



RESEARCH ARTICLE

Comparative evaluation of traditional and improved cultivation practices and cultivars of *Colocasia esculenta* (L.) H. W. Schott in the Borail Hills Range of India

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ABSTRACT

Present work was focused on the comparative evaluation of the Taro tuber productivity by using improved cultivation practices versus traditional cultivation practices. Initially, passport data of all the collected 27 cultivars and wild edible aroids were prepared and their Indigenous Collection Numbers (IC) were procured from the Indian Council of Agricultural Research-National Bureau of Plant Genetic Resources, New Delhi. All the collections were phytochemically evaluated and five variants of *Colocasia esculenta* (L.) H. W. Schott were found to be superior and their IC Numbers are 0631527, 0631529, 0631536, 0631544 and 0631546. Following the randomised block design method for crop productivity evaluation, data of five nutritionally superior cultivar and one check variety were taken in three replications (R1, R2, R3) from eighteen plots of measuring 5×5 m² (25 m²). Taro tuber productivity in kg/plant from the first and second year's data from the ICAR-NBPGR, Umiam and also the farmer's data from Borail Hills Range were analysed by using SPSS software, and that shows significant difference among all the six treatments/variants under Critical Difference at 5% (CD 5%). Total of the data replications (R1+R2+R3) from first, second year data from ICAR-NBPGR, Umiam and also farmer's data from Borail Hills Range are 18.24 kg, 19.45 kg and 12.69 kg respectively; clearly showing the tuber productivity enhancement of improved cultivation practices over the traditional agro- practices.

Introduction

Colocasia esculenta (L.) H. W. Schott belongs to the family Araceae, commonly known as Taro. Taro is grown throughout the tropics and in a few parts of subtropics. It is a highly polymorphic species with wide morphological variability. There are two types of Taro—the Dasheen type and the Eddoe type. The Dasheen type is *C. esculenta* var. *esculenta* and the Eddoe type is *C. esculenta* var. *antiquorum*. The Dasheen type has a large main corm with 2–3 cormels. The sterile appendage of the spadix is short. Generally, the group has 28 chromosomes (1). The Eddoe type has a small or medium corm which is not edible with 5–20 cormels. The sterile appendage of the spadix is larger than the male portion and three times more than that of Dasheen. This group has 42 chromosomes (1).

The Borail Hills Range of Assam lies between 24° 58' N to 25° 50' N latitudes and 92° 50' E to 92° 52' E longitudes. Due to poor road connectivity to the Borail

Hill Range of Assam, the inhabitant ethnic groups have been dependent mainly on *Jhum* cultivation and the forests for their food, medicine etc. The main ethnic groups of the area are the Dimasas, Zeme Nagas, Hmars, Hrangkhols, Biates, Kukis, Sakacheps, Vaipheis and Pnars.

The major food grain rice produced in *Jhum* is limited and one season's production cannot meet the needs of the households for the whole year. When the rice stock decreases, they start mixing rice with the Aroids and other tubers as a supplementary diet. Due to the high starch content with good calorie value, tubers have a major role in meeting the food security of the ethnic people of the area. The tubers are mostly used as vegetable/curry or as subsidiary food for an alternative carbohydrate source after roasting, baking, or boiling. The leaves are also consumed as vegetable. Tubers are rich source of Calcium, Iron, Phosphorus, Zinc, Vitamin A and Vitamin C. As the tribal groups

cultivate the edible aroids in the homestead area and in and around the vicinity of their villages and also sparingly in the *Jhum* lands. It is presumed that the development of an improved cultivation practice/agro-technique is needed for increasing tuber production. This will ensure the enhanced productivity and food security of the tribal groups. Additional income generation by selling their agro-products, including tubers and fresh and dried Taro leaves, is another income source for those ethnic groups (2).

ICAR-CTCRI, Thiruvananthapuram, India, developed clear guidelines for large scale commercial Taro cultivation. However, the agro-technique developed was mainly suitable for lowland and valleys. Emphasis was mainly given to select better planting material, land preparation and method of planting, mulching technique, manuring and weeding, crop protection and harvesting (3), which is mainly cultivated in Eastern and Southern States of India. Most of these edible *Colocasia* species is also sparingly cultivated in the valleys and hills of the North-Eastern parts of India. Some of the lowland Taro variants are cultivated in the plains and valleys and upland Taro variants in the hilly terrains of the region.

With this backdrop, an attempt was made to develop an improved cultivation practice with local need-based modifications for upland farmers of North East India. At the same time, there was a comparative evaluation of crop production from the improved cultivation practices with the traditional cultivation practices of the nutritionally superior Taro accessions. Delivering the improved cultivation package of practice to hill farmers was also an important part of the present work. Taro has been studied in different parts of the world, including India, covering different aspects. Some of the references came across during perusal of literature on taxonomic studies (2, 4, 5, 8, 9), genetic variation (6–9), traditional knowledge on aroids (10, 11), crop improvement (12–20), Taro cultivation practices (21–30), aroid tuber crop harvest (31) and crop productivity evaluation (32, 33).

Materials and Methods

Sample collection, taxonomic identification and field characterisation

Individual sampling was done selectively for collecting all the 27 cultivars and wild edible aroid germplasm samples in the form of tubers since September 2016 to February 2017 and identified the plant samples considering morphological characters by using standard literature (4, 5). In addition, passport information data and also field characterisation on each accession was recorded at the time of collection, following the standard procedure of the National Bureau of Plant Genetic Resource (ICAR-NBPGR) (34).

All the collected aroid germplasm were submitted to ICAR-NBPGR Shillong Regional Station, India, for further conservation and multiplication.

Later Indigenous Collection (IC) numbers of each of the accessions were obtained from National Authority (ICAR-NBPGR, New Delhi).

Sample preparation and phytochemical analysis

Taro tubers *i.e.* corms or cormels were cleaned with water, thin-sliced, and air-dried. Care was taken by regular flipping of the thin tuber slices and allowed to be air-dried to avoid fungus contamination. Then the samples were dried in a hot air oven at 60 °C till a constant weight was obtained. Finally, the dried materials were ground to powder and stored at 4 °C for further analysis. Phytochemical analysis of the prepared tuber powders was carried out in a moisture-free environment in the laboratory.

Estimation of the nutritional properties included total carbohydrate estimation done by following standard procedure Anthrone's method (35) and protein by Lowry's method (36), total fat estimated by using Soxhlet apparatus (Soxhlet method), total crude fibre contents estimated by extracting fibres and expressed as percentage of the original defatted sample (37), and calorific value by using a Bomb calorimeter (Make: Optics Tech). Nutraceutical properties estimation includes total mineral content by Gravimetric method using Muffle furnace (Make: Optics Tech), total phenolic content by *Folin-Ciocalteu's* method (38), antioxidant activity by standard radical scavenging effect of stable DPPH method (39), ascorbic acid by using 2, 6-dichloro phenol indophenol dye (40) and the flavonoid content by spectroscopic (Make: Cystronics 2020) analysis (41).

The standard permissible limit of the oxalate contents in edible aroids is 71 mg/100 gm, and beyond this limit is not recommended for human consumption. Estimation of antinutritional properties (oxalates/ ammonium oxalates) was done by titration method (42).

Quantification of microelement in the selected superior Taro samples was done *viz.* Ca, Fe and Zn by Atomic Absorption Spectrophotometer (Model: AAS-700, Perkin Elmer). Standard methodology (43, 44), was followed for the digestion and analytical procedures for the quantification of total metal concentration in dried sample powders.

Selection of superior Taro germplasm

As the tubers are a reservoir of energy or nutrition and therefore, during the selection of superior cultivar germplasm, emphasis was mainly given to the higher calorific value and low antinutritional properties like oxalates/ammonium oxalates of the tubers or cormels studied. Higher value of total crude fibre, total mineral contents were also taken into consideration for selection of superior Taro accessions. Higher value of the nutraceutical properties *i.e.* total phenolic content, antioxidant activity, ascorbic acid, flavonoid content were also considered but plays less significant role for selection of superior Taro tubers as these are rich in energy/calorific value. Quantification of microelement was done only in the selected five superior Taro accessions.

Improved cultivation practice (Agro-technique) for upland Taro

During the field trial, few notable modifications were made for upland cultivation in the hilly terrains of Borail Hill Range. The use of chemical fertilisers and fungicides/pesticides were avoided for the interest of economically backward hill-dwelling farmers. So, vermicompost and neem seed extracts were used as endogenous resources for the sustainable and organic hill farming practices.

Distinctly, the following are the few important points emphasised during the field trial in the case of improved cultivation practices for upland cultivation of Taro, which was not recorded so far to be practised traditionally in the Borail Hill Range earlier.

1. Taro grows well in warm and humid conditions with mean temperatures ranging from 21-27 °C and rainfall of 1000 mm or above. Taro can be cultivated in all soil types but produces better tuber in well-drained fertile loamy soils. So, the North-eastern hills are a suitable agro-climate for upland Taro cultivation [3]. Agro-climatically, under rainfed conditions in the hills of North East India, traditionally planting is done during April to June, and the same is recommended.
2. Selection of healthy cormels and the corms were given emphasis to be used as planting material.
3. The pit method or raised bed method of land preparation can be adopted. In sandy loam soils in Umrangsho area, the pit method is preferred, whereas, in alluvial soils, raised mounds or beds are better.
4. Mulching helps early sprouting, control growing weeds, regulates soil temperature and also retain soil moisture. The planted seed tubers recommended being mulched with green or dry leaves/straw from the nearby forest or *jhum* land.
5. Traditional Hill Agricultural System in North-eastern India is an organic one. So, no chemical fertiliser application will be suitable to recommend in the region from both cultural and environmental points of view. So, the application of 10-12 tons of Farm Yard Manure (FYM) per hectare and mixing it with soil before planting is recommended. The use of vermicompost is also another option for soil fertility enhancement.
6. For controlling aphids and worms locally, the following are some of the useful measures:
 - a. Use of healthy planting materials
 - b. Early planting to avoid heavy monsoon rains
 - c. Removal of self-grown *Colocasia* plants
 - d. Neem seed extracts to be used to repel insect pests
7. Weeding and earthing-up operations are essential as per planting protocol, but

performing manual weeding is already a common practice among hill farmers.

8. After 6-8 months from planting, harvesting is done by carefully uprooting the plants along with corms and cormels and then separated for consumption and further use as planting material.

Field trials

An improved cultivation practice of the selected superior Taro cultivars for upland cultivation has been done by following the standard guidelines of Central Tuber Crop Research Institute (CTCRI), Thiruvananthapuram, India, with slight modifications as per local needs of the upland areas. CTCRI mainly developed it for valleys and lowland areas. However, clearly, in the present work, emphasis was given to the rain-fed upland and hilly terrains of North East India, including Borail Hills Range.

Two years of field trials using improved cultivation practice was conducted during the month of May to November in the year 2017 and 2018 at ICAR-NBPGR, Umiam for evaluation of Taro tuber productivity. Only the Nutritionally superior selected five cultivar variants were cultivated in the trial station for tuber productivity evaluation. Following the randomised block design method for crop productivity evaluation, data of five nutritionally superior cultivar and one check variety were taken in three replications (R1, R2, R3) from total 18 plots of each one measuring 5 × 5 m² (25 m²). Altitude and soil types of the ICAR-NBPGR, Umiam field trial station were similar to the cultivable lands of Borail Hills Range. Thus, the farmers field of the Borail Hills Range and the field trial station of ICAR-NBPGR, Umiam are agro-climatically similar under the North East Indian region.

Similarly, farmers from Borail Hills Range were also engaged for evaluation of Taro tuber productivity during the month of May to November in the year 2017. Traditional cultivation process was followed strictly by the farmers in the *Jhum* fields of the hilly terrain. Regular weeding, earthing up, mulching were not done and also use of manures and organic pesticides were not practiced in the traditional cultivation practices, in general. During field trial, tuber productivity data were recorded in three replications by using same randomised block design method applied as in ICAR-NBPGR, Umiam trial station.

In both the field trial locations, i.e. ICAR-NBPGR, Umiam and Borail Hills Range, a sixth high yielding cultivar variety *C. esculenta* var. *esculenta* (Cultivar-*Panchamukhi*), collected from local market was used as check variety for comparing the critical/significant difference in tuber productivity with the nutritionally superior five cultivar variants/treatments. So, there are total six treatments/variants were cultivated and also total 18 standard plots/observations were adopted during field trials for both the improved and traditional methods of cultivation. Tuber productivity was considered in kg plant. Thus, clearly tuber productivity data were obtained for a comparative

evaluation between the improved and the traditional method of cultivation practices.

Statistical analysis

For statistical analysis Statistical Package for the Social Sciences (SPSS) software on Windows operating system platform was used. Total six treatments that includes five nutritionally superior *Colocasia* cultivars (T1-IC0631527, T2- IC0631529, T3-IC0631536, T4-IC0631544, T5-IC-0631546) and one check variety *C. esculenta* var. *esculenta* (Cultivar-*Panchamukhi*) were considered. All the data were taken in three replications (i.e. Replication-R1, R2, R3) from each treatment/ *Colocasia* variants. Clearly, a total of 18 observations (i.e. 6 treatments x 3 replications each) were used for tuber productivity data analysis.

Results and Discussion

Field collection of total 27 aroids from Borail Hills Range was successfully done during September 2016 to February 2017. During the collection of samples, were characterised carefully by recording the important features of the collected tuber germplasms. Field characterization of the selected nutritionally superior Taro variants has been listed carefully. Additionally, the starch content in terms of percentage was also recorded after phytochemical estimation (Table 1).

Ammonium Oxalates were found to be ranging from 56.78±0.02 to 62.73±0.19 mg/100 gm, which are below the standard permissible limit of 71 mg/100 gm for human consumption (Table 2).

Comparative evaluation crop productivity: Traditional vs improved cultivation process

During field trial from ICAR-NBPGR, Umiam and the farmers of Borail Hills Range, there were six treatments/ *Colocasia* variants and three replications (R1, R2, R3) for each treatments. Thus, two years randomised block design cultivation trials from ICAR-NBPGR, Umiam trial station and one year from Borail Hills Range were considered. There were total 18 cultivation blocks and observations in total for the six treatments/cultivars and the tuber productivity in kilogram per plant.

Taro tuber productivity from the first year's data analysis using SPSS software from the ICAR-NBPGR, Umiam shows significant difference in productivity between the check variant (Cultivar-*Panchamukhi*) with the six treatments/*Colocasia* variants each, under Critical Difference at 5% (CD =0.28). Again, there is also a significant difference among all the six treatments /*Colocasia* variants (Table 3). Similarly, second year's data analysis from the field trials of ICAR-NBPGR, Umiam also shows significant difference in productivity under CD (5%)=0.31 (Table 4).

Table 1. Field characterisation of the nutritionally superior Taro cultivars.

Botanical name; Coll. No./IC no.	Vern. name	Field characters/Special features
<i>Colocasia esculenta</i> (L.) H.W. Schott cv. <i>Panchamukhi</i> (Dasheen type). PM- GDH-1187/0631527	<i>Bahnar -tam (Hm/Mi); Thakhlong (Di)</i>	Leaf and petiole pale green, corm and cormels are non acrid; Large tuber with predominant 3-5 lateral buds; Good cooking quality and taste; Starch content 63.10 % and protein 2.45%.
<i>Colocasia esculenta</i> var. <i>antiquorum</i> (L.) H.W. Schott (Eddoe type). PM- GDH-1189/0631529	<i>Rawsen (Hm); Thadisa-gajao (Di)</i>	Leaf, petiole, corm and cormels are non acrid; Number of cormels 5-20 with reddish apical cormel buds; Good cooking quality and taste; Starch content 47.21 % and protein 3.28%.
<i>Colocasia esculenta</i> var. <i>esculenta</i> (L.) H.W. Schott (Dasheen type). PM- GDH-1196/0631536	<i>Manjang (Hr); Thahon (Di)</i>	Leaf, petiole, corm and cormels are non acrid. Dark green leaf and petiole; Leaf petiole and corm preferred for edible purpose; Rounded corm with 5-20 cormels; Good cooking quality and taste; Starch content 64.93 % and protein 3.67%.
<i>Colocasia esculenta</i> var. <i>esculenta</i> (L.) H.W. Schott (Dasheen type). PM- GDH-1353/0631544	<i>Hen-then-tut (Ka)</i>	Leaf, petiole, corm and cormels are non acrid; Elongated corm mainly lies above the soil surface; Elongated corm with tapering apex and upto 4 cormels; Good cooking quality and taste; Starch content 45.46% and protein 3.67%.
<i>Colocasia esculenta</i> var. <i>esculenta</i> (L.) H.W. Schott (Dasheen type). PM- GDH-1355/0631546	<i>Hon-phangwo-tar (Ka)</i>	Leaf, petiole, corm and cormels are non acrid; Large 4-5 cormels arise from the base of the main tuber; Elongated cormels are very prominent with tapering apex; Good cooking quality and taste; Starch content 40.6% and protein 3.11%.

Community names abbreviated: *Hm-Hmar*; *Mi-Mizo*; *Di-Dimasa*; *Hr- Hrangkhoh*; *Ka-Karbi*.

Out of 27 cultivar and wild edible aroids estimated phytochemically, five *C. esculenta* variants are found to be nutritionally and nutraceutically superior (i.e. IC-0631527, 0631529, 0631536, 0631544 and 0631546). These were selected and sorted out from the rest of the cultivars for field trials and standardisation of improved cultivation practices for upland cultivation. During the selection of superior germplasm, apart from the nutraceutical properties, emphasis was mainly given to the higher calorific value and less anti-nutritional properties like oxalates/ammonium oxalates. Calorific value in the selected superior Taro variants ranging from 357.78±0.04 to 365.10±0.21 mg/100 gm. Antinutritional properties in the form of Oxalates/

Again, during the cropping season from May to November 2017, Taro productivity data from the field trial of the farmers of Borail Hills Range, India also shows a significant difference in productivity among the treatments/ *Colocasia* variants under CD (5%)=0.20 (Table 5).

Total of the data replications (R1+R2+R3) from first, second year data from ICAR-NBPGR, Umiam and also farmer's data from Borail Hills Range are 18.24 kg, 19.45 kg and 12.69 kg respectively. It also, clearly shows the tuber productivity has significantly enhanced after using improved upland Taro cultivation practices in comparison to the traditional Taro cultivation practices.

Table 2. List of selected nutritionally superior Taro cultivars based on phytochemical analysis.

Collection no./ IC no.	Carbohydrate (%)	Protein (%)	Total fat (%)	Total crude fibre (%)	Total mineral (%)	Ascorbic acid (mg/100 gm)	Total phenolic content ($\mu\text{gGAE}/\text{mg}$)	Antioxidant Activity IC50 ($\mu\text{g}/\text{ml}$)	Flavonoid ($\mu\text{Gqe}/\text{mg}$)	Caloific value (kcal/100 gm)	Oxalates/ Ammonium Oxalates (mg/100 gm)	Micronutrient Content (mg/100 gm)		
												Zn	Ca	Fe
PM- GDH-1187 /0631527	63.10 \pm 0.24	2.45 \pm 0.02	2.35 \pm 0.07	2.15 \pm 0.61	4.72 \pm 0.03	30.83 \pm 0.39	25.32 \pm 0.10	145.73 \pm 0.16	8.43 \pm 0.03	365.10 \pm 0.21	61.89 \pm 0.10	5.83	153.98	6.60
PM- GDH-1189 /0631529	47.21 \pm 0.21	3.28 \pm 0.04	2.27 \pm 0.22	4.25 \pm 0.12	3.05 \pm 0.1	29.43 \pm 0.06	18.34 \pm 0.13	112.53 \pm 1.03	6.26 \pm 0.17	361.82 \pm 0.05	57.52 \pm 0.05	9.07	202.85	1.81
PM- GDH-1196 /0631536	64.93 \pm 0.01	2.77 \pm 0.03	0.49 \pm 0.08	2.5 \pm 0.23	1.72 \pm 0.11	27.02 \pm 0.04	24.53 \pm 0.02	107.32 \pm 0.11	8.48 \pm 0.10	360.74 \pm 0.06	61.17 \pm 0.04	34.12	36.21	38.12
PM- GDH-1353 /0631544	45.46 \pm 0.08	3.67 \pm 0.14	2.45 \pm 0.17	4.76 \pm 0.56	5.80 \pm 0.12	28.56 \pm 0.25	20.04 \pm 0.10	136.90 \pm 0.11	8.40 \pm 0.02	359.49 \pm 0.02	62.73 \pm 0.19	5.32	61.10	8.87
PM- GDH-1355 /0631546	40.6 \pm 0.76	3.11 \pm 0.03	1.56 \pm 0.04	4.89 \pm 0.03	6.30 \pm 0.23	38.56 \pm 0.04	27.32 \pm 0.05	143.54 \pm 0.76	7.38 \pm 0.42	357.78 \pm 0.04	56.78 \pm 0.02	4.72	102.77	10.49

Table 3. First year's (May-November 2017) Taro productivity data analysis from the field trial of ICAR-NBPGR, Umiam.

No of parent/treatment/ genotypes	R1	R2	R3	Total	Mean \pm SD	Mean \pm SE
T1-IC0631527	0.89	0.96	0.92	2.77	0.923 \pm 0.03512	0.923 \pm 0.020276
T2- IC0631529	1	1.2	0.9	3.1	1.03 \pm 0.152753	1.03 \pm 0.088192
T3-IC0631536	0.76	0.72	0.79	2.27	0.757 \pm 0.03512	0.757 \pm 0.020276
T4-IC0631544	0.9	0.7	0.8	2.4	0.800 \pm 0.10	0.800 \pm 0.057735
T5-IC-0631546	0.8	0.65	0.75	2.2	0.733 \pm 0.076376	0.733 \pm 0.044096
<i>C. esculenta</i> var. <i>esculenta</i> (Cultivar-Panchamukhi)	1.5	2	2	5.5	1.83 \pm 0.288675	1.83 \pm 0.166667

*CD (5%) =0.28

Table 4. Second year's (May-November 2018) Taro productivity data analysis from the field trial of ICAR-NBPGR, Umiam.

No of parent/treatment/ genotypes	R1	R2	R3	Total	Mean \pm SD	Mean \pm SE
T1-IC0631527	0.91	0.76	0.72	2.39	0.797 \pm 0.100167	0.797 \pm 0.057831
T2- IC0631529	1.19	1.39	1.09	3.67	1.22 \pm 0.152753	1.22 \pm 0.088192
T3-IC0631536	0.62	0.67	0.72	2.01	0.670 \pm 0.05	0.670 \pm 0.028868
T4-IC0631544	1.08	0.88	0.98	2.94	0.980 \pm 0.1	0.980 \pm 0.057735
T5-IC-0631546	0.95	0.7	0.9	2.55	0.850 \pm 0.132288	0.850 \pm 0.076376
<i>C. esculenta</i> var. <i>esculenta</i> (Cultivar-Panchamukhi)	1.63	2.13	2.13	5.89	1.96 \pm 0.288675	1.96 \pm 0.166667

*CD (5%) =0.31

Table 5. Taro productivity data analysis from the field trial of the farmers from Borail Hills Range, India (May-November 2017).

No of parent/treatment/ genotypes	R1	R2	R3	Total	Mean \pm SD	Mean \pm SE
T1-IC0631527	0.61	0.59	0.62	1.82	0.607 \pm 0.015275	0.607 \pm 0.008819
T2- IC0631529	0.67	0.78	0.95	2.4	0.80 \pm 0.141067	0.80 \pm 0.081445
T3-IC0631536	0.47	0.51	0.48	1.46	0.487 \pm 0.02082	0.487 \pm 0.012019
T4-IC0631544	0.5	0.54	0.55	1.59	0.530 \pm 0.026458	0.530 \pm 0.015275
T5-IC-0631546	0.89	0.64	0.59	2.12	0.707 \pm 0.160728	0.707 \pm 0.092796
<i>C. esculenta</i> var. <i>esculenta</i> (Cultivar-Panchamukhi)	0.96	1.11	1.23	3.3	1.10 \pm 0.135277	1.10 \pm 0.078102

*CD (5%) =0.20

**R1, R2, R3-Replications of data of tuber productivity in kg/plant; SD-Standard Deviation; SE-Standard Error

Farmer's training for Taro cultivation package of practice

Three hundred ninety-two hill farmers from 44 villages belonging to different ethnic communities were trained on the comprehensive package of practice (i.e. Improved cultivation practice) for upland cultivation of Taro. The training programme was organised and long reached with the help of eight local Master Trainers from the Borail Hills Range area during the month of December 2018.

Conclusion

Selection of the superior edible *C. esculenta* variants based on nutraceutical properties can play an

important role in the enhancement of Taro tuber production in the similar upland agro-climatic regions of North East India. So, collection, conservation and multiplication of such important Taro variants are necessary for the benefit of the people of the region. The new, improved agro-technique/cultivation process was proved to be helpful for significantly enhanced tuber productivity in the sustainable hill agricultural system throughout North East India.

From the field trials data analysis, it is concluded that the upland Taro tuber productivity has significantly been enhanced after using improved upland Taro cultivation practices. Thus, by selling the surplus tubers and their products in the

makeshift/weekly markets will help for adding to the farmer's household budget. Production and marketing of the commercial starch from tuber crops are used in adhesives, dextrans, food, sweeteners, ethyl alcohol, soaps and detergents, laundry, cosmetic, pharmaceuticals and biodegradable plastics etc. will also be helpful for the opening of new vistas for agro-based cottage industries for the economic wellbeing of the ethnic people of North East India.

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Authors' contributions

PM carried out the Taro germplasm collection, taxonomic identification, phytochemical analysis, improved upland Taro cultivation practice for productivity enhancement at ICAR-NBPGR, Umiam as well as Borail Hills Range, and also farmers' training for capacity building. AS contributed to the phytochemical analysis. HGD assisted in getting Indigenous Collection (IC) numbers, field trial at ICAR-NBPGR, Umiam for upland Taro tuber productivity evaluation and also farmers' training for capacity building.

Conflict of interests

Authors do not have any conflict of interests to declare.

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