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Conservation, Cultivation and Propagation of *Zingiberaceae* Species of Manipur and Ethnobotanic Utility: A Review

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Abstract

Among the members of the Zingiberaceae family of Manipur State, 45 species were surveyed, identified and their ethnobotanical uses were recorded. *Hedychium marginatum* C.B. Clarke. and *Curcuma angustifolia* Roxb., which are under threatened category were cultivated and propagated under ICAR, Research Complex for NEH Region, Manipur Centre, Lamphelpat field condition. Experiments were planned with Factorial Randomized Block Design for 3-crop seasons (2018 to 2020). The study encompasses the growth and development, seedlings, influenced by spacing, vermicomposting and correlations amongst the growth parameters, so as to validate the most favourable conservation method for these two endangered plants. During the three crop seasons, the third crop (2020) is the best. Strong positive correlation between leaf surface area and plant height on the growth and development was found to be effective among other correlations.

Keywords: Zingiberaceae Species, Endangered, Ethnobotanical Uses, Cultivation, Propagation, Growth, development, Correlation, Soil nutrient, Spacing and vermicomposting.

1. Introduction

Zingiberaceae is regarded as one of the most highly evolved, natural and rather distinct of monocotyledonous families. The members are distributed mainly in tropics and subtropics with the centre of distribution in the Indo-Malayan region, however, extending through tropical Africa to Central and South America. It consists of aromatic perennial herbs with creeping horizontal and tuberous rhizomes. The family is characterised by small to large herbaceous plants with distichous leaves, with basal sheaths that overlap forming a pseudostem. It usually grows in shady habitat as forest undergrowth's or in marshy wetlands and in open forests. It is either self-supporting or epiphytic in nature. Inflorescence usually a spike or raceme, flowers hermaphrodite, zygomorphic and always epigynous [1].

Manipur, a state of the north eastern India, is known for its ecologically distinctive and rich biodiversity having many endemic flora and fauna and rich cultural diversity [1]. Manipur mainly comprises of hilly terrain. This plant is cultivated for its rhizome in tropical areas of South and East India [2]. Family Zingiberaceae consists of a large number of medicinal plants and is well known for its ethnomedicine [3]. Few Zinger varieties such as *Zingiber cassumunar* Roxb. and *Zingiber zerumbet* (L.) Sm. are used in indigenous folk medicines [4,5,6].

Conflicts between authorities and indigenous population over resource sharing has been observed and reported for decades [7,8]. This may be a cause for the loss of biodiversity. Utilization of wild edible plants as food is a global phenomenon and has been reported from

many countries [9]. Plant collection pattern is associated with the perception and relative importance of useful plants which depends on cultural factors [10]. The important genera under Zingiberaceae are *Alpinia, Amomum, Curcuma, Elettaria, Hedychium, Kaempferia* and *Zingiber* which has been exploited in the wild and some of them are domesticated [4,5,6].

Zingiberaceae is considered as one of the most difficult, due to close resemblance of vegetative parts of taxa within a genus or the family. The flowering season is short and on the other hand flowers are short lived and delicate. Because of the ephemeral flowers, taxonomic study of the family is difficult and the classification is still incomplete. The family has been variously divided into a number of tribes and recognised four tribes: Hedychieae, Zingibereae, Alpineae and Globbeae [4,5,6].

There is a taxonomic and nomenclatural confusion surrounding many genera established between the time of the Linnaeus [11,12], and of Roxburgh [13]. Bentham and Hooker [14], Engler and Prantl [15] and Schumann [16], gave an account of Zingiberaceae. Nowadays, most of the forests are fast disappearing due to encroachment and many anthropogenic activities such as over exploitation of the plant parts for food and medicine and have placed many taxa as endemic species such as *Hedychium greenii* W.W.Sm., *Hedychium speciosum* Wall., *Hedychium wardii* C.E.C.Fisch., *Hedychium marginatum, Curcuma angustifolia,* etc.[4,5,6].

The genus *Curcuma* of the family Zingiberaceae comprises of about 80 species, widely distributed in tropic of Asia, Africa, Southeast Asia, Australia and other warm parts of the world [17]. It consists of creeping horizontal and tuberous rhizomes comprising about 52 genera and more than 130 species distributed throughout tropical regions of Asia including India and North Eastern India, Africa, America and Australia, Indomalaya region being the main Centre of its occurrence [17,18, 19, 20,21, 22].

C. angustifolia is a fast-growing annual herb, generally distributed in the foothills, at an elevation of 915 to 1220 m above the mean sea level in Manipur. It attains a height up to 90-180 cm. The genus *Curcuma* of the family Zingiberaceae comprises of about 80 species, widely distributed in tropic of Asia, Africa, Southeast Asia, Australia and other warm parts of the world [17]. *C. angustifolia* Roxb., commonly known as East Indian Arrowroot or *Yaipal*, is an important medicinal plant [23], having tremendous export value in national and international market. *C. angustifolia* is called by different names in India *i.e., Tikhur* in Hindi, *Keturi Halodhi* in Bengali, *Tavakshira* in Sanskrit, *Yaipal* in Manipuri, *Tavakeera* in Marathi, *Koova* in Malayalam, *Ararut-kizhagu* in Tamil, *Koove-hittu* in Kannada, *Ararut-gaddalu* in Telugu. It is a rhizomatous perennial herb [23].

Hedychium marginatum (Zingiberaceae) of Nagaland is very rare and included in the threatened species was reported [24]. Species extinction occurs due to anthropogenic ecological disturbances, and the extinction may be because of the cataclysmic events, but today's accelerated rate of extinction episodes can be traced only to the influence of human race. Today we are losing at least one higher plant species per day from tropical forest alone [25, 26, 27].

Hedychium Koening genus holds 87 species mainly distributed in eastern Himalaya to southern China, India and south eastern Asia [28,29]. In zingiberaceae family *Hedychium* is the largest genus of India with 44 taxa, naturally distributed as an endemic species in the north eastern states [29]. Among the species *H. marginatum* C.B. Clarke is facing high risk of threat in the wild, and assessed as Vulnerable as per IUCN guidelines [30,31].

2. Materials and Methods

2.1.*Ethnobotanical Survey*

The method of plant collection and documentation is done following Das, A.K. *et al.*, Devi [32]. For taxonomical identification of the Zingiberaceae species, herbarium was prepared as methodology recommended [33]. The authentic identification of the plants was done with the help of the available floristic literature such as Genera Plantarum ad exemplaria, Scitamineae1862-188 [14]; Flora of India, 1820 [13]; Flora of Tripura State, vol. I & II (Deb, 1981 and 1983) [22]. A complete morphological characterization of the vegetative and reproductive features of the plants is describe, illustrated and photographed [32]. Botanical illustration is done [14]. The second criterion of plant identification is having a list of the possibilities. Clarke [18, 34]; Kanjilal *et al.*, and Deb [20, 21]); floras are typically used to be sure that it encompasses that of the unknown plant. Morphological characters were critically study, illustration and photographs were made from live specimens [13].

2.2.*Phytochemical Screening*

The preliminary phytochemical screening was carried out by following the procedures of Kokate[35]. Total phenol content was estimated using Folin-Ciocalteu's reagent (FCR) Thimmaiah, [36]. Total phenol content was estimated using Folin-Ciocalteu's reagent (FCR) [36]. Total phenol content was estimated using Folin-Ciocalteu's reagent (FCR) [36]. Relatively stable organic radical DPHH has been widely used in the determination of the antioxidant activities of plant extracts. The method is sensitive and requires small sample amounts [37].

2.3.*Cultivation, Cultivation, Propagation*

Study site

The present work has been taken up to cultivate *Hedychium marginatum,* and *Curcuma angustifolia* plants, commonly known as *Takhellei angangba* and *Yaipal* respectively in Manipuri, which are under the Rare Endangered and Threatened (RET) category, so as to conserve the plant species by following modern tools of agricultural practices under ICAR, Lamphelpat, Imphal field condition. Plantation and Cultivation of *Takhellei angangba* and *Yaipal* was done during 2018 to 2020 (3 seasons) in the study plots of ICAR Research Complex for NEH Region, Manipur Centre, Lamphelpat, Imphal [Fig.1].

Treatments

For the treatment of *Hedychium marginatum* and *Curcuma angustifolia* plant***s***, two factors viz., were employed; Factor 1: Spacing 3 levels, (S_1=60 cm, S_2=75 cm, S_3= 90 cm); Factor 2: Vermicomposting 3 levels (V_1= 2 ton/ha (600 gm/plant), V_2= 3 ton/ha (900 gm/plant), V_3= 4 ton/ha (1200 gm/plant) and Design: Factorial Randomized Block Design, Plot Size: 4.0 m x 5.0 m [Table 1].

Meteorological Data

Meteorological Data of the experimental farm was recorded from ICAR Complex during the tenure of the research program. Soil analysis of the experimental farms were analysed at ICAR Research Complex for NEH Region, Manipur Centre, Lamphelpat, Imphal. Plant Leaf surface area was measured by using a Mobile-application technique called "Petiole: Plant Leaf Area Meter".

Cultivation and propagation, which leads to conservation steps of plant species like, *Hedychium marginatum*, and *Curcuma angustifolia*, for a detailed study was performed, with treatments of growth and development; spacing, vermicomposting, weeding and trimming. Correlations amongst the growth parameters were also incorporated (Singh *et al.* a, b, 2021) [38,39].

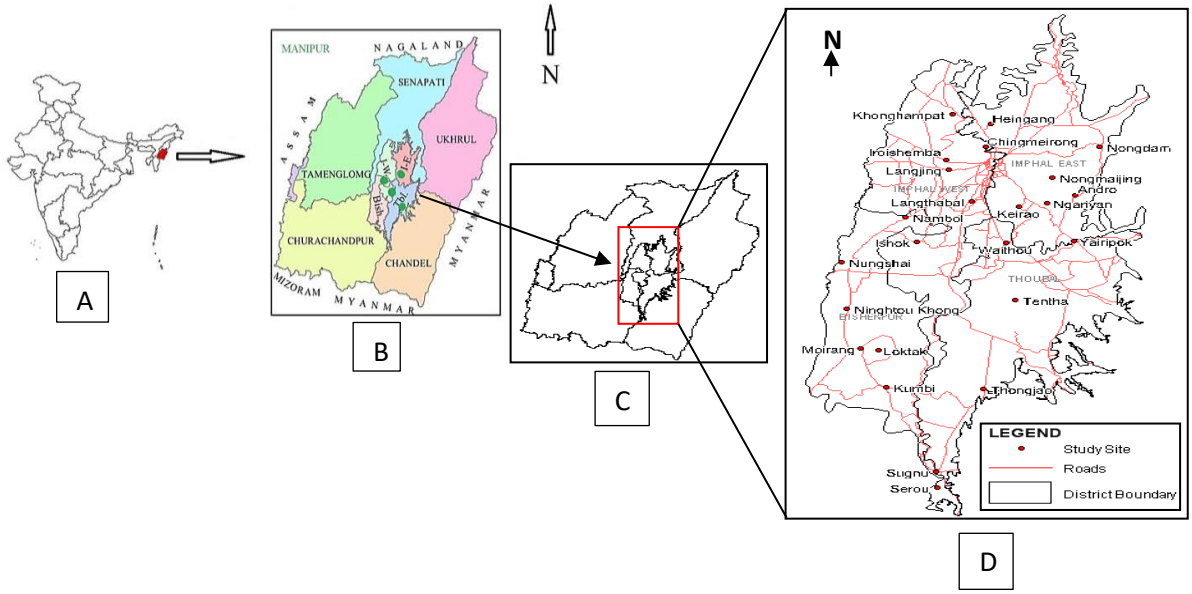

Fig. 1 Study area: A. Map of India showing the location of Manipur; B. Map of Manipur showing districts; C. Map of Manipur showing the location of Imphal valley; D. Map of Imphal valley and study sites ICAR, Lamphelpat.

Table 1: Layout Plan for the Cultivation and Propagation of *Curcuma angustifolia* and *Hedychium marginatum* (Singh *et al.,* 2021a,b)[38, 39].

Plot Size:	4.0m x5.0m	**Design:**	Factorial Randomized Block Design
Treatment:	Factor 1:		Spacing 3 levels: (S_1= 60 cm, S_2= 75 cm, S_3= 90 cm)
	Factor 2:		Vermicomposting 3 levels: V_1= 2 ton/ha (600 g/plant), V_2= 3 ton/ha (900 g/plant), V_3= 4 ton/ha (1200 g/plant)
Rows (R):			
R_1	R_2	R_3	**Treatments:**
T_5	T_6	T_3	T_1= S_1V_1 (60 cm x 2 ton/ha (600 g/plant)
T_3	T_4	T_5	T_2= S_1V_2 (60 cm x 3 ton/ha (900 g/plant)
T_9	T_8	T_7	T_3= S_1V_3 (60 cm x 4 ton/ha (1200 g/plant)
T_6	T_9	T_6	T_4= S_2V_1 (75 cm x 2 ton/ha (600 g/plant)
T_1	T_1	T_1	T_5= S_2V_2 (75 cm x 3 ton/ha (900 g/plant)
T_4	T_7	T_4	T_6= S_2V_3 (75 cm x 4 ton/ha (1200 g/plant)
T_8	T_5	T_2	T_7= S_3V_1 (90 cm x 2 ton/ha (600 g/plant)
T_2	T_3	T_9	T_8= S_3V_2 (90 cm x 3 ton/ha (900 g/plant)
T_7	T_2	T_8	T_9= S_3V_3 (90 cm x 4 ton/ha (1200 g/plant)

3. Results and Discussion

3.1.*Ethnobotanical Survey*

The present work involves the study of a total number of 45 species of 8 genera. Traditional uses of rhizomes, leaves, flowers and tubers are used by both local and tribal community has been recorded (Table 1), out of which, some are generally used as vegetable. Among these some are sold in market having economic value. *Hedychium* species, *Kaempferia* species are also an important ornamental plant apart from its high medicinal value. The diversity of the species is shown in Table 2. It shows the presence and absence of the flora in the area [4,5,6, 40,41,42].

Table 2: Ethnobotanically Important Zingiberaceae Species of Manipur and their Utility (Devi *et al*., 2014) [40,41,42,43].

SL NO	SCIENTIFIC NAME	LOCAL NAME	USES OF THE PLANTS	SCIENTIFIC REPORTS
1	*Alpinia calcarata* Roscoe.	*Elaichi*	–Rhizomes used in treating fever, intestinal gas and as a stimulant, fever, muscle pain. New record.	Devi *et al.* (2017). Int. J. Adv. Res. 5(1), 1114-1115.
2	*Alpinia galanga* (L.) Willd.	*Kanghu*	Fresh rhizome is used as condiment, seeds as spice; medicinally abortifacient, carminative, anti-tuberculosis and stimulant properties. Ground rhizome is also used in the treatment of skin infections such as eczema, ringworm etc.	Devi *et al.* (2016). International Journal of Innovative Science, Engineering & Technology, (IJISET), 3(7): 661-665.
3	*Alpinia nigra* (Gaertn.) Burtt.	*Pullei*	Rhizomes and young shoots are used as spices and food flavoring agent. Medicinally in stomach complaints, tonic, diuretic, expectorant, appetizer and analgesic. The inner portion of the aerial parts is cooked as a vegetable and is used in curry for flavoring. The root is used for seasoning.	Devi *et al.* (2016). International Journal of Innovative Science, Engineering & Technology, (IJISET), 3(7): 661-665.
4	*Alpinia officinarum* Hance	*Pullei-manbi*	Rhizomes is stimulant, carminative, stomachic, digestive effects, spicy flavor and aromatic scent, and high concentrations of flavonol galangin.	Devi *et al.* (2016). International Journal of Innovative Science, Engineering & Technology, (IJISET), 3(7): 661-665.
5	*Alpinia zerumbet* (Pers.) B.L. Burtt & R.M. Sm.	*Elaichi-achouba*	Leaves used as herbal tea, anti- diabetic, antioxidant activities of different parts of the plant.	Upadhyay *et al.* J. Agric. Food Chem. 2011, 59. 2857– 2862,
6	*Amomum aromaticum* Roxb.	*Namra*	The seeds are used as condiment and flavoring food, appetizer, tonic for heart and liver, high blood pressure. Young shoots are taken as vegetable. Seed oil contents cineol and applied to the eye inflammations. The husk is mixed with cattle feed in powdered form.	Devi *et al.* (2016). International Journal of Innovative Science, Engineering & Technology, (IJISET), 3(7): 661-665.
7	*Amomum dealbatum* Roxb.	*Namra-manbi*	Root extract applied on boils, fruits edible, young shoots eaten as vegetables.	Devi *et al.* (2016). International Journal of Innovative Science, Engineering & Technology, (IJISET), 3(7): 661-665.
8	*Amomum maximum* Roxb.	*Namra-manbi*	Fruit masticatory, spice and used as a natural insecticide and repellent, oil its bioactive against two stored-product insects.	Guo *et al.*, J. Oleo. Sci. 2015; 64 (12): 1307 – 14. Epub. 2015. Nov. 19.
9	*Amomum pterocarpum* Thwaites.	*Namra-manbi*	Fruit masticatory, spice and condiments, toothache, for curing dysentery, diarrhoea, rheumatism, vomiting, dyspepsia, lung diseases. New record,	Devi *et al.* (2018). Int. J. Adv. Res. 6(1), 546-549,

10	*Amomum subulatum* Roxb.	*Elaichi-achouba*	Fruit is used as a spice, flavoring as food aditives, medicinal, folklore and masticatory mouth freshener.	Devi *et al.* (2016). International Journal of Innovative Science, Engineering & Technology, (IJISET), 3(7): 661-665.
11	*Boesenbergia longiflora* Kuntze.	*Yai- asinba*	Leaves eaten in making dishes. Rhizomes in the treatment of inflammatory bowel diseases, colitis and abscess.	Devi *et al.* (2016). International Journal of Innovative Science, Engineering & Technology, (IJISET), 3(7): 661-665.
12	*Boesenbergia rotunda* (L.) Mansf.	*Yai- macha*	Rhizomes are used in dry cough, muscular pain, applied on toothache, in dermatitis, gum diseases, swelling, wounds and as a diuretic	Devi *et al.* (2016). International Journal of Innovative Science, Engineering & Technology, (IJISET), 3(7): 661-665.
13	*Curcuma amada* Roxb.	*Yai-heinouman*	The rhizome as a condiment, colouring agent, in pickles, and other cuisines, carminative, stimulant, expectorant, appetizer, diuretic, laxative and in skin diseases, stomachic properties and used on sprains, bronchitis.	Devi *et al.* (2016). International Journal of Innovative Science, Engineering & Technology, (IJISET), 3(7): 661-665.
14	*Curcuma angustifolia* Roxb.	*Yaipal*	Source of starch, inflorescence taken as vegetable, rhizomes are used in cough, dysentery and worm infection, fever, gastrointestinal tracts or in the excretory system.	Devi *et al.* (2016). International Journal of Innovative Science, Engineering & Technology, (IJISET), 3(7): 661-665.
15	*Curcuma aromatica* Salisb.	*Lam yaingang*	Rhizomes used as a substitute for turmeric, as cosmetics, herbal medicines and as a culinary ingredient in limited quantities as a food flavor and cultivated frequently.	Devi *et al.* (2016). International Journal of Innovative Science, Engineering & Technology, (IJISET), 3(7): 661-665.
16	*Curcuma caesia* Roxb.	*Yaimu*	The rhizomes are used in cough, sprains, bruises, dysentery, treatment of pneumonia, cough and cold in children and for fever and asthma in adults.	Devi *et al.* (2016). International Journal of Innovative Science, Engineering & Technology, (IJISET), 3(7): 661-665.
17	*Curcuma leucorrhiza* Roxb.	*Yaingou*	Rhizomes are used for treating cough, enlarged liver, spleen, ulcer.	Devi *et al.* (2016). International Journal of Innovative Science, Engineering & Technology, (IJISET), 3(7): 661-665.
18	*Curcuma longa* L.	*Yaingang*	Turmeric is widely cultivated for spice and dye from the rhizome, in foods for flavor and color. Rhizomes are tonic, stimulant, blood purifier, gastrointestinal upset, arthritic pain, digestive disorders, cancer and liver problems and healing of wounds.	Devi *et al.* (2016). International Journal of Innovative Science, Engineering & Technology, (IJISET), 3(7): 661-665.
19	*Curcuma montana* Roxb.	*Yaimu*	The rhizome is used in dysentery and as folk medicine.	Devi *et al.* (2016). International Journal of Innovative Science,

				Engineering & Technology, (IJISET), 3(7): 661-665.
20	*Curcuma zedoaria* (Christm.) Roscoe.	*Lam – yaingang*	Rhizomes used as intestinal worm repellent, in Asthma, analgesic, inflammtion of skin.	Devi *et al.* (2016). International Journal of Innovative Science, Engineering & Technology, (IJISET), 3(7): 661-665.
21	*Elettaria cardamomum* Maton.	*Elaichi*	Fruits are used as masticatory, food flavouring agent, chewed in bad breath. Seed as food flavouring agent, treatment of cold and cough, stomach disorders, urinary systems, asthma, bronchitis, heart problems.	Devi *et al.* (2016). International Journal of Innovative Science, Engineering & Technology, (IJISET), 3(7): 661-665.
22	*Globba bulbifera* Roxb.	*Elaichi-manbi*	Used as folk medicine, ornamental.	Devi *et al.* (2016). International Journal of Innovative Science, Engineering & Technology, (IJISET), 3(7): 661-665.
23	*Hedychium angustifolium* Roxb.	*Takhellei*	Used as folk medicine, ornamental.	Devi *et al.* (2016). International Journal of Innovative Science, Engineering & Technology, (IJISET), 3(7): 661-665.
24	*Hedychium aurantiacum* Roscoe.	*Engellei-hangampal*	Used as folk medicine, ornamental.	Devi *et al.* (2016). International Journal of Innovative Science, Engineering & Technology, (IJISET), 3(7): 661-665.
25	*Hedychium chrysoleucum* Hook.	*Takhellei*	Used as folk medicine, ornamental.	Devi *et al.* (2016). International Journal of Innovative Science, Engineering & Technology, (IJISET), 3(7): 661-665.
26	*Hedychium coccineum* Buch-Ham. ex Sm.	*Engellei-angangba*	Used as folk medicine, ornamental.	Devi *et al.* (2016). International Journal of Innovative Science, Engineering & Technology, (IJISET), 3(7): 661-665.
27	*Hedychium coronarium* J. Koenig.	*Loklei*	Rhizomes used in asthma, bronchitis, blood purification, gastric treatment. Ornamental, food flavouring agent.	Devi *et al.* (2016). International Journal of Innovative Science, Engineering & Technology, (IJISET), 3(7): 661-665.
28	*Hedychium flavescens* Carey ex Roscoe.	*Lam-yaingang*	Used as folk medicine, ornamental, socio-cultural uses.	Devi *et al.* (2016). International Journal of Innovative Science, Engineering &

				Technology, (IJISET), 3(7): 661-665.
29	*Hedychium flavum* Roxb.	*Takhellei*	Used as folk medicine, ornamental.	Devi *et al.* (2016). International Journal of Innovative Science, Engineering & Technology, (IJISET), 3(7): 661-665.
30	*Hedychium gardnerianum* Sheppard ex Kar Gawl.	*Takhellei*	Used as folk medicine, ornamental.	Devi *et al.* (2016). International Journal of Innovative Science, Engineering & Technology, (IJISET), 3(7): 661-665.
31	*Hedychium marginatum* C.B. Clarke.	*Takhellei angangba*	Socio religious uses, ornamental, headache, sinusitis, arthritis.	Devi *et al.* (2016). International Journal of Innovative Science, Engineering & Technology, (IJISET), 3(7): 661-665.
32	*Hedychium maximum* Roscoe.	*Takhellei angouba*	Socio religious uses, folk medicine, ornamental.	Devi *et al.* (2016). International Journal of Innovative Science, Engineering & Technology, (IJISET), 3(7): 661-665.
33	*Hedychium rubrum* A. S.Rao & Verma .	*Takhellei angangba*	Socio religious uses, folk medicine, ornamental.	Devi *et al.* (2016). International Journal of Innovative Science, Engineering & Technology, (IJISET), 3(7): 661-665.
34	*Hedychium spicatum* Sm.	Takhellei-hangampal	Socio religious uses, folk medicine, ornamental. It is used in treatment of nausea, vomiting, diminished appetite and local inflammation. The rhizomes are used in treating asthma and internal injuries.	Devi *et al.* (2016). International Journal of Innovative Science, Engineering & Technology, (IJISET), 3(7): 661-665.
35	*Hedychium stenopetalum* Lodd.	*Engelei angouba*	Socio religious uses, folk medicine, ornamental.	Devi *et al.* (2016). International Journal of Innovative Science, Engineering & Technology, (IJISET), 3(7): 661-665.
36	*Kaempferia galanga* L.	*Yaithamna-manbi*	Rhizome is for the treatment of stomach ulcers, headache, cough, sprains, and diarrhoea.	Parida, et. al., 2010
37	*Kaempferia parviflora* Wall. ex Baker in Hook	*Leibaklei*	Rhizomes used in paralysis. New record	Devi *et al.* (2016). International Journal of Innovative Science, Engineering & Technology, (IJISET), 3(7): 661-665.
38	*Kaempferia rotunda* L.	*Leipaklei*	Roots are stomachic, applied to reduce swellings, tubers made into powder and applied locally on mumps and ointment, efficacious in healing wounds. The flowers contain the toxin benzyl benzoate used to make ointments to treat, scabies and potential antioxidant effects	Nugroho *et al.* (1996); Chopra *et al.* (1956); Nugroho *et al.* (1996). Priya et al. (2008).
39	*Zingiber capitatum* Roxb.	*Sing-manbi*	Socio religious uses, folk medicine, ornamental.	Devi *et al.* (2016). International Journal of Innovative Science, Engineering & Technology, (IJISET), 3(7): 661-665.

40	*Zingiber cassumunar* Roxb.	*Nagasing*	Socio religious uses, folk medicine, ornamental.	Devi *et al.* (2016). International Journal of Innovative Science, Engineering & Technology, (IJISET), 3(7): 661-665.
41	*Zingiber chrysanthum* Roscoe	*Sing-manbi*	Socio religious uses, folk medicine, ornamental.	Devi *et al.* (2017). IOSR Journal of Pharmacy and Biological Sciences (IOSR-JPBS), 12(3): 29-32
42	*Zingiber kangleipakense* Kishor & Skornick	*Sing-manbi*	Socio religious uses, folk medicine, ornamental, young shoot eaten in making chutney	Devi *et al.* (2016). International Journal of Innovative Science, Engineering & Technology, (IJISET), 3(7): 661-665.
43	*Zingiber officinale* Roscoe.	*Shing*	Plant is used as spice, food flavoring agent, cough and cold, irregular menstruation. Improves digestion, reduce edema and swelling, asthma, arthritis, dizziness, menstrual pain, headache, weight loss.	Devi *et al.* (2014). IOSR Journal of Environmental Science, Toxicology and Food Technology (IOSR-JESTFT). 8(2): 21-23.
44	*Zingiber roseum* (Roxb.) Roscoe	*Sing-manbi*	Socio religious uses, folk medicine, ornamental, young shoot eaten in making chutney. New record.	Devi *et al.* (2016). Indian Journal of Applied Research, 6(10): 551-552.
45	*Zingiber zerumbet* (L.) Sm.	*Lam-sing*	Socio religious uses, folk medicine, ornamental, young shoot eaten in making chutney	Devi *et al.* (2016). International Journal of Innovative Science, Engineering & Technology, (IJISET), 3(7): 661-665.

Pytochemical Screening of Zingiberaceae Family

From the Table 3, it is found that *Boesenbergia longiflora* (Wall.) Kuntze. has the highest in phenol content with 5.53 mg and minimum in *Zingiber cassumunar* Roxb. with 3.28 mg. *Alpinia galanga* (L.) Willd. has the highest flavonoid content with 5.54 mg and minimum in *Hedychium coronarium* J. Koenig with 0.32 mg. Tannin is highest in *Hedychium coronarium* with 14.4 mg and lowest in *Alpinia galanga* (L.) Willd. with 0.04 mg (Table 3). From the above Table 2, *Alpinia galanga* (L.) Willd. is found to be the plant with maximum absorbance for free radical scavenging activity with 837.12 mg and minimum in *Boesenbergia longiflora* (Wall.) Kuntze. In this method, the more the absorbance value indicates that the plant extract has more bioactive substances [40,41,42,43].

Table 3: Estimation of Phenolic Compounds and Antioxidants in the selected species of Zingiberaceae

Name of the species	Total Phenol	Total Flavonoid	Total Tannin	Antioxidants
Alpinia galanga (L.) Willd.	3.87±0.35	5.54±2.15	0.04±0.09	837.12±0.15
Amomum subulatum Roxb.	5.32±3.39	0.72± 0.11	0.70± 1.22	705.58±0.79
Boesenbergia longiflora (Wall) Kuntze.	5.53±2.74	1.81±0.09	0.55± 5.01	55.65±1.95
Curcuma angustifolia Roxb.	4.12±0.23	1.57 ±0.53	0.66±2.26	724.19± 2.24
Hedychium coronarium J.Koenig.	5.39±0.34	0.33±0.25	14.49 ±3.51	724.19 ± 2.24
Zingiber cassumunar Roxb.	3.28±0.90	1.72 ± 0.11	0.73 ± 3.99	448.31 ±2.54

The present results show that *Amomum subulatum* Roxb. was recorded to have the highest phenol content (5.65 mg/g) among the plant extract and lowest was recorded in *Curcuma angustifolia* Roxb. with 4.11 mg/g (Table-2). *Boesenbergia longiflora* (Wall.) Kuntze was found to have the highest flavonoid content with 1.8 mg/g and lowest content was recorded in *Amomum subulatum* Roxb. with 0.69 mg/g. The highest tannin content in the methanol extracts of plant species was recorded in *Amomum subulatum* Roxb. (3.52 mg/g) and lowest in *Boesenbergia longiflora* (Wall.) Kuntze with 2.85 mg/g. Presence of phenols plays a vital role in cells which acts as antioxidants thus protecting the human system [35]. They form the active ingredients of medicinal plants [44]. Flavonoids reduce metal cations through chelation and function as free radical scavengers and thus they have antioxidant property by inhibition of free radicals [45,46]. Tannins forms strong complexes with proteins and other molecules where different approaches of bioprospecting of the plant can be reinforced [47].

There are certain literatures which proved that there were correlations between the flavonoid and the tannin content in the plant. The higher the flavonoid content in the plant the lower will be the tannin content and vice versa [45]. Members of this plant family have been consumed and utilized as culinary and medicinal purpose. They are important as they have high antioxidant property [48]. A significant relationship between antioxidant capacity and total phenolic content was found indicating that the higher the phenolic compound, the higher will be the antioxidant properties of the plant species [49, 50, 51]. The presence of phenolic compounds in the selected species shows that they possess a high antioxidant activity having significant ethnobotanical importance. It is beneficial to consume such food plants that have a high antioxidant compound content which will defend us from certain chronic diseases, viz. diabetes, cancers and cardiovascular diseases and they can be a potential and promising drug for the future pharmacological industries [52].

Experiments on the cultivation of *Hedychium marginatum* (*Takhellei-angangaba*) was performed and recorded that, T_5 (S_2 V_2) and T_9 (S_3 V_3) were found to be the best, Spacing of 75-90 cm with vermicompositing at 3-4 tons/ha. It can be clearly seen in case of Interaction (SxV), the highest record was noticed in T_9 (S_3 V_3), the highest record was noticed *i.e.*, Plant height (100.869 cm), No. of flower/spike (24.222), Weight of rhizome/clump (593.686 g) and Leaf area (137.168 cm^2) respectively. Here it is very clear that in *H. marginatum* cultivation, spacing of 75-90 cm with vermicompositing at 3-4 tons/ha in treatments T_5 and T_9 were the best. For a researcher, the most important aims and objective is to get the appropriate scientific way of most luxuriant growth and good yield of the particular crop. As a concluding remark, the pooled value of rhizome yield was found the best (24.90 tons/ha) in T_9 (S_3 V_3) (Table 4) [38].

Soil samples of the experimental plots were analyzed at ICAR Research Complex for NEH Region, Manipur Centre, Lamphelpat, Imphal. Soil pH value was 4.7 i.e. acidic; E.C. was 0.040; organic carbon was 1.3 %; available N, P and K were found to be 405, 20 and 439 kg/ha respectively. Some micronutrients viz., Cu, Fe, Zn and Mn ranges from 2.0, 78.20, 1.2 and 32.80 mg/kg respectively (Fig.2). Correlation between growth parameters were made on the growth and development of *C. angustifolia*. Strong positive correlation between leaf surface area and plant height was found to be effective among other correlations (Fig.4) [39].

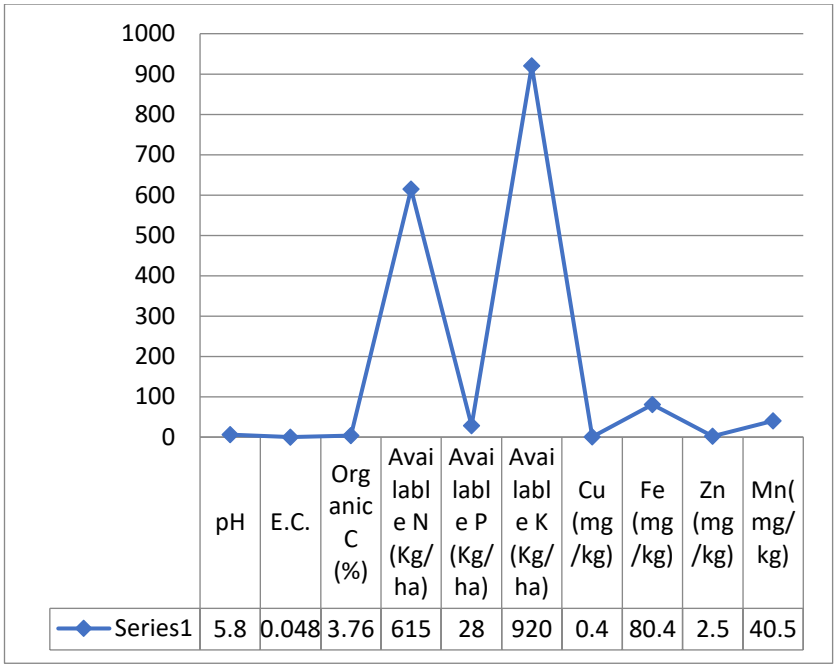

Fig. 2 Soil analysis of the Experimental Fields of *Curcuma angustifolia* Roxb., *Hedychium marginatum* C. B. Clarke., Lamphelpat*
*Soil analysis of the experimental fields was conducted at ICAR Manipur Centre, Lamphelpat, Imphal. (Singh *et al.,* 2021a,b)[38, 39].

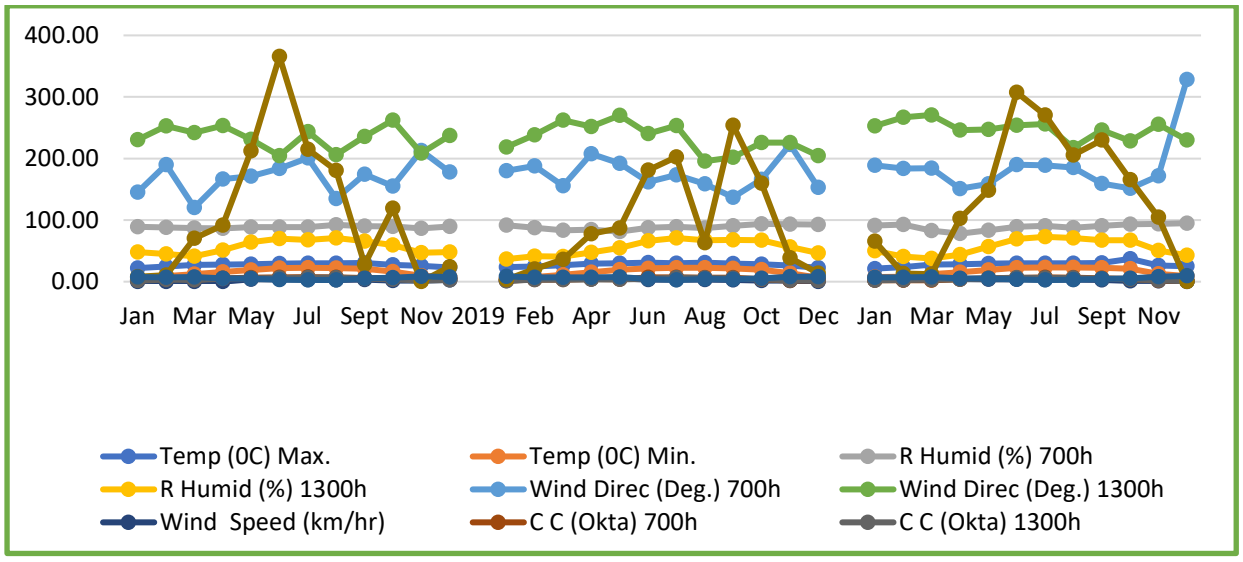

Fig. 3 Weather data of *Curcuma angustifolia* Roxb., *Hedychium marginatum* C. B. Clarke., experimental farm at ICAR Research Complex, Lamphelpat, Imphal from 2018 to 2020 [Source: ICAR Manipur Centre, Lamphelpat]. (Singh *et al.,* 2021a,b)[38, 39].

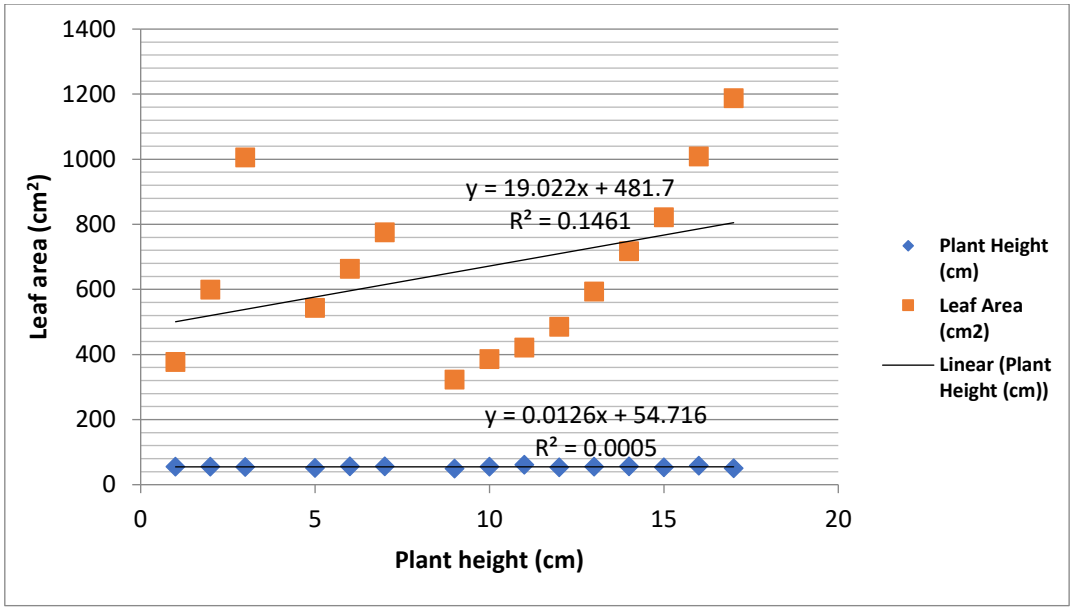

Fig. 4 Correlation between leaf surface area and plant height on the growth and development of *Curcuma angustifolia* Roxb. (Singh *et al.,* 2021b)[39].

Indian arrowroot (*Curcuma angustifolia* Roxb.) commonly known as *Yaipal* in Manipuri belongs to the family Zinziberaceae, is a RET medicinal plant, naturally available in Manipur State, North Eastern India.Continuous exploitation, habitat degradation, unsustainable harvesting and over-exploitation bring substantial loss of their habitat. Scientific cultivation of Indian arrowroot was done at ICAR Research Complex for NEH Region, Manipur Centre, Lamphelpat, Imphal. QPMs (Quality Planting Materials) were adopted in the present research program. Plant Growth Analysis and good harvesting techniques were also adopted to conserve the plant and the findings should be reached to the farmers. Indian arrowroot should be planted at a spacing of 75-90 cm during the month of July, vermicomposting at 3-4 tons/ha, flowering during March to May and harvesting of rhizomes followed. Soil samples for the cultivation of Indian arrowroot should be maintained as follows: Soil pH value was 4.7 i.e. acidic; E.C. was 0.040; organic carbon was 1.3 %; available N, P and K were found to be 405, 20 and 439 kg/ha respectively. Some micronutrients viz., Cu, Fe, Zn and Mn ranges from 2.0, 78.20, 1.2 and 32.80 mg/kg respectively (Fig.2). Weather data of the experimental farm shows that high rainfall noticed during the months of July and September every year; during the plantation months i.e. July temperature is highest and during winter (November to February) the plant dried up and harvesting follows during April-May i.e. spring season [Fig. 3, 5].

Table 4. Influence of spacing and vermicompost on growth and development of *Hedychium marginatum*

Treatment	Plant height (cm)	No. of leaves/ plant	No. of plants/ clump	Days to spike emer -gence	No. of inflores -cence/ clump	No. of flower / spike	No. of rhizomes/ clump	Weight of rhizome (g)	Leaf area (cm^2)
Year (Y)									
Y_1 (2018)	80.45	12.00	14.14	269.96	14.14	15.34	12.98	483.47	100.10
Y_2 (2019)	82.96	12.35	13.71	278.30	13.71	15.44	12.84	484.22	101.14
Y_3 (2020)	82.63	12.61	14.65	281.55	14.65	16.05	12.89	484.25	101.91
S.E.(m)±	0.695	0.268	0.276	3.264	0.276	0.416	0.141	2.439	1.721
C.D. at 5%	1.976	NS	NS	9.282	NS	NS	NS	NS	NS
Spacing (S)									
S_1 (60 cm)	71.02	9.870	10.578	285.43	10.57	10.54	10.66	415.46	77.536
S_2 (75 cm)	80.52	11.88	14.404	269.99	14.40	14.82	13.69	474.96	102.70
S_3 (90 cm)	94.50	15.215	17.526	274.39	17.52	21.48	14.36	561.51	122.91
S.E.(m)±	0.695	0.268	0.276	3.264	0.276	0.416	0.141	2.439	1.721
C.D. at 5%	1.976	0.761	0.786	9.282	0.786	1.182	0.402	6.936	4.893
Vermicom post (V)									
V_1 (2 tons/ha)	77.21	10.59	12.96	281.91	12.96	13.43	12.42	448.37	94.606
V_2 (3 tons/ha)	82.14	13.35	14.267	276.23	14.26	15.85	13.22	493.19	100.34
V_3 (4 tons/ha)	86.70	13.02	15.27	271.67	15.27	17.54	13.08	510.38	108.21
S.E.(m)±	0.695	0.268	0.276	3.264	0.276	0.416	0.141	2.439	1.721
C.D. at 5%	1.976	0.761	0.786	NS	0.786	1.182	0.402	6.936	4.893
Interaction (SxV)									
$T_1 = S_1V_1$	67.68	8.556	8.978	290.13	8.978	9.089	9.256	394.32	71.378
$T_2 = S_1 V_2$	73.18	9.522	10.844	285.68	10.84	10.53	10.82	412.55	74.704
$T_3 = S_1 V_3$	72.20	11.53	11.911	280.46	11.91	12.00	11.92	439.51	86.527
$T_4 = S_2 V_1$	75.34	10.53	13.90	277.33	13.90	13.37	14.28	444.23	98.572
$T_5 = S_2V_2$	79.19	12.26	14.44	269.16	14.44	14.66	13.45	482.72	106.60
$T_6 = S_2V_3$	87.02	12.86	14.867	263.48	14.86	16.42	13.34	497.95	102.94
$T_7 = S_3V_1$	88.59	12.68	16.022	278.26	16.02	17.84	13.73	506.55	113.86
$T_8 = S_3V_2$	94.04	18.28	17.511	273.84	17.51	22.37	15.38	584.30	119.71
$T_9 = S_3V_3$	100.86	14.66	19.044	271.06	19.04	24.22	13.97	593.68	135.16
S.E.(m)±	1.203	0.464	0.479	5.654	0.479	0.720	0.245	4.225	2.981
C.D. at 5%	3.422	1.318	NS	NS	NS	NS	0.697	12.014	8.476
C.V.	4.402	11.28	10.133	6.132	10.13	13.83	5.692	2.619	8.849

*NS=Nonsignificant, while others are significant (Singh *et al.*, 2021a)[38].

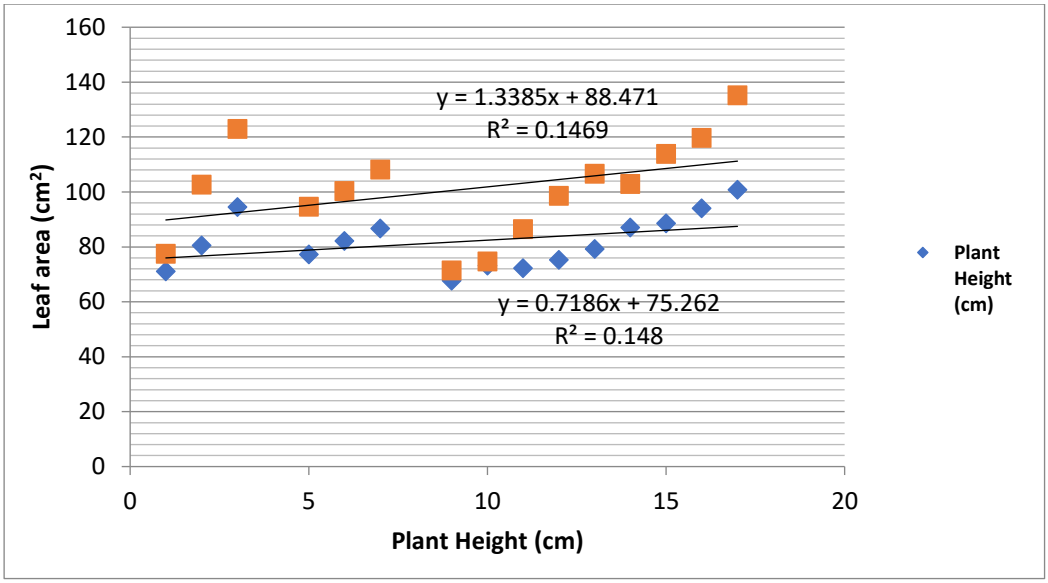

Fig. 5 Correlation between leaf surface area and plant height on the growth and development of *Hedychium marginatum* C. B. Clarke. (Singh *et al.,* 2021a)[38].

Indian arrowroot (*Curcuma angustifolia*) commonly known as *Yaipal* in Manipuri belongs to the family Zinziberaceae, is a RET medicinal plant, naturally available in Manipur State, North Eastern India. Continuous exploitation, habitat degradation, unsustainable harvesting and over-exploitation bring substantial loss of their habitat. Scientific cultivation of Indian arrowroot was done at ICAR Research Complex for NEH Region, Manipur Centre, Lamphelpat, Imphal. QPMs (Quality Planting Materials) were adopted in the present research program. Plant Growth Analysis and good harvesting techniques were also adopted to conserve the plant and the findings should be reached to the farmers. Indian arrowroot should be planted at a spacing of 75-90 cm during the month of July, vermicomposting at 3-4 tons/ha, flowering during March to May and harvesting of rhizomes followed (Table 4).

Soil samples for the cultivation of Indian arrowroot should be maintained as follows: Soil pH value was 4.7 *i.e*. acidic; E.C. was 0.040; organic carbon was 1.3 %; available N, P and K were found to be 405, 20 and 439 kg/ha respectively. Some micronutrients viz., Cu, Fe, Zn and Mn ranges from 2.0, 78.20,1.2 and 32.80 mg/kg respectively. Weather data of the experimental farm shows that high rainfall noticed during the months of July and September every year; during the plantation months *i.e*. July temperature is highest and during winter (November to February) the plant dried up and harvesting follows during April-May *i.e*. spring season (Fig. 2, 3, 4,5) [39].

Extracted leaf essential oil of *C. angustifolia* was found to be predominant with oxygenated sesquiterpenes (68.20 %). Because of the presence of remarkable phytoconstituents, the leaf essential oil of *C. angustifolia* would have enough significance in the food and pharmaceutical industries [53].

An experiment was carried out in *C. angustifolia* cultivation program, based on the influence of spacing on yield, quality and economics of *Tikhur*. Closest spacing of T_1- 45 cm × 20 cm produced highest rhizome yield per plot, rhizome yield per hectare and starch yield per hectare. Starch recovery per cent and protein content did not change due to

different plant spacing. Spacing of T_1-45 cm × 20 cm recorded maximum gross return and net return however maximum benefit: cost ratio was observed in spacing of T_4-60 cm × 20 cm [54]. He conducted that, an experiment during 2018-2019 on the effect of spacing on growth and yield of *Tikhur* (*C. angustifolia* Roxb). In respect of growth parameters closer plant spacing *i.e*. higher plant density produced maximum plant height and leaf area index [55]. Whereas wider spacing produced maximum number of leaves per plant, leaf length and leaf breadth, while, lesser spacing produced the maximum yield per plot and yield per hectare [54].

Shankar *et al* (2014) [56] observed that, high heritability coupled with high genetic advance was for weight of secondary finger rhizome per plant, weight of mother rhizome per plant, etc. [57] did the assessment of genetic divergence of quantitative characters of 20 genotypes of *Tikhur* plant and concluded that genotypes IGBT10-4 and IGSJT-10-2 is recommended to be used as parents for starch recovery per cent and total rhizome yield. flowering plant with modest and small spiked inflorescence and found throughout the EasternIndia, Central and Southern India [58].

Conservation, Cultivation and Propagation of *Zingiberaceae* Species

In India, tribal people consume *C. angustifolia* for healing various ailments such as jaundice, kidney disorders, thirst, fever and flattening the body [59]. Rhizomes are used in treating bone fractures, inflammation and intestinal disorders [33]. The rhizome part of this species is used to cure peptic ulcers, diarrhoea, colitis and also used in treatment of dysentery [60]. Leaf oil of possessed antimicrobial activity [61] and the essential oil extracted from this species are used for its antibacterial and antifungal properties [62]. Both leaves and rhizome of *C. angustifolia* have a camphoraceous aroma and comprises diverse functional constituents such as phenolics, flavonoids and various antioxidant enzymes. The species is of substantial nutritional value particularly as a source of starch for medicine and Indian food. The starch or the powder derived from starch is highly nutritive and digestible and therefore suggested for weak children, infants and invalids. Starch of *C. angustifolia* used as Tugaksheeree is an important ingredient in many Ayurvedic medicines [63].

Yaipal rhizomes are used as an appetizer reducing burning sensations and stomach pains, removal of stone from kidney, useful for ulcer patient [64] and rhizome pulp is used for treatment of headache as well as it gives cooling effect [65]. The rhizome pulp is a remedy for fever, joint pains and leucorrhoea. The starch of *Yaipal* is used for the preparation of many sweet meals and herbal dishes like halwa, barfi, jalebi, etc. It is used specially during fast (Vrata, Upwas). Farmers also prepare herbal drink "*sarbat*" through *tikhur* starch during summer due to its cooling effect [66].

Table 5. Influence of spacing and vermicomposting on growth and development of *Curcuma angustifolia* Roxb.

Treatment	Plant height (cm)	No. of leaves /plant	No. of plants/ clump	Days to spike emerg-ence	No. of inflores-cence/clu mp	Length of flower	Weight of individ-ual flower	No. of rhizome/ clump	Weight of rhizome /clump (g)	Leaf area (cm^2)
Year (Y)										
Y_1 (2018)	52.139	10.622	14.044	278.752	11.163	18.519	19.651	21.744	366.091	680.28
Y_2 (2019)	57.091	10.719	14.548	277.370	10.689	19.118	20.338	22.193	378.924	645.64
Y_3 (2020)	55.277	11.363	14.526	273.696	11.200	18.217	20.733	23.496	389.816	655.59
S.E.(m)±	1.071	0.207	0.305	3.024	0.368	0.301	0.473	0.495	5.363	10.337
C.D. at 5%	3.046	NS*	NS	NS	NS	NS	NS	1.408	15.521	NS
Spacing (S)										
S_1 (60 cm)	55.444	11.674	12.185	282.022	11.526	14.166	14.415	18.052	311.341	376.652
S_2 (75 cm)	54.920	11.459	16.326	266.904	11.830	21.467	18.967	22.848	377.787	598.954
S_3 (90 cm)	54.143	9.570	14.607	280.893	9.696	20.221	27.340	26.533	445.703	1005.91
S.E.(m)±	1.071	0.287	0.305	3.024	0.368	0.301	0.473	0.495	5.363	10.337
C.D. at 5%	NS	0.815	0.867	8.598	1.046	0.855	1.345	1.408	15.251	29.394
Vermicompo sting (V)										
V_1 (2 tons/ha)	51.885	10.326	13.733	284.311	10.326	17.345	17.261	19.604	333.003	543.301
V_2 (3 tons/ha)	56.314	10.933	14.956	274.396	12.015	19.323	20.875	22.430	380.145	662.864
V_3 (4 tons/ha)	56.309	11.444	14.430	271.111	10.711	19.185	22.586	25.400	421.683	775.356
S.E.(m)±	1.071	0.287	0.305	3.024	0.368	0.301	0.473	0.495	5.363	10.337
C.D. at 5%	3.046	0.815	0.867	8.598	1.046	0.855	1.345	1.408	15.251	29.394
Interactio n (SXV)										
T_1= S_1V_1	49.469	10.089	10.956	291.333	10.044	11.542	12.107	14.889	276.361	322.696
T_2= S_1 V_2	55.332	11.311	12.378	285.067	12.800	13.642	15.496	17.022	298.081	385.982
T_3= S_1 V_3	61.530	13.622	13.222	269.667	11.733	17.313	15.642	22.244	359.580	421.279
T_4= S_2 V_1	53.219	10.867	15.356	277.533	11.133	20.089	16.229	20.100	333.533	485.604
T_5= S_2V_2	54.974	11.800	17.889	256.822	12.867	23.307	19.582	23.511	393.704	593.827
T_6= S_2V_3	56.568	11.711	15.733	266.356	11.489	21.004	21.091	24.933	406.123	717.432
T_7= S_3V_1	52.968	10.022	14.889	284.067	9.800	20.404	23.449	23.822	389.114	821.602
T_8= S_3V_2	58.634	9.689	14.600	281.300	10.378	21.020	27.547	26.756	448.650	1008.78
T_9= S_3V_3	50.828	9.000	14.333	277.311	8.911	19.238	31.023	29.022	499.344	1187.35
S.E.(m)±	1.856	0.496	0.528	5.237	0.637	0.521	0.819	0.857	9.290	17.905
C.D. at 5%	5.277	1.412	1.501	NS	NS	1.480	NS	NS	26.415	50.912
C.V.	10.152	13.661	11.021	5.680	17.348	8.389	12.143	11.444	7.367	8.132

*NS=Nonsignificant, while others are significant, Singh *et al.*,2021b, [39]

C. angustifolia is a fast-growing annual herb, generally distributed in the foothills, at an elevation of 915 to 1220 metres above the mean sea level in Manipur. It attains a height up to 90-180 cm. The genus *Curcuma* of the family Zingiberaceae comprises of about 80 species, widely distributed in tropic of Asia, Africa, Southeast Asia, Australia and other warm parts of the world [17].

C. angustifolia Roxb., commonly known as East Indian Arrowroot, is an important medicinal plant [23], having tremendous export value in national and international market. *C. angustifolia* is called by different names in India *i.e*. Tikhur in Hindi, Keturi Halodhi in Bengali, Tavakshira in Sanskrit, Yaipal in Manipuri, Tavakeera in Marathi, Koova in Malayalam, Ararut-kizhagu in Tamil, Koove-hittu in Kannada, Ararut-gaddalu in Telugu. It is a rhizomatous perennial flowering plant with modest and small spiked inflorescence and found throughout the Eastern India, Central and Southern India [58].

In India *Yaipal* is commonly used as a demulcent, nutritious, contains starch which is used for children due to easily digestible. It is an excellent diet in the form of conjee in case of dysentery, dysuria, gonorrhoea, etc. *Yaipal* is used in many ailments' dates back close to 5000 years. Ayurveda codified about 8000 herbal remedies. *Tavaksheeri* is a drug used in many ailments for its various pharmacological activities. *Tavaksheeri* is the starch obtained from the rhizomes of *Curcuma angustifolia*. Dalhana identified that tugakshiri is something which is quite similar to vamsalochana and now identified as *Curcuma angustifolia*. In Manipur State *Yaipal* is a common plant with high demand for its flower as well as rhizome. Flowers developed after monsoon *i.e*., during the month of March- April and continues up to May-June before the development of young shoots. People of Manipur indiscriminately harvested the flowers for the preparation of many delicacies (*Bora, Eronba, Athongba, Kanghou*, etc.) as a vegetable.

The flowers are selling in the local market @ Rs.100 to 200 per kg in fresh or in dried condition. So, in Manipur, there is continuous exploitation, habitat degradation, unsustainable harvesting and over-exploitation bringing substantial loss of the habitat of *Yaipal* is still going on. Keeping this in view, an experiment was designed to validate the most favourable cultivation practices by following the Agricultural practices of ICAR, Research Complex for NEH Region, Manipur Centre, Lamphelpat field condition [39].

H. marginatum is commonly known as "Red Ginger Lily" or "Garland Flower" bears beautiful and often aromatic flowers having sweet scented flowers, so the plant is cultivated for its flower ornamenting women's hair in the north eastern India. The rhizome along with tender plant as a whole is edible, yield essential oils used in delicate and high-quality perfumes besides in traditional system of medicine for the treatment of asthma, bronchitis, eye diseases, gastric diseases, and as a tonic and blood purifier [38].

So many researchers have investigated the utility of Red Ginger Lily in the treatment of various ailments. The plant is important in natural resources that provide useful products such as food, spices and condiments, medicines, dyes, perfumes and aesthetics to man [4,5,6]. Red Ginger lilies are cultivated for its rhizome in tropical areas of South and East India [51]. It is enriched by a large number of medicinal plant species with well-known properties of ethno-medicine [3]. Many researchers from every corner of our globe are interested for the cultivation of this Lily [67,68,69, 70,71, 72,73,74].

Plantation of *Takhellei-angangba* was done in the month of July, in 3 levels of spacing. Vermicomposting was also done in 3 levels; flowering was recorded during the month of March to May of the next year and harvesting follows. Among the treatments, larger the

spacing and more vermicomposting results best flower initiation and good rhizome weight. During the three crop seasons, the third crop (2020) is the best in all the parameters.

Hedychium marginatum C. B. Clarke of the family Zingiberaceae was cultivated under ICAR, Research Complex for NEH Region, Manipur Centre, Lamphelpat field condition. Experiments were planned with Factorial Randomized Block Design for 3-crop seasons (2018 to 2020). The study deals with the growth and development of *H. marginatum*, seedlings, influenced by spacing, vermicomposting and correlations amongst the growth parameters, so as to validate the most favourable conservation method for this endangered plant. The third crop (2020) was found the best, during the three crop seasons. Among the treatments, T_5 (S_2 V_2) and T_9 (S_3 V_3) were found to be the remarkable crop production and plant growth parameters. Spacing of 75-90 cm with compositing at 3-4 tons/ha) were the best. Whereas, lowest value of Treatment T_1 (60 cm spacing and 2 tons/ha vermicomposting) was found unsuitable. Strong positive correlation between leaf surface area and plant height on the growth and development was found to be effective among other correlations (Table 4) [38].

While in *Curcuma angustifolia* cultivation program, maximum benefit: cost ratio was observed in spacing of T_4 - 60 cm × 20 cm (Ghyar *et al*., 2019, 2020). However, in the present *Takhellei-angangba* cultivation spacing of 75-90 cm with compositing at 3-4 tons/ha) in treatments T_5 and T_9 were the best. Whereas, lowest value of treatment T_1 in which 60 cm spacing and 2 tons/ha compositing was unfavorable for the growth of *Takhellei-angangba.* The plant can grow luxuriantly in the ICAR Experimental Farm, Lamphelpat. However, among the treatments, T_5 (S_2 V_2) and T_9 (S_3 V_3) found the remarkable crop production and plant growth parameters (Table 5)[39].

Conclusion

There is a scope for collection and documentation of these plant species. So, the present study would emphasize to study the flora of Zingiberaceae in the valley districts of Manipur which would help in conservation of the existing diversity and to protect such potentially useful economic plant wealth for present use and for prosperity.

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