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Effect of Soil Amendments and Nutrient Management on Growth and Growth Attributes of Tannia (*Xanthosoma sagittifolium* (L.) Schott) in the South-Central Laterites (AEU 9) of Kerala, India

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Authors' contributions

This work was carried out in collaboration among all authors. Author KSS did the conceptualization, methodology, formal analysis, draft the original data, performed the statistical analysis, wrote the first draft of manuscript, wrote the protocol. Author PPS did the conceptualization, methodology, literature searches, data validation, project administration and supervised the study. All authors read and approved the final manuscript.

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ABSTRACT

The study was conducted to assess the effect of soil amendments and nutrient management on growth and growth attributes of tannia during the period from Feb-Dec 2021 in a farmer's field (AEU 9) at Kollam district. The experiment was laid out in RCBD with 13 treatments (4 x 3 + 1) and three replications. The treatments included soil amendments [a_1: Dolomite (80 g plant^{-1}), a_2: Phosphogypsum (50 g plant^{-1}), a_3: Compost (1kg plant^{-1}) + dolomite, and a_4 : Compost (1kg plant^{-1}) + phosphogypsum] and nutrient management [n_1: RDN + borax (10 kg ha^{-1}) at 4 MAP + solubor (0.1%) at 5, 6 and 7 MAP, n_2: RDN + $ZnSO_4$ (20 kg ha^{-1}) at 4 MAP + $ZnSO_4$ (1%) at 5, 6 and 7 MAP and n_3: RDN + borax (10 kg ha^{-1}) + $ZnSO_4$ (20 kg ha^{-1}) at 4 MAP + solubor (0.1%) + $ZnSO_4$ (1%) at 5,6 and 7 MAP] and control (KAU POP). The soil was sandy loam in texture, strongly acidic in reaction (surface soil-5.45 and sub soil-5.05). Cormel pieces (100 g) of local variety planted with a spacing of 90 x 90 cm. The plant height and number of leaves per plant increased up to 6 MAP, and after that it declined in all the treatments up to harvest. The treatment a_4 and n_3 resulted in the tallest plants (114.37 cm and 100.06 cm) with more number of leaves per plant (8.34 and 7.20) at 6 MAP. The treatment combination a_4n_3 recorded higher dry matter production (4.92 t ha^{-1}) which was on par with a_4n_2, a_3n_3, and a_4n_1 and found superior to KAU POP. Subsoil acidity is the most chemical impediment in tuber development. Therefore, improving acidic soil with the right amendments and nutrients was essential for tannia's growth and development.

Keywords: Soil amendments; subsoil acidity; dolomite; phosphogypsum; dry matter production.

1. INTRODUCTION

Tuber crops are typically grown in marginal lands with low native soil fertility [1] mainly in lateritic soils (acidic ultisols) of india. Tannia prefers warm humid climate with high rainfall, it can also adapt to areas receiving 100 cm to 200 cm rainfall [2]. The temperature range of 20°C to 35°C and a pH range of 5.5 to 6.5 is suitable for growing tannia [3]. Subsoil acidity has been identified as a significant yield limiting factor in hot, humid, tropical climate regions [4, 5, 6]. It is the acidification below the plough layer, usually below 20 cm due to the presence of H^+ and Al^{3+} and restricted Ca. Thus, the two main factors impeding crop growth in acid soil were the toxicity of Al and lack of Ca. Acid soils frequently exhibits poor root penetration and multiplication, as shown by [7,8]. By attaching to the phosphate section of DNA in the nuclei of the root cells, trivalent aluminium in acid soil impeded the growth of the roots by reducing the activity of the template and cell division [9]. Acidity in subsurface soil is largely caused by plant roots generating acid due to excessive cation uptake during nutritional requirements [10].

The acidity of surface soil is typically reduced by liming. Whereas, reducing the acidity of subsurface soil is extremely challenging as the lime moves slowly through soil profiles. This necessitates application of high rates of lime as top dressing to improve the subsoil [11]. It may also negatively impact other crops in the rotation [12] or result in nutrient deficiencies. It was found to be impractical to apply lime deep into the soil. Therefore, an alternative for lime with improved mobility could be a feasible option [13-17]. Dolomite was identified as the most suitable soil amendment for the Ultisols of Kerala because of its good response in tannia growing soils [18]. The problem was resolved, and crop output and vegetative growth were enhanced by standardising the application rate at 1 t ha^{-1} or 80 g plant^{-1} [19]. Similarly for phosphogypsum applications, the pH of the soil in the dark red latosol was found to rise by 0.8 units [20] and raised the soils capacity for cation exchange [21]. Phosphogypsum is cheap and widely available industrial byproduct, hence lime could be easily replaced with phosphogypsum [22,23]. Likewise, nutrient management also play a vital role in improving the growth and yield of tannia. As the crops are more productive, there is a significant amount of nutrient loss from the soil due to their high nutrient uptake [24]. Hence to improve the growth of tannia, proper nutrient management and soil acidity correction is inevitable to stabilise the crop cultivation.

2. MATERIALS AND METHODS

The study was conducted in a farmer's field at Ambalathumkala in Kollam district which is situated at 9.02°N latitude and 76.7°E longitude at an altitude of 57 m above mean sea level. This area comes under South Central Laterites (AEU 9). The field experiment was conducted during the period from February to December 2021. The objective was to analyse the effect of soil amendments and nutrient management on growth attributes and growth of tannia.

The field experiment, laid out in RCBD comprised 13 treatments (4 x 3 + 1), replicated thrice. The treatments consisted of combinations of four soil amendments [a_1: Dolomite, a_2: Phosphogypsum, a_3: Compost + dolomite, and a_4 : Compost + phosphogypsum] and three nutrient management practices [n_1: Recommended dose of nutrients (RDN) + borax (10 kg ha^{-1}) at 4 MAP + solubor (0.1%) at 5, 6 and 7 MAP, n_2: RDN + $ZnSO_4$ (20 kg ha^{-1}) at 4 MAP + $ZnSO_4$ (1%) at 5, 6 and 7 MAP and n_3: RDN + borax (10 kg ha^{-1}) + $ZnSO_4$ (20 kg ha^{-1}) at 4 MAP + solubor (0.1%) + $ZnSO_4$ (1%) at 5,6 and 7 MAP] and control (Kerala Agricultural University Package of Practices - KAU POP). The soil of the experimental site was sandy loam in texture, strongly acidic in reaction (surface soil with a pH of 5.45 and sub soil with a pH of 5.05), A local variety procured from the farmer's field was used for the study. Cormel pieces weighing 100 g each were planted at a spacing of 90 cm x 90 cm. Dolomite (80 g $plant^{-1}$) and phosphogypsum was applied 20 days before planting. The requirement of phosphogypsum, was computed as 46.77 g $plant^{-1}$ (rounded off to 50 g $plant^{-1}$) based the lime requirement of the soil. Compost (1kg $plant^{-1}$) was applied as basal before planting. The RDN (N, P, K) was supplied as Urea (46 per cent N), Rajphos (20 per cent P_2O_5) and Muriate of potash (60 per cent K_2O) respectively at the rate of 80:50:150 kg NPK ha^{-1} was given equally to all treatments as per KAU POP [2]. The entire dose of P and FYM (25 t ha^{-1}) were applied as basal, whereas N and K were given as split doses at 2 MAP, 4 MAP, and 6 MAP. Green manure cowpea (sown at 20 kg ha^{-1}), biofertilizer (*Azotobacter chroococcum*) at the rate of 10 g per plant, neem cake (375 kg ha^{-1}), and green leaf mulching (*Glyricidia sepium*) at 15 t ha^{-1} were also applied in each treatment. Timely operations of earthing up and weeding were also carried out after fertilizer applications. The crop was harvested at the 10 months of age when all the leaves showed yellowing and drying.

3. RESULTS AND DISCUSSION

3.1 Growth and Growth Attributes

Plant height and number of leaves were observed at monthly interval from 5 MAP up to harvest. Total dry matter production during harvest was also recorded.

3.1.1 Plant height

Soil amendments, nutrient management and their interaction had significant effect on the plant height of tannia at all stages of observation (Table 1).

Plant height was observed to increase up to 6 MAP and then decreased in all the treatments till harvest. Application of compost and phosphogypsum (a_4) recorded taller plants at 5 MAP (97.00 cm), 6 MAP (114.37 cm), 7 MAP (112.71 cm), 8 MAP (94.57 cm), and harvest (83.33 cm). Shorter plants were observed in treatments without compost. At 6 MAP, the effect of a_3 (compost + phosphogypsum) was 34.33 per cent greater than that of a_1 (dolomite) in terms of plant height. Similarly, compared to a_2, a_4 resulted in 28.74 per cent taller plants. Among the three nutrient management treatments, application of RDN + borax (10 kg ha^{-1}) + $ZnSO_4$ (20 kg ha^{-1}) at 4 MAP + solubor (0.1%) + ZnSO4 (1%) at 5, 6 and 7 MAP (n_3) resulted in taller plants at all stages of observation followed by n_2 and n_1. Considering the interaction effect of soil amendments and nutrient management (A × N) on plant height of tannia, the treatment combination a_4n_3 recorded the tallest plants (102.70 cm) among the treatments followed by a_4n_2 and a_4n_1, at 5 MAP. While comparing treatments against control (KAU POP), the treatment combination a_4n_3 was superior to control with respect to plant height at all growth stages, except at 8 MAP and harvest.

Plant height was observed to increase up to 6 MAP and later it decreased. Similar findings have been reported in taro, which exhibited a grand growth period up to 20- 24 weeks and thereafter declined [25]. The photosynthates produced are mostly used to produce corm and cormels afterwards, thus the plant height decreased after 180 DAS [26]. Dolomite and phosphogypsum performed well along with compost application. Compost might have provoded an alkaline condition in the soil as it supplied additional Ca and increased the soil pH and made the soil condition ideal for crop growth [27].

3.1.2 Number of leaves per plant

Irrespective of treatments, the number of leaves per plant increased up to 6 MAP and declined later till harvest. Soil amendments and nutrient management had a significant effect on the number of leaves per plant at 5 MAP, 6 MAP, 7 MAP, 8 MAP and at harvest (Fig. 1). Application of compost + phosphogypsum (a_4) recorded the highest number of leaves at all stages of observation. It was followed by a_3, a_2 and a_1. At 6 MAP, a_3 and a_4 produced 2.81 and 3.07 times more number of leaves per plant than a_1 and a_2. In the case of nutrient management, n_3 [RDN + borax (10 kg ha^{-1}) + $ZnSO_4$ (20 kg ha^{-1}) at 4 MAP + solubor (0.1%) + $ZnSO_4$ (1%) at 5, 6 and 7 MAP] recorded more number of leaves at all stages of observation. The interaction effect (A x N) on number of leaves per plant was observed to be significant at all stages except at 6 MAP (Table 2).

The treatment combination a_4n_3 recorded more number of leaves per plant at 5 MAP (8.00), 7 MAP (8.30), 8 MAP (7.93) and at harvest, (5.81). The treatment combinations a_4n_2 and a_4n_3 were observed to be superior to control and a_4n_1, a_3n_3 and a_3n_2 were found to be at par with control. The decline in leaf number after 6 MAP was in conformity with the findings of [28] and reduction in leaf number up to harvest might be due to the drying out of the existing leaves. Application of phosphogypsum along with compost resulted in more number of leaves. Considering the strongly acidic soil of the experimental site, phosphogypsum might have ameliorated the soil acidity and increased the soil pH, and thereby promoted the growth of tannia as suggested by [21].

Table 1. Effect of soil amendments, nutrient management, and its interaction on plant height of tannia, cm

Treatment	Plant height				
Soil amendments (A)	**5 MAP**	**6 MAP**	**7 MAP**	**8 MAP**	**Harvest**
a_1 – dolomite	42.22^{d}	74.93^{d}	73.32^{d}	52.94^{d}	37.83^{d}
a_2 – phosphogypsum	68.78^{c}	88.84^{c}	84.57^{c}	58.98^{c}	47.17^{c}
a_3 - compost + dolomite	76.98^{b}	100.65^{b}	98.07^{b}	84.08^{b}	76.13^{b}
a_4 - compost + phosphogypsum	97.00^{a}	114.37^{a}	112.71^{a}	94.57^{a}	83.33^{a}
SEm (±)	0.50	0.47	0.61	0.79	0.93
CD (0.05)	1.471	1.391	1.791	2.32	2.723
Nutrient management (N)					
n_1 - RDN + borax (10 kg ha^{-1}) at 4 MAP + solubor (0.1%) at 5,6 and 7 MAP	64.42^{c}	90.15^{c}	87.01^{c}	65.87^{c}	53.78^{c}
n_2 - RDN + $ZnSO_4$ (20 kg ha^{-1}) at 4 MAP + $ZnSO_4$ (1%) at 5, 6 and 7 MAP	69.47^{b}	93.89^{b}	92.49^{b}	73.67^{b}	61.17^{b}
n_3 - RDN + borax (10 kg ha^{-1}) + $ZnSO_4$ (20 kg ha^{-1}) at 4 MAP + solubor (0.1%) + $ZnSO_4$ (1%) at 5,6 and 7 MAP	79.84^{a}	100.06^{a}	97.01^{a}	78.39^{a}	68.41^{a}
SEm (±)	0.43	0.41	0.53	0.69	0.80
CD (0.05)	1.274	1.205	1.551	2.009	2.358
Soil amendment (A) x Nutrient management (N)					
a_1n_1	40.67^{j}	73.00^{i}	70.33^{h}	51.44^{i}	32.63^{e}
a_1n_2	41.33^{j}	74.00^{i}	73.48^{g}	52.00^{i}	37.52^{f}
a_1n_3	44.67^{i}	77.80^{h}	76.15^{g}	55.37^{h}	43.33^{e}
a_2n_1	56.33^{h}	80.35^{g}	74.10^{g}	50.40^{g}	38.04^{e}
a_2n_2	60.00^{g}	86.88^{f}	85.26^{f}	61.03^{g}	49.15^{d}
a_2n_3	90.00^{c}	99.30^{d}	94.33^{e}	65.51^{f}	54.33^{d}
a_3n_1	70.00^{f}	95.23^{e}	93.30^{e}	75.57^{e}	65.44^{cd}
a_3n_2	78.93^{e}	99.59^{d}	97.66^{d}	85.33^{d}	75.33^{c}
a_3n_3	82.00^{d}	107.14^{c}	103.26^{c}	91.33^{c}	87.63^{ab}
a_4n_1	90.67^{c}	112.03^{b}	110.29^{b}	86.04^{d}	79.00^{b}
a_4n_2	97.62^{b}	115.07^{a}	113.57^{a}	96.33^{b}	82.67^{ab}
a_4n_3	102.70^{a}	116.00^{a}	114.28^{a}	101.33^{a}	88.33^{a}
SEm (±)	0.87	0.82	1.06	1.37	1.61
CD (0.05)	2.548	2.41	3.102	4.018	4.716
Control (KAU POP)	82.40	107.48	98.30	70.48	70.48
Treatment *vs* Control	S	S	S	NS	NS

S - Significant; NS - Not Significant

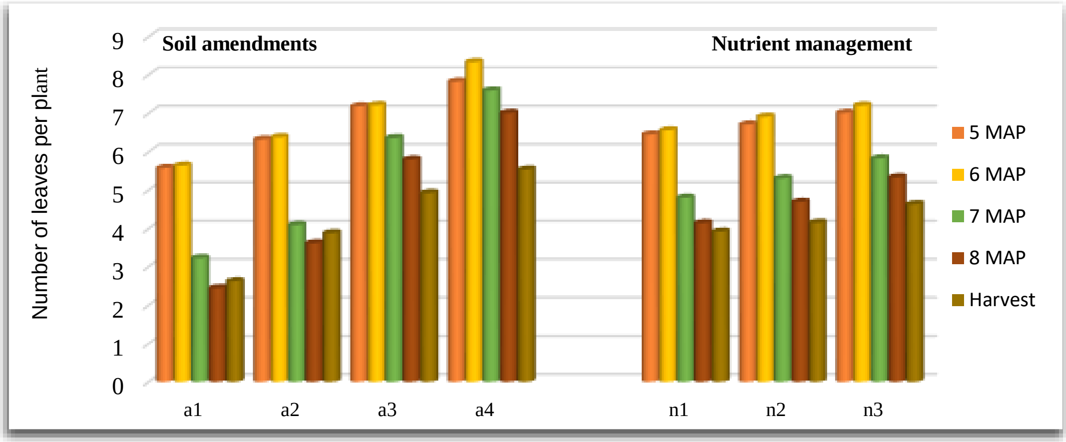

Fig. 1. Effect of soil amendments and nutrient management on number of leaves per plant

Table 2. Effect of A x N interaction on number of leaves per plant in tannia

Treatment	Number of leaves per plant				
	Soil amendment (A) x Nutrient management (N)				
a_1n_1	5.25^{i}	5.30	3.08^{h}	2.15^{i}	2.84^{e}
a_1n_2	5.57^{h}	5.59	3.25^{h}	2.25^{i}	2.12^{f}
a_1n_3	5.88^{g}	6.01	3.33^{h}	2.92^{h}	2.90^{e}
a_2n_1	6.01^{g}	6.14	3.85^{g}	3.48^{fg}	3.17^{e}
a_2n_2	6.29^{f}	6.34	3.92^{g}	3.44^{g}	4.18^{d}
a_2n_3	6.65^{e}	6.67	4.52^{f}	3.95^{f}	4.27^{d}
a_3n_1	6.78^{e}	6.80	5.61^{e}	5.12^{e}	4.48^{cd}
a_3n_2	7.28^{d}	7.31	6.26^{d}	5.77^{d}	4.74^{c}
a_3n_3	7.49^{cd}	7.53	7.19^{c}	6.50^{c}	5.53^{ab}
a_4n_1	7.76^{b}	8.01	6.69^{d}	5.80^{d}	5.20^{b}
a_4n_2	7.70^{bc}	8.42	7.78^{b}	7.28^{b}	5.57^{ab}
a_4n_3	8.00^{a}	8.60	8.30^{a}	7.93^{a}	5.81^{a}
SEm (±)	0.08	0.10	0.16	0.17	0.14
CD (0.05)	0.223	NS	0.462	0.506	0.402
Control (KAU POP)	6.60	7.57	5.11	4.50	4.05
Treatment *vs* Control	NS	S	NS	NS	NS

S - Significant; NS - Not Significant

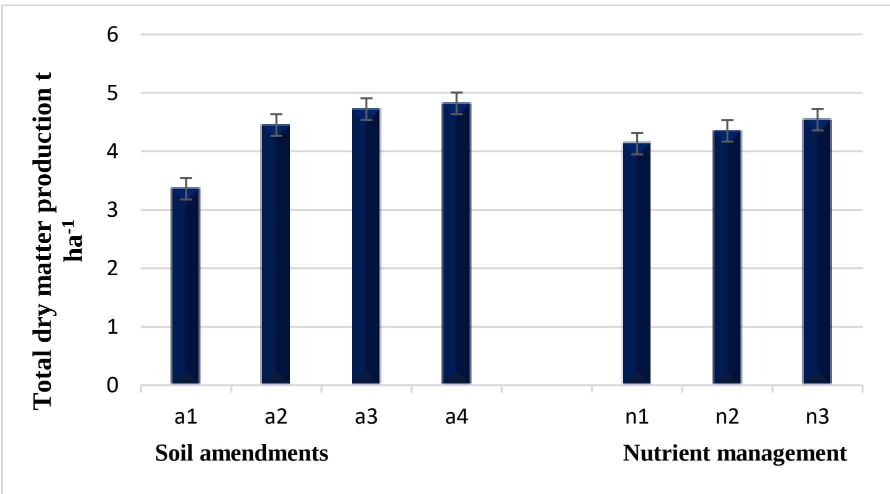

Fig. 2. Effect of soil amendments and nutrient management on total dry matter production t ha^{-1}

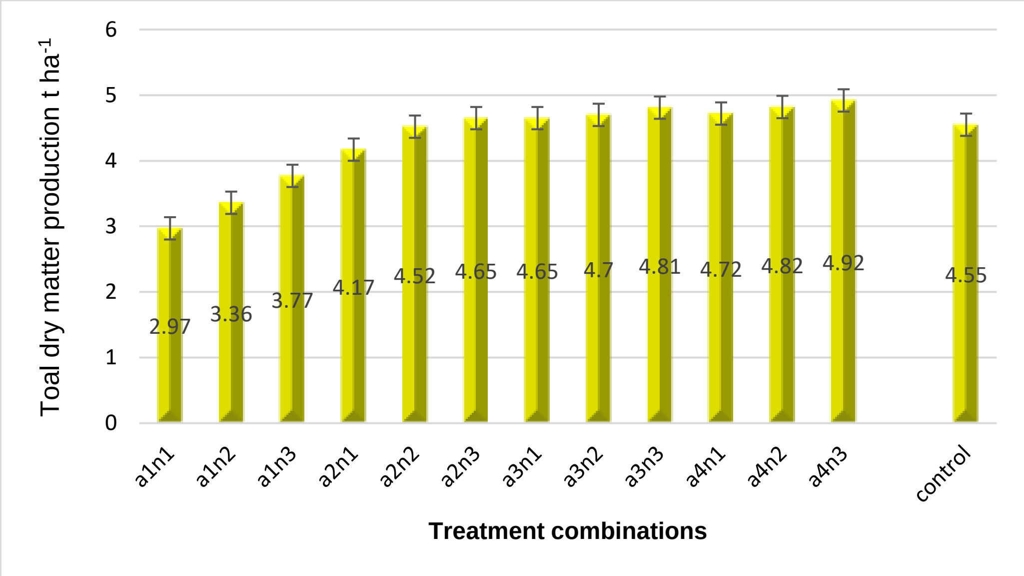

Fig. 3. Effect of A x N interaction on total dry matter production t ha^{-1}

3.1.3 Total dry matter production

Significant difference was noticed in dry matter production in response to soil amendments and nutrient management and its interaction (Fig. 2). The total dry matter production at harvest was observed to be higher (4.82 t ha^{-1}) in a_4 (compost + phosphogypsum) and was on a par with a_3 (compost + dolomite) (4.72 t ha^{-1}), followed by a_2 and a_1. In the case of nutrient management, n_3 recorded the highest dry matter production (4.54 t ha^{-1}) followed by n_2 (4.35 t ha^{-1}) and n_1 (4.13 t ha^{-1}).

The treatment combination, a_4n_3 recorded higher dry matter production (4.92 t ha^{-1}) which was on par with a_4n_2 (4.82 t ha^{-1}), a_3n_3 (4.81 t ha^{-1}) and a_4n_1 (4.72 t ha^{-1}) (Fig. 3). The treatment combination a_4n_3 proved superior over control. Other treatments *viz*., a_2n_2, a_2n_3, a_3n_1, a_3n_2, a_3n_3, a_4n_1, and a_4n_2 were at par with KAU POP.

The soil amendment, phosphogypsum performed well over dolomite in acidic soil conditions as the mobility of Ca ion in phosphogypsum might have been rapid compared to dolomite. This might have afforded a better amelioration of soil acidity. Hence the dry matter accumulation was higher in plants supplied with phosphogypsum [16]. In the case of nutrient management, combination of Zn and B recorded the highest dry matter production. This could be attributed to the synergistic effect of Zn and B in the uptake of nutrients as reported by [29] which in turn increased the dry matter production than the application of Zn and B in isolation. The combination of these treatments showed its superiority in total dry matter production to other treatments and control [30].

4. CONCLUSION

Combination of compost along with soil amendments recorded better growth in tannia. Plant height and number of leaves generally increased up to 6 MAP in tannia and later it decreased. Application of phosphogypsum as soil amendment was observed to improve the growth of tannia than dolomite. Compost and phosphogypsum along with Zn and B, both as soil and foliar application resulted in better growth of tannia in the South-Central Laterites of Kerala. Thus, application of suitable soil amendments to ameliorate acidity is very important for a good crop growth condition. Supplementing micronutrients along with balanced fertilization at right time and right method recommended by Kerala Agricultural University to tannia growing laterite soil is crucial in correcting multi nutrient deficiencies coupled with acidity.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Nair KM, Kumar KSA, Srinivas S, Koyal A, Parvathy S, Sujatha K, Thamban C, Mathew J, Chandran, KP, Haris A, Krishnakumar, V, and Srinivasan, V. Surface soil and subsoil acidity in natural and managed land-use systems in the humid tropics of peninsular Ind. Curr. Sci. 2019;116(7):1201-1211.
2. KAU [Kerala Agricultural University]. Package of Practices Recommendations: *Crops* (15th Ed.). Kerala Agricultural University, Thrissur. 2016;393.
3. Lopez M, Vasquez E, Lopez F. Raices y tuberculos. Pueblo y Educacion, Universidad Central de Las Villas, Cuba. 1995;312.
4. Adams F, Moore, BL, Chemical factors affecting root growth in subsoil horizons of coastal plain soils. Soil Science Society of America Journal. 1983;47(1):99-102.
5. McKenzie RC, Nyborg M, Influence of subsoil acidity on root development and crop growth in soils of Alberta and northeastern British Columbia. Canadian Journal of Soil Science.1984;64(4)681-697.
6. Farina MDW, Channon P. Acid subsoil amelioration II. Gypsum effects on growth and subsoil chemical properties. Soil Sci. Soc. Am. J. 1988;54:993-998.
7. Sharma UC, Singh RP. Acid soils of India: their distribution, management, and future strategies for higher productivity. Fertiliser News. 2002;47(3), pp.45-52.
8. Vizcayno C, Gonzalez GTM, Marcole FY, Santano J. Extractable forms of aluminium as affected by gypsum and lime amendments to an acid soil. Coinmun. Soil Sci. PI. Anal. 2001;32:2279-2292.
9. Matsumoto H, Morimura S. Repressed [emplate activity of chromatin of pea roots treated with aluminium. PI. Cell Physiol. 1980;21:951-959.
10. Tang C. Causes and management of subsoil acidity. December 2004; In SuperSoil: 3rd Australian New Zealand Soils Conference.
11. Whitten M. Subsurface acidification: estimating lime requirements from lime dissolution rates in the field. In 'Proceedings of the fourth triennial Western Australian soil science conference'. (Ed DR Williamson). (Australian Society of Soil Science Inc. (WA Branch): Perth). 1997;128-131.
12. McLay CDA, Ritchie GSP, Porter WM. Amelioration of subsurface acidity in sandy soils in low rainfall regions. I. Responses of wheat and lupins to surface-applied gypsum and lime. Australian Journal of Soil Research. 1994;32:835-846.
13. Brown BA, Munsell RI. Soil acidity at various depths as influenced by time since application, placement, and amount of limestone. Soil Science Society of America Journal. 1939;3.
14. Pearson RW, Childs J, Lund, ZF. Uniformity of limestone mixing in acid subsoils as a factor in cotton root penetration. Soil Sci. Soc. Am. Proc. 1973;37:727-732.
15. Recheigl, J.E., Reneau, R.B. and Starrier, D.E. Effect of subsurface amendments and irrigation on alfalfa growth. Agron. J. 1985;77:72-75.
16. Sumner ME, Shahandeh H, Bouton J, Hammel J. Amelioration of an acid soil profile through deep liming and surface application of gypsum. Soil Sci. Soc. Am. J. 1986;50: 1254-1258.
17. Farina MDW, Channon P. Acid subsoil amelioration II. Gypsum effects on growth and subsoil chemical properties. Soil Sci. Soc. Am. J. 1988;54: 993-998.
18. CTCRI [Central Tuber Crops Research Institute]. Annual Report 2010-2011. ICAR-Central Tuber Crop Research Institute, Thiruvananthapuram, Kerala, India. 2011;179.
19. John KS, Raj RTR, Suja G. Dolomite: The best soil ameliorant for tannia in an Ultisol of Kerala. Indian Journal of Fertilisers. 2013;9(11):44-51.
20. Ritchey KD, Souza DMG, Lobato E, Correa 0. Calcium leaching to increase rooting depth in Brazilian Savannah Oxisol. Agron. J. 1980;72: 40-44.
21. Alva AK, Sumner ME, Miller MP. Salt absorption in gypsum amended acid soils. Planr - Soil Interactions ar Low pH. (eds. Wright, R.J., Baligar, V.C. and Murrman, R.P.). Kluwer Academic Publisher, Dordrecht. 1991;93-97.
22. Mathew J. Feasibility of phosphogypsum as an ameliorant for soil acidity in laterite soil (Doctoral dissertation, Department of

Soil Science and Agricultural Chemistry, College of Agriculture); 2003.

23. Kuriakose DK. Amelioration of subsoil acidity by calcium sources in laterite soils of black pepper garden (Doctoral dissertation, Department of Soil Science and Agricultural Chemistry, College of Horticulture, Vellanikkara); 2008.
24. Orji KO, Mbah EU. Effect of Integrated Plant Nutrient Management on Some Mineral Composition of Taro (Colocasia esculenta) and tannia (*Xanthosoma sagittifolium*) in Umudike. Nigeria Agricultural Journal. 2022;53(3):52-59.
25. Sivan P. Growth and development of taro under dryland conditions in Fiji in: Proceedings of fifth International Symposium on Tropical Root and Tuber Crops, 17-21 September 1979, Los Banos, Philippines. Philippine Council for Agriculture and Resources Research, Philippines. 1982;637-646.
26. Thokchom M, Devi LS, Thirumdasu RK, Devi AKB, James KH. Growth, physiological studies, and yield of taro (*Colocasia esculenta* Schott) cv. Mukhi Pan as influenced by intercropping and row pattern under Manipur condition. Int. J. Curr. Microbiol. App. Sci. 2018;7(5):925-931.
27. Alter D, Mitchell A. Use of vermicompost extract as an aluminium inhibitor in aqueous solutions. Communications in soil science and Plant Analysis. 1992;*23*(3-4):231-240.
28. Rajasree J, Nutrient management for intercropped *Colocasia esculenta* var Thamarakannan. M. Sc. (Ag) thesis, Kerala Agricultural University, Thrissur, Kerala. 1993;106.
29. Murmu S, Saha, Sushanta., Saha, Bholanath. and Hazra, GC. Influences on Zn and B on the yield and nutrition of two widely grown potato cultivars (*Solanum tuberosum* L.). Annals of Biology, 2014; 30(1):37-41.
30. Bossolani JW, Crusciol CAC, Moretti LG, Garcia A, Portugal JR, Bernart L, Vilela RG, Caires, EF, Amado, TJC, Calonego JC, dos Reis AR. Improving soil fertility with lime and phosphogypsum enhances soybean yield and physiological characteristics. Agron. Sus. Dev. 09 December 2023;42:26. Available:https://doi.org/ ff10.1007/s13593-022-00765-9.

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