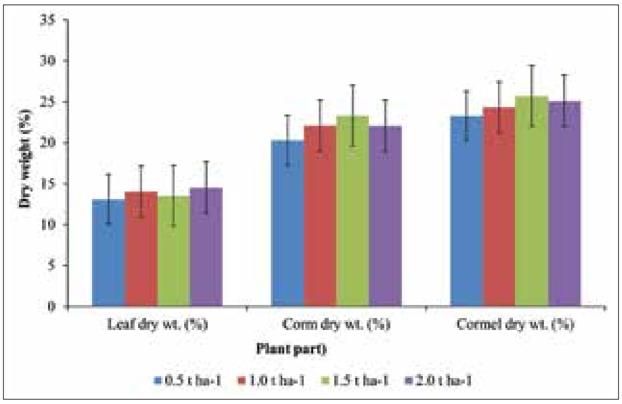

Fig. 1. Plant dry matter percentage under different levels of dolomite

In the case of leaf, corm and total plant dry matter production, significant effect of levels of dolomite was noticed. The leaf dry matter production was highest under dolomite @ 2 t ha^{-1}, but it was on par with 1 t ha^{-1} and 1.5 t ha^{-1}. Dolomite @ 0.5 t ha^{-1} resulted in significantly lower leaf dry matter. The same trend was noticed in the case of corm and total dry matter production. The mean leaf, corm and cormel dry matter production under different levels of dolomite and K were 1.641, 2.085, 2.484 and 6.210 t ha^{-1}, respectively (Table 2). The effect of higher levels of dolomite and K on the dry matter contents of different plant parts of tannia and hence on total plant dry matter corroborates to the reports of Jayarama and D' Souza in coffee (2012) and Radhakrishnan and Mohankumar in tea (2012) that the wholistic effect of combined application of higher quantities of organic manures and dolomite in ameliorating the soil acidity to create a favourable soil environment which in turn can increase the plant response to application of other nutrients. Jayapal et al., (2021) reported a cormel dry matter content of 3.37 t ha^{-1} under INM in tannia in the red soils of Kerala.

Table 2. Effect of levels of dolomite on plant dry matter production

Level of dolomite	Leaf dry matter	Corm dry matter	Cormel dry matter	Total plant dry matter
	t ha^{-1}			
0.5	0.963	1.464	2.016	4.442
1	1.798	2.102	2.433	6.333
1.5	1.797	2.35	2.613	6.76
2	2.006	2.423	2.874	7.303
Mean	1.641	2.085	2.484	6.210
CD (0.05)	0.213	0.421	NS	1.257

Levels of K significantly influenced the corm, cormel and total plant dry matter production. As in the case of levels of dolomite, K @ 150 kg ha^{-1} resulted in the highest corm, cormel and total plant dry matter which was on par with K @ 100 kg ha^{-1}. K @50 kg ha^{-1} resulted in significantly the lowest of these values. The mean leaf, corm and cormel dry matter production was 1.51, 2.09 and 2.49 t ha^{-1} respectively under different levels of K (Table 3). The interaction effect was not significant in the case leaf, corm, cormel and total plant dry matter production. The response of higher levels of K in tannia was already reported by Milan-Morales et al., (1992) where in for the traditional areas of tannia cultivation in parts of Pacific islands he reported a K_2O recommendation of 285 kg ha^{-1} for better yield and plant growth. In Kerala, Pushpakumari et al., (1999) reported the K recommendation of 125 kg ha^{-1} K_2O for tannia.

Table 3. Effect of levels of K on plant dry matter production

Level of K	Leaf dry matter	Corm dry matter	Cormel dry matter	Total plant dry matter
	t ha^{-1}			
50	1.291	1.429	1.962	4.682
100	1.51	2.215	2.559	6.284
150	1.729	2.618	2.943	7.291
Mean	1.51	2.09	2.49	6.09
CD (0.05)	NS	0.315	0.324	0.963

Plant nutrient contents

The independent and interaction effect of levels of dolomite and K on the contents of N, P, K, Ca, Mg and Mn in different parts of the plant *viz.,* leaf, corm and cormel did not show any significant effect. Orji and Mbah (2022) found that the nutrient content in the different plant parts of tannia are not affected by fertilizer application. However, a drastic variation in the content of these nutrients was observed among different plant parts (Fig. 2).

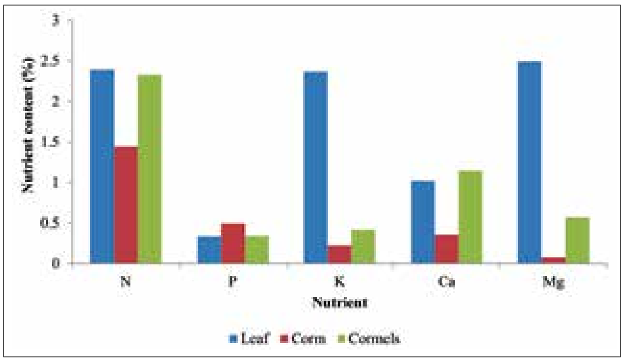

Fig. 2. Variation in the nutrient content (%) of different parts of tannia

The mean values are 2.40, 1.446, 2.334% N, 0.334, 0.493, 0.333% P, 2.37, 0.226, 0.419% K, 1.017, 0.356, 1.141% Ca, 2.49, 0.079, 0.565% Mg, and 147.5, 31.92, 40.83 ppm Mn in leaves, corm, and cormels, respectively. It was observed that N, K and Mg are high in leaves, P in corms and Ca in cormels. Orji and Mbah (2022) reported consistently and significantly higher N in leaves than petiole and corms, P in petiole than in leaves and corms, K in leaves than petiole and corm, Ca in leaf and petiole than corm, Mg in petiole than corm and leaf. The content of Mn did not show much variation among the three different plant parts. Chandler et al., (1982) reported an N, P, K, and Ca content of 3.2, 0.25, 2.3 and 1.3% in the leaf lamina of well fertilized tannia plant. In taro grown in the laterite soils of Kerala, Kabeerathumma et al., (1987) reported nutrient contents to the tune of 3.26%, 1.66 and 1.50 % N, 0.46, 0.33, 0.29 % P, 2.60, 3.60, 1.50% K, 0.91, 0.71, 0.32% Ca, 0.49, 0.32, 0.18% Mg and 556, 350 and 92 ppm in leaves, petiole and tuber, respectively.

Total plant nutrient uptake

The total uptake of nutrients mentioned above was calculated independently for the three different plant parts and by summing up of the leaf, corm and cormel uptake, the total uptake of the plant was determined. Statistical analysis of the data revealed significant effects of levels of dolomite and levels of K on the uptake of all nutrients. The uptake was on par for dolomite application @ 2.0, 1.5 and 1.0 t ha^{-1}, and 0.5 t ha^{-1} dolomite resulted in significantly lower uptake for all these nutrients. However, for N, K, Mg and Mn, dolomite @ 2 t ha^{-1} resulted in highest uptake and for the other two nutrients *viz.,* P and Ca, the uptake was highest at 1.5 t ha^{-1} dolomite application (Table 4). The mean uptakes of N, P, K, Ca, Mg and Mn were 261.38, 72.22, 105.03, 78.19, 92.33 and 0.84 kg ha^{-1}, respectively. Jayapal et al., (2020) reported an N, P, K uptake of 54.75, 10.33 and 113.45 kg ha^{-1} under INM in the red soils of southern Kerala.

Table 4. Effect of dolomite on total plant nutrient uptake

Level of dolomite (t ha^{-1})	Uptake of nutrients (kg ha^{-1})					
	N	P	K	Ca	Mg	Mn
0.5	119.97	35.16	60.61	38.88	51.17	0.56
1.0	295.95	92.74	115.55	85.99	98.22	0.97
1.5	284.60	94.90	115.31	94.20	102.09	0.82
2.0	345.01	66.09	128.66	93.69	117.84	0.99
Mean	261.38	72.22	105.03	78.19	92.33	0.84
CD (0.05)	168.03	32.08	56.24	48.12	48.39	0.29

The K uptake was significantly influenced by levels of K with K @150 kg ha^{-1} resulting in the highest uptake, which was on par with 100 kg ha^{-1}. However, K @ 50 kg ha^{-1} caused significantly lower uptake of all the nutrients. The mean uptakes were 161.28, 28.55, 86.93, 66.63, 91.10 and 0.86 kg ha^{-1} for N, P, K, Ca, Mg and Mn, respectively (Table 5). In taro, Kabeerathumma et al., (1987) reported higher utilization of K compared to N and K during all stages of growth indicating a higher requirement of K by the crop and reported an uptake of 100, 29, 145, 40 and 18 kg ha^{-1} for N, P, K, Mg, Ca respectively.

Table 5. Effect of K on total plant nutrient uptake

Level of K_2O (kg ha^{-1})	Uptake (kg ha^{-1})					
	N	P	K	Ca	Mg	Mn
50	125.97	22.56	70.92	52.91	75.56	0.67
100	162.03	28.98	87.24	67.53	91.68	0.89
150	195.85	34.11	102.62	79.46	106.05	1.01
Mean	161.28	28.55	86.93	66.63	91.10	0.86
CD (0.05)	34.29	7.13	16.38	12.58	16.96	0.24

Soil chemical properties

Both the initial nutrient status and the post harvest soil nutrient status were analyzed to study the effect of tannia cultivation on soil chemical properties. The initial soil characters of the experimental plot were as given below. pH: 5.54, Organic carbon: 0.77%, Available N: 147 kg ha^{-1}, Available P: 69 kg ha^{-1}, Exchangeable K: 489 kg ha^{-1}, Exchangeable Ca: 2.58 meq 100g^{-1}, Exchangeable Mg: 2.17 meq 100 g^{-1}, Available Mn: 21.26 ppm. Statistical analysis of the post-harvest soil samples indicated significant effect of levels of dolomite on soil pH, exchangeable Ca and Mg. Increase of the above parameters was noticed with increase in the level of application of dolomite. Dolomite @ 2 t ha^{-1} caused significantly higher pH and hence on both exchangeable soil Ca and Mg. The effect of application of dolomite was significant with an application rate of 1.5 and 2 t ha^{-1} compared to the other two levels. The increase between the levels of 0.5 and 1, 1 and 1.5 and 1.5 and 2 t ha^{-1} were not significant. Salas et al., (1996) found an increase in pH with concomitant increase in exchangeable Ca and Mg with the application of dolomite in tannia. In the case of exchangeable Ca and Mg also, an increase in their status was seen with an increase in the rate of application of dolomite with Ca and Mg recording to the tune of 2.12 and 1.765 meq 100 g^{-1} respectively. The highest status was seen with dolomite @ 2 t ha^{-1}, which in turn was significantly higher than 0.5 and 1.0 t ha^{-1} dolomite application in the case of exchangeable Ca. Significant difference between the four levels were noticed in the case of exchangeable Mg (Table 6). Over the initial status, slight to moderate decline was seen for all nutrients except N, P and Mn, which in turn was almost maintained on par with the initial level. The substantially higher Mn content in soil associated with application of dolomite is in accordance to the reports of Merino- Gergichevich et al., (2010) stating that in extremely acidic soils having pH below 4.8, there is the presence of toxic concentrations of Mn.

Table 6. Effect of dolomite on post-harvest soil chemical properties

Level of dolomite (t ha^{-1})	pH	N	P	K	Ca	Mg	Mn
		(kg ha^{-1})			(meq 100 g^{-1})		$\mu g\ g^{-1}$
0.5	4.96	132.7	63.6	278.8	1.16	0.933	15.3
1	5.19	153.3	56	267	1.51	1.24	20.7
1.5	5.33	157.3	62.3	262.8	1.78	1.593	19.9
2	5.43	157.8	61.8	258.2	2.12	1.765	19.4
CD (0.05)	0.266	NS*	NS	NS	0.394	0.065	NS

*Not significant

The level of K significantly influenced only pH and K of the soil. The pH was significantly higher with K @ 150 kg ha^{-1}, while the other two levels *viz.,* 50 and 100 kg ha^{-1} were on par. But in the case of K, an increase in available K status of the soil was observed with an increase in the rate of K application. The difference was significant between the three rates *viz.,* 50, 100 and

150 kg ha^{-1} (Table 7). Jayapal et al., (2020) reported no significant increase in pH due to INM compared to organic nutrition. However, build up of K was noticed over initial K status.

The interaction effect of levels of dolomite and K levels was found significant in the case of pH and Mn. In the case of pH, both the levels of K, levels of dolomite and their interaction were found significant. The highest pH of 5.50 was observed with K @ 150 kg ha^{-1} along with dolomite @ 2 t ha^{-1} which in turn was on par with dolomite @ 1.5 t ha^{-1} along with K @ 100 and 150 kg ha^{-1} and dolomite @ 2 t ha^{-1} along with K @ 50 and 100 kg ha^{-1}. However, the data indicated comparatively lower pH values with lower levels of dolomite as 0.5 and 1.0 t ha^{-1} even with higher doses of K as 100 and 150 kg ha^{-1}.

Table 7. Effect of levels of K on post harvest soil chemical properties

Level of K (kg ha^{-1})	pH	N	P	K	Ca	Mg	Mn
		(kg ha^{-1})			(meq 100 g^{-1})		(μg g^{-1})
50	5.22	146.6	61.0	253.6	1.614	1.34	17.79
100	5.18	150.9	58.3	266.3	1.617	1.38	20.25
150	5.28	153.3	63.4	280.2	1.687	1.43	18.44
CD (0.05)	0.05	NS*	NS*	11.49	NS*	NS*	NS*

*Not significant

The Mn status of the soil was significant with 2 t ha^{-1} dolomite along with K @ 150 kg ha^{-1}, recording the highest soil Mn content of 26.70 ppm. But no definite trend was observed with respect to the application of both these inputs on Mn status of the soil. The increased Mn content observed could be attributed to the presence of Mn as impurity in both the amendments/fertilizers (dolomite and MOP) used. (Table 8).

Conclusion

Among the tropical tuber crops, tannia is one of the most remunerative crops, as it is a best intercrop in plantations and fetches good price in the markets especially in the southern states of Kerala. Compared to other tropical tuber crops, the tubers are more palatable, and the leaves are known as a good leafy vegetable due to the presence of significant amounts of phytochemicals especially protein and minerals. This crop is seasonal and very sensitive to soil conditions, especially soil acidity. The present paper described the effect of the integrated nutrient management practices evolved for this crop with emphasis on standardizing the rates of the soil ameliorant, dolomite and the most significant nutrient potassium on various plant and soil attributes. Among the four levels of dolomite and three levels of K tested, dolomite @ 1 t ha^{-1} and K_2O @ 150 kg ha^{-1} were evolved as the most economic treatments which resulted in the highest corm and cormel yields of 12.535 and 11.703 t ha^{-1}, respectively. Though the INM did not cause any remarkable effect on plant nutrient contents, the study revealed the percentage nutrient contents in the leaf, corm and cormels and established the superiority of tannia leaves as one of the best leafy vegetables, rich in protein and minerals especially N, K, Ca and Mg. With respect to the dry matter production and uptake of nutrients, the above standardized levels of dolomite and K were found better. The effect of higher levels of application of dolomite and potassium too was studied on the post harvest soil properties especially in enhancing the pH, K, Ca and Mg. Taking into account all these factors, it was very well understood that tannia is a unique crop among the tropical tuber crops that need specific soil

Table 8. Interaction effect of dolomite and K on soil chemical parameters

Level of dolomite (t ha^{-1})	Level of K (kg ha^{-1}) pH			Mean	Level of K (kg ha^{-1}) Mn (ppm)			Mean
	50	100	150		50	100	150	
0.5	5.07	4.82	4.99	4.96	13.55	16.25	16.10	15.30
1.0	5.18	5.16	5.22	5.19	21.85	24.50	15.75	20.70
1.5	5.21	5.36	5.41	5.33	19.75	24.75	15.20	19.90
2.0	5.42	5.39	5.50	5.43	16.00	15.50	26.70	19.40
Mean (K)	5.22	5.18	5.28		17.79	20.25	18.44	
CD (0.05) (K)	0.050				NS			
CD (0.05) (D)	0.266				NS			
CD (0.05) (D×K)	0.249				7.213			

fertility management for good crop growth and better tuber yield.

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