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Morpho chemical characterisation of some underutilised vegetables under different shade conditions

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Abstract
With the ever increasing world population, agriculture is under pressure to produce greater quantities of food, feed and bio fuel on limited land resources. Current over-reliance on a handful of major staple crops has inherent agronomic, ecological, nutritional and economic risks and is probably unsustainable in the long run. Wider use of today's underutilized minor crops provides more options to build temporal and spatial heterogeneity into uniform cropping systems and will enhance resilience to both biotic and abiotic stress. The aim of the experiment was to check the performance of the five selected important underutilised vegetables of the region with medicinal properties under different shade conditions of and to develop the cultivation practices of these underutilised vegetables. Five different UVs were grown in different shade conditions of 25%, 50%, 75% and open conditions in RBD. Various morphological and biochemical characters were studied under the different treatments. It was found out the morphological and biochemical characters of the five UVs differ under the different treatments and according to their performance the best shade condition can be identified. Different species performed differently under different shade conditions. As a whole the performance of V1 is best under 75% and 50%; V2 under 75% and 50%; V3 under 50%; V4 under 50% and V5 under 50%. Best shade conditions can be used for planting these plants for better yield and better biochemical contents.

Keywords: Underutilised vegetables, North east India, Shade, biochemical, morphological

Introduction

Agriculture is under increasing pressure to produce greater quantities of food, feed and biofuel on limited land resources for the projected nine billion people on the planet by 2050 (Godfray *et al*. 2010) [4]. It is envisioned that agricultural production has to increase by 70% by 2050 to cope with an estimated 40% increase in world population Bruinsma (2009) [1]. Ninety percent of this growth is expected to result from enhanced cropping intensity and higher crop yields, while the remainder has to be produced on land currently not used for agricultural production. As contrast to the above-mentioned major staple crops, underutilized, undervalued or neglected crops-also branded development opportunity crops (DOCs) (Kahane *et al.* 2013) [12]-are categorized in this article as—minor crops that are already cultivated, but are underutilized regionally or globally given their still relatively low global production and market value (Stamp 2012; Ochatt and Jain 2007; Jain and Gupta 2013) [18, 16, 11]. Some of these crop species may be found widely distributed globally, but are restricted to a more local production and consumption system. Many of these traditional crops are grown for food, fibre, fodder, oil and as sources of traditional medicine but they play a major role in the subsistence of local communities and frequently are of special social, cultural and medicinal value. They adapt well in marginal lands and constitute an important part of the local diet of rural communities providing valuable nutritional components, which are often lacking in staple crops. As a result of the Green Revolution, many of these local, traditional crop species and varieties have been replaced by high-yielding staple crop cultivars developed by modern breeding programs. Traditional crops typically do not meet modern standards for uniformity and other characteristics as they have been neglected by breeders from the private and public sectors (Stamp *et al*. 2012) [18]. Thus they tend to be less competitive in the marketplace compared with commercial cultivars which are developed through meticulous efforts. Landraces and crop wild relatives have hitherto been increasingly valued and exploited for genes that provide increased biotic resistance, tolerance to abiotic stress, yield and quality {Frison *et al*. 2011; Jackson *et al.* 2007; McCouch (2013) [3, 9, 15]. Many traditional or indigenous vegetables are characterized by a high nutritional value compared with global vegetables like tomato and cabbage (Keatinge *et al*. 2011) [13]. As an alternate source of essential vitamins, micronutrients, protein and other phytonutrients, traditional vegetables or underutilized vegetables have the potential to play a major role in strategies to attain nutritional security. Apart from the provision of essential vitamins, many of the vegetable crops included in home garden kits are known to be naturally nutrient-dense (Hughes and Keatinge 2013) [7]. These vegetables are also considered important for sustainable food production as they reduce the impact of production systems on the environment apart from their cultural, medicinal and social importances. Many of these crops are hardy, adapted to specific marginal soil and climatic conditions, and can be grown with minimal external inputs {De la Peña *et al.* 2011; Hughes and Ebert 2013 [2, 6]}. Collection and consumption of raw plant parts from the wild is the common practice of the people of north eastern region of India especially living in hilly and rural areas. There is an ample supply of these vegetables from the wild and fallow lands. Documentation of these local vegetables used by the tribal people on daily basis and highlighting the important Nutraceuticals and important chemicals content will give us a scope of exploiting these vegetables. Developing scientific methods of agro techniques and post harvest management will help in the popularizing of these underutilized vegetables. Popularity of these vegetables in turn will help in lessening the dependence on standard crops and at the same time consumers can enjoy the medicinal benefits as well as new food. Collection and maintenance of these germplasm will serve as the genetic resources for the regular plant breeders and screening of the germplasm will give elite clones existing in the nature. Development of high throughput cultivation practices and packages will fulfill the substantial demand in the global pharmaceutical market and also promote the livelihood of the farmers of North East India. In order to realize this developmental need, we are concentrating its efforts on the spread of proven and sustainable technology packages which create employment, raise income and improving standard of live of economically weaker sector of the society. As per the urgent need for collection, documentation and development of cultivation practices of these underutilized vegetable species found in the region the research work was implemented. Five underutilized vegetables with medicinal properties were collected and planted in the college research plots. The species selected for the studies are *Acmella oleraceae, Clerodendrum coolebrookianum, Solanum torvum, Pouzolzia hirta* and *Eryngium foetidum*. Various morphological and biochemical characters were recorded for these species.

Material and method

Five underutilized vegetable plants with ethno medicinally important values were selected for the present study. The species selected were V1-*Acmella oleracea,* V2-*Solanum torvum,* V3-*Clerodendrum coolebrookianum,* V4 - *Pouzolzia hirta* and V5 -*Eryngium foetidum* (Fig. 1) and they are planted at the College of Horticulture and Forestry field at Pasighat, Arunachal Pradesh. The plots were laid out in RBD under 3 different shade conditions (S1-75%, S2-50% and S3-25%) and open condition (O) as control. Morphological and biochemical parameters were recorded at the time of maturity of the economical parts. Quantitative estimation of Biochemical components such as total chlorophyll, total carbohydrate, reducing sugar, total soluble protein, total alkaloids, flavonoids and vitamin C were carried out as per the standard protocol [Jagota and Dani 1982; Lowry *et al*. 1951; Sadasivam and Manickam 2005; Vijay and Rajendra 2014) [11, 16, 19, 22]. Statistical calculations were done as per Gomez and Gomez 1976 [6].

Results and discussion

The experiment was conducted for three years and the data were pooled. Out of the five species planted, the two were shrubs (*Solanum torvum* and *Clerodendrum coolebroookianum*) and the other three species were herbs (*Acmella oleracea, Pouzolzia hirta* and *Eryngium foetidum*). These five underutilised plants are important daily vegetables consumed by the local people of the region. *Solanum torvum* and *Clerodendrum coolebroookianum* are perennial while *Acmella oleracea*, *Pouzolzia hirta* and *Eryngium foetidum* are annuals but can be maintained as perennial under proper maintenance and care. Various morphological and biochemical data recorded that the performance of these plant species vary according to the different shade conditions.

Morphological Parameters

In *A. oleracea*, plant height was maximum in 50% shade condition (19.67 cm) which was at par with plants grown under 25% (17.22 cm) and open condition (19.11 cm). The minimum reading was recorded in 75% conditions (9.67 cm). Plant spread was maximum under open conditions (24.56 cm) and the lowest was found in 75% shade conditions (11.89 cm). There was no significant difference amongst the treatments on the leaf length in this species. Leaf breadth was recorded maximum under 50% shade conditions (3.43 cm) and the lowest was recorded in open conditions (2.82 cm). The leaf area was found to be maximum in plants grown in 50% shade (10.33 cm^2) and the lowest was found in plants grown under 75% shade conditions (5.92 cm^2). (Table 1)

In *Solanum torvum*, plant height was maximum in 50% shade (1.96 m) and the minimum was recorded in plants grown in open conditions (1.46 m). Differences plant spread was found to be statistically non significant. Leaf length was found to be maximum under 75% shade conditions (29.69 cm) and the minimum leaf length was recorded in plants grown in open conditions. The leaf breadth was found to be maximum in 50% shade (30.60 cm) which was at par with plants grown in 75% shade (29.27 cm). The minimum leaf breadth reading was found in plants grown under open condition (23.54 cm). Maximum leaf was recorded in 75% (712.33 cm^2) and the minimum was recorded in plants grown under open conditions (359.86 cm^2). (Table 2)

Plant height and plant spread was found to be non significant in *C.coolebrookianum*. Leaf length was found to be highest in S2 (24 cm) which is at par with S1 (23.67 cm). The minimum reading was recorded in O (14.22 cm). Leaf area was recorded highest in S2 (353.69 cm^2) and the lowest was recorded in O (164.15 cm^2). (Table 3)

Plant height in *P. hirta* was recorded highest in V4 (18.81 cm) and the minimum was recorded in O (6.00 cm). Differences in plant spread under the different treatment was found to be non significant under the different treatments. Maximum leaf length was recorded in V4 (4.79 cm) which was at par with S2 (4.35 cm) and S3 (4.19 cm) respectively. Minimum leaf area was recorded in O (3.47 cm). Maximum leaf breadth was recorded in S2 (4.05 cm) and the minimum was recorded in O (1.47 cm). Leaf area recorded highest in S2 (12.oo cm^2) and the minimum was recorded in O (4.62 cm^2). (Table 4)

In *E. foetidum*, Maximum plant height was recorded in S1 (8.93 cm) which was in par with S2 (7.20 cm) and the minimum was recorded in O (4.47 cm). Plant spread was recorded maximum in V2 (15.60 cm) which was at par with

S1 (14.53 cm) and S3 (14.27 cm) respectively. Maximum leaf length was observed in S1 (12.80 cm) which was at par with that of S2 (12.00 cm), O (12.13 cm) and S3 (10.93 cm) respectively. Maximum leaf breadth was recorded in S1 (17.07 cm) and the minimum was recorded in O (12.89 cm). Leaf area recorded maximum in S1 (3.75 cm^2) which is at par with S2 (3.47 cm^2), S3 (3.53 cm^2) and O (3.41 cm^2) respectively. (Table 5)

Biochemical Parameters

In *A. Oleracea* total alkaloid content was found to be highest in S1 (292.28) and the lowest was observed in O (32.95). Highest total soluble protein was found in S1 (405.91) and the lowest was found in O (220.46). Total carbohydrate was found highest in S3 (25.56) and the minimum was found in S1 (6.54). Highest reducing sugar was observed in S1 (0.47) and the lowest was observed in O (0.07). The flavonoid content was highest in S3 (1.70) and the lowest was observed in S1 (0.79). Total phenol content was found to be highest in S3 (3.29) and the lowest was observed in S1 (1.09). Total Chlorophyll content was highest in S2 (75.29) and the lowest was found in O (27.66). (Table 6)

Total alkaloid content in *C. Coolebrookianum* was highest in S2 (193.53) and the lowest was observed in O (77.05). Vitamin C content was found in S3 (0.04) which was at par with S2 (0.02) and the lowest observed in S1 (0.01). Highest total soluble protein was found in S2 (320.83) and the lowest was found in S1 (154.91). Total carbohydrate was found highest in S3 (35.79) and the minimum was found in S1 (7.02). Highest reducing sugar was observed in S2 (0.22) and O (0.22). The lowest was observed in S1 (0.09). The flavonoid content was highest in S3 (0.93) and the lowest was observed in S1 (0.28). Total phenol content was found to be highest in S2 (2.41) which is at par with O (2.32) and the lowest was observed in S1 (1.78). Total Chlorophyll content was highest in S3 (96.45) which is at par with S2 (96.29) and the lowest was found in S1 (73.14) (Table 7).

In *S. torvum*, maximum total alkaloid content was found to be highest in S1 (262.25) and the lowest was observed in S3 (86.70). Highest total soluble protein was found in O (263.71) and the lowest was found in S2 (76.59). Total carbohydrate was found highest in S2 (54.23) and the minimum was found in S1 (11.09). Highest reducing sugar was observed in S2 (0.42) and the lowest was observed in S3 (0.07). The flavonoid content was highest in O (1.41) and the lowest was observed in S1 (0.64). Total phenol content was found to be highest in S2 (3.42) and the lowest was observed in S1 (0.62). Total Chlorophyll content was highest in S1 (92.6) which is at par with S3 (81.1). The lowest reading was recorded in S2 (41.4). (Table 8)

In *P. hirta*, maximum total alkaloid content was found to be highest in S2 (190.51) and the lowest was observed in O (86.70). Highest Vitamin C content was found in S2 (0.03) which was at par with S1 (0.01), S3 (0.02) and O (0.01). Highest total soluble protein was found in S1 (151.50) and the lowest was found in O (109.35). Total carbohydrate was found highest in S2 (18.85) and the minimum was found in S3 (8.98). Highest reducing sugar was observed in S2 (0.25) and the lowest was observed in S1 (0.09). The flavonoid content was highest in S2 (1.56) and the lowest was observed in S1 (0.96). Total phenol content was found to be highest in S2 (2.30) and O (2.30) and the lowest was observed in S1 (0.70). Total Chlorophyll content was highest in S3 (81.92) which is at par with S1 (79.41) and S2 (78.56). The lowest reading was recorded in S1 (66.0). (Table 9)

In *E. foetidum*, maximum total alkaloid content was found to be highest in S1 (148.46) and the lowest was observed in O (83.38). Differences in Vitamin C content under different treatments were found to be non-significant. Highest total soluble protein was found in O (271.23) and the lowest was found in S1 (83.08). Total carbohydrate was found highest in S2 (24.38) and the minimum was found in S1 (4.85). Differences in reducing sugar content under different treatments were found to be non-significant. The flavonoid content was highest in S2 (1.01) and S3 (1.01) and the lowest was observed in S1 (0.48). Total phenol content was found to be highest in S2 (2.34) and the lowest was observed in S1 (0.65). Total Chlorophyll content was highest in S1 (79.39) which is at par with S2 (76.15). The lowest reading was recorded in O (66.85). (Table 10)

Summary and conclusion

The study was carried out to investigate on the best time and methods of planting and to develop the package of practices for 5 selected underutilised vegetable plants which also have medicinal properties. Five underutilized vegetable plants with ethno medicinally important values were selected for the present study. The species selected were V1-*Acmella oleraceae*, V2-*Solanum torvum*, V3*Clerodendrum coolebrookianum*, V4 - *Pouzolzia hirta* and V5 - *Eryngium foetidum* and they are planted at the College of Horticulture and Forestry field at Pasighat, Arunachal Pradesh (Fig. 1). The plots were laid out in RBD under 3 different shade conditions (S1-75%, S2-50% and S3-25%) and open condition (O) as control. Morphological and biochemical parameters were recorded at the time of maturity of the economical parts.

As per the results of the various morphological and biochemical characters we have recorded the different types of treatments have different effects on each species and base on the highest morphological recordings and biochemical readings the recommendation for cultivating the various species can be done. On the basis of the various characters recorded the recommended package of practices of the different species are as follows.

Acmella oleracea

Habit – Annual herb but can be maintained as perennial
Soil – sandy loam soils
Climate – warm humid, tropical
Propagation – seeds and cuttings
Seed/ cuttings rate – 25000 to 30000 cuttings per hectare
Spacing – 60m x 60m
Manures and fertilizers – Organic manures like FYM, Vermicompost as per need
Date of planting – March-April
Method of planting – Transplanting
Best shade condition – 75% and 50%
Method of harvesting – cutting the shoot 5-6 cm from the apex with tender leaves and flowers
Storage – Cool shady place

Clerodendrum Coolebrookianum

Habit – Perennial shrub
Soil – Sandy loam soils
Climate – warm humid, tropical
Propagation – seeds and cuttings
Seed/ cuttings rate – 10000 -12000 cuttings per hectare
Spacing – 1m x 1m

Manures and fertilizers – Organic manures like FYM, Vermicompost as per need
Date of planting – Feb- March
Method of planting – Transplanting
Best shade condition – 75% and 50%
Best time for harvesting – All round the year after
Method of harvesting – Cutting the shoot 4-5 cm from the apex with tender leaves
Storage – Cool shady place

Solanum torvum
Habit – Perennial shrub
Soil – Sandy loam soils
Climate – warm humid, tropical
Propagation – seeds
Seed rate – per hectare – 200 to 300 gm per Ha.
Spacing – 1m x 1m
Manures and fertilizers – Organic manures like FYM, Vermicompost as per need
Date of planting – March- April
Method of planting – Transplanting
Best shade condition – 50%
Best time for harvesting – All round the year after
Method of harvesting – Collection of immature fruits
Storage – Cool shady place

Pouzolzia hirta
Habit – Annual herb but can be maintained as perennial
Soil – Sandy loam soils
Climate – warm humid, tropical
Propagation – Runners
Seed/ cuttings rate – 25000 to 30000 cuttings per hectare
Spacing –60cm x 60cm
Manures and fertilizers – Organic manures like FYM, Vermicompost as per need
Date of planting – March-April
Method of planting – Transplanting
Best shade condition – 50%
Best time for harvesting – All round the year
Method of harvesting – harvesting the shoot 4-5 cm from the apex with tender leaves and shoots
Storage – cool shady place

Eryngium foetidum
Habit – Annual herb but can be maintained as perennial
Soil – Sandy loam, clayey soils
Climate – warm humid, tropical
Propagation – seeds
Seed/ cuttings rate – 35000 to 36000 cuttings per hectare
Spacing –20cm x 20cm
Manures and fertilizers – Organic manures like FYM, Vermicompost as per need
Date of planting – March-April
Method of planting – Transplanting
Best shade condition – 50%
Best time for harvesting – All round the year
Method of harvesting – harvesting the matured leaves from each plant or cutting the whole plant at the base
Storage – cool shady place

The numerous varieties of UVs offer potential sources of micronutrients; nevertheless, just like other plants, they contain varying levels of alkaloids, flavanoids too. Consumption of the UVs will definitely benefit the people especially of the developing nations in relation to reducing hidden hunger, thus ensuring food and nutritional security. The package and practice of cultivation techniques will surely help in more large scale cultivation and promotion of these underutilised crops and gain commercial status.

Table 1: Morphological characters of *Acmella oleracea*

Treatment	Plant height (cm)	Plant spread(cm)	Leaf length (cm)	Leaf breadth(cm)	Leaf area (cm^2)
S1V1	9.67	11.89	2.94	2.88	5.92
S2V1	19.67	16.44	4.04	3.43	10.33
S3V1	17.22	16.00	3.54	2.97	7.26
OV1	19.11	24.56	3.30	2.82	6.94
Lsd	4.373*	7.095	NS	0.3946	2.861
CV%	8.49	20.49	13.8	6.27	17.08

Table 2: Morphological characters of *Clerodendrum Coolebrookianum*

Treat ment	Plant height (cm)	Plant spread(cm)	Leaf length (cm)	Leaf breadth(cm)	Leaf area (cm^2)
S1V2	1.77	3.05	29.69	29.27	712.33
S2V2	1.96	3.06	26.46	30.60	479.53
S3V2	1.89	2.74	25.16	26.12	558.68
OV2	1.46	3.22	19.34	23.54	359.86
Lsd	0.328	NS	2.846	3.964	78.87
CV%	9.27	11.83	3.74	4.78	4.94

Table 3: Morphological characters of *Solanum torvum*

Treatment	Plant height (cm)	Plant spread(cm)	Leaf length (cm)	Leaf breadth (cm)	Leaf area (cm^2)
S1V3	1.89	5.27	21.96	23.67	310.51
S2V3	1.69	4.84	21.50	24.00	353.69
S3V3	1.48	5.21	18.50	21.50	306.30
OV3	1.67	4.56	14.22	17.16	164.15
Lsd	NS	NS	1.576	2.305	14.52
CV%	14.88	8.64	2.74	3.53	1.69

Table 5: Morphological characters of *Eryngium foetidum*

Treatment	Plant height (cm)	Plant spread(cm)	Leaf length (cm)	Leaf breadth (cm)	Leaf area (cm^2)
S1V5	8.93	14.53	12.80	17.07	3.75
S2V5	7.20	15.60	12.00	15.29	3.47
S3V5	4.93	14.27	10.93	14.30	3.53
OV5	4.47	12.07	12.13	12.89	3.41
Lsd	2.604	2.335	2.595*	0.2825	13.7*
CV%	20.42	8.28	5.76	4.02	11.11

Table 4: Morphological characters of *Pouzolzia hirta*

Treatment	Plant height (cm)	Plant spread (cm)	Leaf length (cm)	Leaf breadth (cm)	Leaf area (cm^2)
S1V4	18.81	31.43	4.79	2.14	9.12
S2V4	9.00	29.93	4.35	4.05	12.00
S3V4	7.93	29.80	4.19	1.85	7.86
OV4	6.00	23.20	3.47	1.47	4.62
Lsd	7.474*	NS	0.7422	1.713	1.895
CV%	23.66	21.65	8.84	36.04	11.71

Table 6: Biochemical characters of *Acmella oleracea*

Treatment	Total Alkaloid (mg/100 g)	Vitamin C (mg/100 g)	Total soluble protein (mg/100 g)	Total carbohydrate (mg/100 mg)	Reducing sugar (%)	Flavonoid Content (mg/100 g)	Total phenol (mg/100 g)	Total chlorophyll (mg/100g)
S1V1	292.28	0.00 (0.71)	405.91	6.54	0.47 (0.98)	0.79 (1.14)	1.09 (1.26)	67.27
S2V1	61.87	0.01 (0.71)	305.81	11.23	0.16 (0.81)	1.21 (1.31)	2.24 (1.66)	75.29
S3V1	111.70	0.06 (0.75)	264.16	25.56	0.22 (0.85)	1.70 (1.48)	3.29 (1.95)	60.14
OV1	32.95	0.02 (0.72)	220.46	13.81	0.07 (0.75)	1.57 (1.44)	2.78 (1.81)	27.66
Lsd (p=0.05)	20.41	NS	18.23	2.093	0.030	0.030	0.096	4.19
Cv%	5.41	0	2.01	4.84	0.96	0.95	1.74	2.40

Table 7: Biochemical characters of *Clerodendrum Coolebrookianum*

Treatment	Total Alkaloid (mg/100 g)	Vitamin C(mg/100 g)	Total soluble protein (mg/100 g)	Total carbohydrate (mg/100 mg)	Reducing sugar (%)	Flavonoid Content (mg/100 g)	Total phenol (mg/100 g)	Total chlorophyll (mg/100g)
S1V2	163.12	0.01 (0.71)	154.91	7.02	0.09 (0.77)	0.28 (0.88)	1.78 (1.51)	73.14
S2V2	193.53	0.02 (0.72)	320.83	15.73	0.22 (0.85)	0. 60 (1.05)	2.41 (1.70)	96.29
S3V2	164.15	0.04 (0.73)	275.94	35.79	0.18 (0.83)	0.93 (1.20)	2.12 (1.62)	96.45
OV2	77.05	0.01 (0.72)	205.91	8.67	0.22 (0.85)	0.56 (1.03)	2.32 (1.68)	80.02
Lsd (p=0.05)	13.71	0.030	16.76	1.083	0.030	0.030	0.096	4.56
Cv%	3.03	0.40	2.31	2.13	1.20	1.17	1.56	1.74

Table 8: Biochemical characters of *Solanum torvum*

Treatment	Total Alkaloid (mg/100 g)	Vitamin C(mg/100 g)	Total soluble protein (mg/100 g)	Total carbohydrate(mg/100 mg)	Reducing sugar (%)	Flavonoid Content (mg/100 g)	Total phenol (mg/100 g)	Total chlorophyll (mg/100g)
S1V3	262.25	0.02 (0.72)	152.42	11.09	0.13 (0.79)	0.64 (1.07)	0.62 (1.06)	9.26
S2V3	192.92	0.02 (0.72)	76.59	54.23	0.42 (0.96)	0.90 (1.18)	3.42 (1.98)	4.14
S3V3	86.70	0.00 (0.71)	136.46	21.75	0.07 (0.76)	1.01 (1.23)	0.85 (1.16)	8.11
OV3	105.71	0.01 (0.72)	263.71	17.05	0.26 (0.87)	1.41 (1.38)	1.05 (1.24)	7.90
Lsd (p=0.05)	25.56	NS	12.86	1.56	0.030	0.030	0.17	1.43
Cv%	5.22	0	2.71	1.99	1.35	1.40	4.32	6.44

Table 9: Biochemical characters of *Pouzolzia hirta*

Treatment	Total Alkaloid (mg/100 g)	Vitamin C(mg/100 g)	Total soluble protein (mg/100 g)	Total carbohydrate(mg/100 mg)	Reducing sugar(%)	Flavonoid Content (mg/100 g)	Total phenol (mg/100 g)	Total chlorophyll (mg/100g)
S1V4	149.62	0.01 (0.71)	151.50	14.65	0.09 (0.77)	0.96 (1.21)	0.70 (1.10)	79.41
S2V4	190.51	0.03 (0.73)	139.92	18.85	0.25 (0.87)	1.56 (1.43)	2.30 (1.67)	78.56
S3V4	146.60	0.02 (0.72)	115.31	8.98	0.14 (0.80)	0.98 (1.22)	1.72 (1.49)	81.92
OV4	65.87	0.01 (0.72)	109.35	12.49	0.16 (0.82)	1.01 (1.23)	2.30 (1.67)	66.00
Lsd (p=0.05)	18.82	0.030	5.473	0.46	0.030	0.030	0.096	4.73
Cv%	4.50	0.40	1.40	1.09	0.85	1.10	2.37	2.04

Table 10: Biochemical characters of *Eryngium foetidum*

Treatment	Total Alkaloid (mg/100 g)	Vitamin C(mg/100 g)	Total soluble protein (mg/100 g)	Total carbohydrate (mg/100 mg)	Reducing sugar (%)	Flavonoid Content (mg/100 g)	Total phenol (mg/100 g)	Total chlorophyll (mg/100g)
S1V5	148.46	0.00 (0.71)	83.08	4.85	0.14 (0.80)	0.48 (0.99)	0.65 (1.07)	79.39
S2V5	117.89	0.04 (0.73)	132.04	24.38	0.21 (0.84)	1.01 (1.23)	2.34 (1.69)	76.15
S3V5	114.61	0.01 (0.72)	116.60	9.44	0.31 (0.90)	1.01 (1.23)	0.98 (1.22)	71.40
OV5	83.38	0.01 (0.72)	271.23	14.80	0.11 (0.78)	0.63 (1.07)	1.60 (1.45)	66.85
Lsd (p=0.05)	10.33	NS	12.80	0.58	NS	0.030	0.096	4.84
Cv%	2.94	1.20	2.81	1.44	8.96	1.76	2.52	2.18

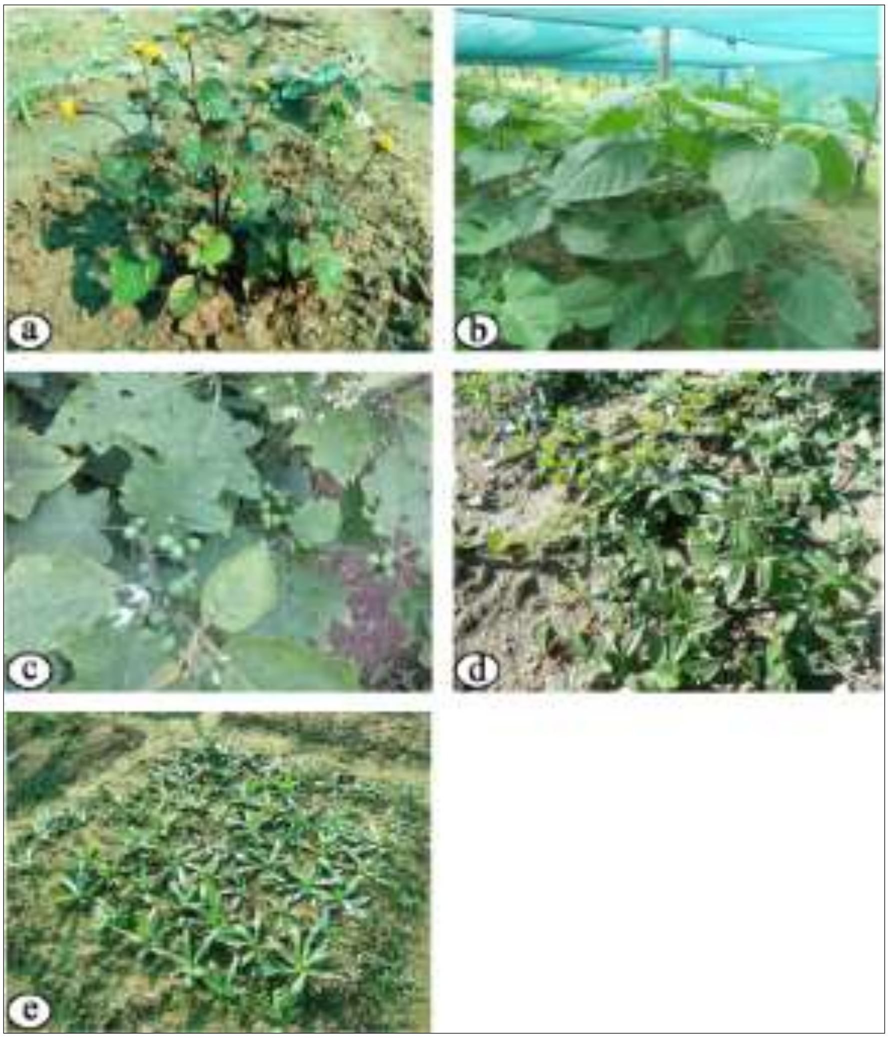

Fig 1: The five underutilised plants under study (a) *Acmella oleracea* (b) *Clerodendrum coolebrookianum* (c) *Solanum torvum* (d) *Pouzolzia hirta* (c) *Eryngium hirta*

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