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Integrated nutrient management for productivity enhancement in arrowroot (*Maranta arundinacea* L.)

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Abstract
West Indian arrowroot is a tuber crop valued for its starch, which has medicinal uses and is utilized in various industries. Despite its importance, no specific nutrient management guidelines exist for its cultivation. Hence, a field experiment was conducted from 2023 to 2024 at the College of Agriculture, Vellanikkara, Thrissur, Kerala, to evaluate the effects of integrated nutrient management on the growth, yield, and quality of West Indian Arrowroot The experiment was laid out in Factorial Randomized Block Design, involved 12 treatment combinations of three FYM levels (10, 15, and 20 t ha^{-1}) and four NPK levels (25:25:50, 50:25:50, and 50:25:75 N, P_2O_5 and K_2O kg ha^{-1} as well as no NPK) replicated thrice. The result indicated that integrated application of FYM @ 20 t/ha and NPK fertilizer at 50:25:75 N: P_2O_5: K_2O kg ha^{-1} enhanced growth and tuber yield of arrowroot. The crude fibre content of the tubers was not influenced by nutrient management; however, the starch content increased with the higher rates of manure and NPK fertilizer application.

Keywords: Tuber yield, leaf area index, organic manure, crude fibre, starch

1. Introduction
West Indian Arrowroot (*Maranta arundinacea* L.), popularly known as arrowroot, is a valuable tuber crop. This herbaceous plant belongs to the Marantaceae family and is cultivated for its tuberous rhizomes, which are a rich source of high-quality starch. Native to Mexico, Central, and South America, arrowroot is widely grown for its starch-rich rhizomes and is a common crop in Kerala homesteads. In India, its cultivation is prominent in states like Uttar Pradesh, Bihar, Odisha, West Bengal, Assam, and Kerala. Recently, the commercial production of this high-value tuber has been expanding, driven by growing demand for arrowroot starch in both domestic and international markets. Arrowroot starch is primarily used as a diet for infants and invalids. The tuber contains 21 to 25% starch, 0.5 to 1% crude protein and 3 to 4.8% crude fibre on fresh weight basis (Swadija *et al*., 2013) [7]. The starch possess demulcent and anti-diarrhoeal properties and is used in the treatment of intestinal disorders, which add medicinal value to the crop. The starch has diverse uses in cosmetic, food and ayurvedic industries. It is being used in the preparation of many value-added food products.

The availability of essential nutrients such as nitrogen, phosphorus, and potassium is vital for crop production. Potassium is especially important in tuber crops, as it plays a key role in the metabolic and physiological processes involved in tuber initiation and bulking. It is particularly crucial for the synthesis as well as transfer of the carbohydrates to tubers which act as an active sink.

In India, arrowroot is a minor tuber crop, so fertilizer management practices are underdeveloped. Integrated nutrient management is a sustainable technology for maintaining soil fertility and to enhance crop productivity. The use of organic manures can help address minor deficiencies in secondary and micronutrients while improving the physical and biological properties of soil. Farmyard manure (FYM) is the most commonly used organic manure in crop production.

Despite arrowroot being an important tuber crop with both nutritional and medicinal value, there are currently no specific nutrient management recommendations for this crop in KAU Package of Practices. Hence, a study was undertaken to study the effect of different levels of organic

manures and fertilizers in enhancing growth and productivity of arrowroot.

2. Materials and Methods

Field experiments were conducted during 2023 to 2024 at the Agronomy farm of the College of Agriculture, Vellanikkara, Thrissur. The experimental soil was sandy clay loam texture with strongly acidic soil reaction (pH- 5.22) and electrical conductivity of 0.14 dS/m. and the soil was medium in organic carbon (0.78%). The available soil N, P and K status was 280,13 and 224 kg ha^{-1}, respectively. The experiment was laid out with 12 treatment combinations and these combinations included three levels of FYM and four NPK fertilizer levels in a Factorial Randomized Block Design replicated thrice. The treatments included three levels of FYM (10, 15 and 20 t ha^{-1}) and three levels of NPK fertilizers (25:25:50, 50:25:50 and 50:25:75 N: P_2O_5: K_2O kg ha^{-1}) with no NPK application as control. The plot size was 4.5 m × 3 m.

Farmyard manure was incorporated basally as per the treatments. The tubers were planted on raised beds of 90 cm width at a spacing of 30 cm × 30 cm. Urea (46% N) and Factomfos (20% N and P_2O_5) and Muriate of potash (60% K_2O) were used as the source of nitrogen, phosphorous and potassium, respectively. One-third dose of N and K and a full dose of P were applied as basal and the remaining dose of N and K were applied as two split doses at 2 and 4 months after planting (MAP) along with earthing up. Hand weeding was done at 30, 90 and 120 days after planting. The crop was ready for harvest nine months after planting. Growth parameters like plant height, number of suckers per clump, number of leaves per clump and leaf area index (LAI) were measured periodically till harvest. At harvest, plot wise fresh samples of rhizomes were collected and yield parameters such as total number of tubers per plant, length of tuber and tuber yield per plant were recorded. The rhizome samples were collected, washed thoroughly, chopped and dried in open and then in a hot air oven at 70±5 ºC until constant weight. Dried rhizome samples were analysed for qualitative characteristics like starch and crude fibre content using the Anthrone method (Hodge and Hofreitem, 1962) [2] and the muslin cloth method (Maynard, 1970) [4]. The experimental data were analysed statistically by using KAU GRAPES (General R- shiny based Analysis Platform Empowered by Statistics) a platform developed by Kerala Agricultural University (Gopinath *et al*., 2020) [1].

3. Results and Discussion

Plant height (cm)

The taller plants were observed with the application of FYM at 20 t ha^{-1} at all growth stages, followed by the other FYM levels (Table 1). At 3 MAP the plant height recorded with 20 t ha^{-1} FYM application was 81.7 cm, while, height of 120.33 cm was registered at the harvesting stage. Among various levels of NPK fertilizer, application of fertilizer @ 50:50:75 N: P_2O_5: K_2O kg ha^{-1} resulted in significantly higher plant height at 3, 6 MAP and harvest stages (86.07 cm, 124.5 cm and 133.2 cm, respectively) compared to rest of the treatments. Nitrogen stimulates plant height by enhancing rapid meristematic activity and potassium also supports the growth of meristematic tissue (Tisdale *et al*., 1995) [8].

Number of suckers and leaves per clump

More number of suckers per clump was noticed with increasing levels of FYM, N and K fertilizer levels at 6 months after planting (Table 2). FYM application @ 20 t ha^{-1} and NPK fertilizer @ 50:25:75 N: P_2O_5: K_2O kg ha^{-1} resulted in significantly higher number of suckers per clump (10 and 9.57, respectively) at 6 MAP compared to other growth stages. A positive influence of N on tillering was noticed by Vidhyadharan (2000) [9] in arrowroot.

At harvest, higher number of leaves per clump of (82) was observed in plants which received FYM @ 20 t/ha compared to other two levels of FYM (Table 3). Lower number of leaves per clump was observed with FYM @ 10 t/ha (67). A linear trend of number of leaves per clump was noticed with increasing levels of NPK fertilizer also. Same trend as that of suckers per clump was observed in the case of leaves also in all growth stages. Similar results regarding the effect of NPK fertilizer on leaf production was reported by Ramesan (1991) [6] in arrowroot.

A similar trend was observed in LAI also (Table 4). FYM application @ 20 t ha^{-1} resulted in higher LAI (11.82), followed by FYM @ 15 t ha $^{-1}$ (10.27) and FYM @ 10 t ha^{-1} (9.08) Table 4. The supply of FYM and fertilizer resulted in production of more number of suckers which lead to higher number of leaves and this higher LAI. The favouable effect of FYM and NPK levels on LAI of arrowroot have been reported by Vidhyadharan (2000) [9] also.

Tuber yield

The tuber yield of arrowroot was significantly influenced by varying levels of FYM and NPK fertilizer (Table 4). Significantly higher tuber yield was observed when FYM @ 20 t ha^{-1} and NPK fertilizer application at 50:25:75 N: P_2O_5: K_2O kg ha^{-1} (11.44 t ha^{-1} and 11.65 t ha^{-1}) over other levels of FYM and NPK fertilizer application. The per cent increase in rhizome yield per hectare at 50:25:75 N: P_2O_5: K_2O kg ha^{-1} registered 65 per cent compared to no fertilizer. It has been reported that tuber formation is strongly affected by potassium availability, which also increases the number of storage roots. Ramesan (1991) [6] observed that the application of 150: 75:150 N: P_2O_5: K_2O kg ha^{-1} resulted in a higher arrowroot yield of 14 t ha^{-1}. The average tuber yield per plant and tuber yield per hectare increased with rising potassium levels up to 75 kg/ha, after which a declining trend was noted. Mary (2023) [3] reported that applying potassium at 100 kg ha^{-1} did not increase the tuber yield of sweet potato compared to 75 kg. However, with increase in K doses from 50 to 75 kg, increase in yield was observed.

Quality parameters of tuber

Starch and crude fiber content of tubers were estimated (Table 4). The application of different levels of FYM, nitrogen, and potassium fertilizers led to an increase in the starch content of arrowroot tubers whereas there was no significant difference with respect to crude fibre. Among the tested levels, the highest starch content (74.75%) was observed with the 20 t ha^{-1} of FYM. Nitrogen and potassium had a significant impact on starch content, with nitrogen enhancing carbohydrate synthesis and activating enzymes involved in starch production, while potassium was vital for both starch formation and its distribution within the plant. Vijayan and Aiyer (1969) [10] found that nitrogen application up to 150 kg/ha significantly influenced starch content in cassava. Similarly, Mohandas and Sethumadhavan (1980) [5] reported that in taro starch content increased with potassium levels up to 150 kg/ha. The beneficial effect of potassium on starch content in arrowroot was also observed by Ramesan (1991) [6], Vidhyadharan (2000) [9] and Mary (2022) [3].

Table 1: Effect of nutrient management practices on plant height of arrowroot

Treatments	Plant height		
	3 MAP	6 MAP	At harvest
FYM (M)			
M_1	67.50	95.26	101.98
M_2	74.39	101.32	104.48
M_3	81.77	118.84	120.33
S.Em(±)	1.22	2.03	3.85
CD	3.57	5.95	11.30
NPK levels (T)			
T_1	63.16	86.02	83.77
T_2	72.05	96.06	100.07
T_3	76.93	113.98	118.68
T_4	86.07	124.49	133.19
S.Em(±)	1.40	2.34	4.45
CD	4.13	6.87	13.05

Table 2: Effect of nutrient management practices on number of suckers per clump of arrowroot

Treatments	Number of suckers per clump		
	3 MAP	6 MAP	At harvest
FYM (M)			
M_1	4.27	7.85	6.73
M_2	4.86	8.91	7.58
M_3	5.23	10.00	8.28
S.Em(±)	0.08	0.04	0.11
CD	0.25	0.12	0.35
NPK levels (T)			
T_1	4.26	8.26	6.57
T_2	4.57	8.71	7.06
T_3	5.00	9.13	7.86
T_4	5.31	9.57	8.62
S.Em(±)	0.09	0.04	0.13
CD	0.28	0.14	0.40

Table 3: Effect of nutrient management practices on number of leaves per clump of arrowroot

Treatments	Number of leaves per clump		
	3 MAP	6 MAP	At harvest
FYM (M)			
M_1	38.00	47.00	67.00
M_2	43.00	54.00	77.00
M_3	46.00	62.00	82.00
S.Em(±)	1.11	1.10	1.00
CD	3.26	3.24	2.00
NPK levels (T)			
T_1	36.00	52.00	67.13
T_2	41.00	52.30	71.00
T_3	45.00	55.14	74.51
T_4	47.00	58.68	80.08
S.Em(±)	1.30	1.27	0.78
CD	3.80	3.74	2.30

Table 4: Effect of nutrient management practices on leaf area index, tuber yield, cude fiber and starch content of arrowroot

Treatments	LAI (6MAP)	Tuber (Yield t/ha)	Crude fiber (%)	Starch content (%)
FYM				
M_1	9.08	8.86	10.88	72.41
M_2	10.27	9.85	12.12	73.03
M_3	11.82	11.44	13.32	74.75
S.Em(±)	0.10	245.56	0.36	0.30
CD	0.31	720.22	NS	0.89
NPK levels				
T_1	8.44	7.99	10.06	71.95
T_2	9.89	9.60	10.83	72.54
T_3	11.02	10.96	11.80	73.97
T_4	12.20	11.65	13.08	75.13
S.Em(±)	0.12	283.55	0.42	0.35
CD	0.36	831.69	NS	1.02

4. Conclusion

The results indicated that a nutrient management strategy with the application of organic manure together with chemical fertilizer can improve the growth, yield, and quality of arrowroot. Application of FYM @ 20 t ha^{-1} along with NPK fertilizer @ 50:25:75 kg ha^{-1} resulted in higher tuber yields and starch content in arrowroot.

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