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FOCUS

Underutilized fruits of arid & semi-arid regions for nutritional and livelihood security

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ABSTRACT

Underutilized fruits are considered as mines of nutrients and antioxidants. Despite being highly nutritive with medicinal attributes and their ability to grow under adverse soil and climatic conditions, they have not received the desired attention. However, these underutilized fruits are integral part of traditional foods, especially in rural areas and among tribal communities. A wealth of flora such as Lasoda (Cordia myxa), Ker (Capparis decidua), Phalsa (Grewia subinaequalis), Pilu (Salvadora oleoides and S. persica), Karonda (Carissa carandus), Wood apple (Feronia limonia), Bael (Aegle marmelos), Jamun (Syzigium cumini), Khirni (Manilkara hexandra), Chironji (Buchnania lanzan), Cactus pear (Opuntia ficus indica), Mulberry (Morus spp.*) etc. harbors the arid & semi-arid ecosystem which are to be optimally utilized. The recent awareness regarding the potential of these ecologically fragile lands for production of quality horticultural produce has not only opened up scope for providing economic subsistence for the people of these regions, but also for bringing new areas to increase fruits production. Besides, the underutilized fruits have a wide scope of export for various processed products. In the present article, attempt has been made to present a succinct description of scope, nutritive values, uses, and improved varieties of underutilized fruits of arid & semi-arid regions.*

Keywords: Minor fruits, biodiversity, nutritional security, value addition

Arid refers to prolonged dryness, and is used with regards to the climate itself, and the land below it. In such regions the ability to produce agricultural crops is limited. In general, on arid lands the potential evaporation of water from the land exceeds the rainfall. In India, a vast land resource 39.54 mha (~12% of the total geographical area) and 169 mha (~53% of the total geographical area) falls under arid and semi-arid regions, respectively. The arid agro-eco region encompasses south-western parts of the states of Punjab and Haryana, western parts of Rajasthan, Kutch peninsula and northern part of Kathiawar peninsula in Gujarat State. The semi-arid regions include Karnataka, interior Tamil Nadu, western Andhra Pradesh and central Maharashtra. These regions are characterized by extremes of both high and low temperatures, low & erratic rainfall, low relative humidity, high potential evapo-transpiration, high sunshine, abundant solar energy and high wind speed, particularly, during summers. These regions consist of vast sandy and other wastelands, which have productivity constraints such as salinity in soil and irrigation water, low soil fertility and extreme climatological stress conditions.

India holds a prominent position in horticulture and has emerged as the second largest producer of fruits and vegetables in world (Anon., 2017). India is home to many fruit crops. Fruits like mango, banana, citrus, apple, guava, papaya, pomegranate, grapes, sapota, pineapple, litchi etc. are well known in both local and international markets, and their country-wise production and export data are also available. . These fruit crops are being grown in different parts of the country as commercial fruit crops in organized orchards and prospered continuously due to their economic, nutritive, social and religious values. Many of them were supported and improved by villagers, growers and horticulturists for wide adoption due to their acceptable flavour and delicious taste (Bhardwaj and Pandey, 2011). On the other hand, underutilized or minor fruits are not so extensively cultivated and their consumption and trade tend to be more limited, geographically and quantitatively, than those of the major fruits (Saúco, 2013) despite being highly nutritive with medicinal attributes and also their ability to grow under adverse soil and climatic conditions. But these so-called underutilized/ minor fruits remained uncared and

confined mainly natural wild, semi-wild and semi-domesticated conditions, albeit with large ever increasing genetic diversity. The underutilized fruits are integral part of traditional foods, especially in rural areas and among tribal communities. A wealth of flora harbors the arid & semi-arid ecosystem which has remained to be optimally utilized. These includes *Lasoda* (*Cordi*a *myxa*), *Ker* (*Capparis decidua*), Phalsa (*Grewia subinaequalis*), *Pilu* (*Salvadora oleoides and S. persica), Karonda* (*Carissa carandus*), Wood apple (*Feronia limonia*), Bael *(Aegle marmelos*), Jamun (*Syzigium cumini*), Khirni (*Manilkara hexandra*), Chironji (*Buchnania lanzan*), Cactus pear (*Opuntia ficus indica*), Mulberry (*Morus* spp.), Marula nut (*Sclerocarya birrea* subsp. *caffra*) etc. (Singh *et al*., 2018). Due to hardy plant types, these fruits can thrive well under drought situations, which is common in arid & semi-arid regions. The recent awareness regarding the potential of these

Table 1: Some important underutilized fruit crops of arid & semi-arid regions.

Some underutilized fruit crops presently grown under Indian arid & semi-arid regions			
S. No.	Botanical name	Family	Common name
1.	*Ziziphus rotundifolia*	Rhamnaceae	*Boradi*
2.	*Ziziphus nummularia*	Rhamnaceae	*Jharber*
3.	*Cordia* spp.	Boraginaceae	*Goonda, Lasoda*, Indian cherry
4.	*Caparis decidua*	Capparaceae	*Ker*, *Kirir, Karril*
5.	*Grewia* spp.	Tiliaceae	*Phalsa*
6.	*Salvadora* spp.	Salvadoraceae	*Pilu*, *Jaal*, toothbrush tree, mustard tree, mustard bush
7.	*Acacia senegal*	Fabaceae	*Kumat*
8.	*Syzygium cumini*	Myrtaceae	*Jamun*, jambolan, Java plum or black plum
9.	*Carissa carandas* L.	Apocynaceae	*Karonda,* Christ's thorn
10.	*Buchanania lanzan*	Anacardiaceae	*Chironji, charoli*, Almondette tree
11.	*Madhuca indica*	Sapotaceae	*Mahua*, Indian Butter Tree
12.	*Manilkara hexandra*	Sapotaceae	*Khirni, Rayan*, Ceylon Iron Wood, milk tree, wedge-leaved ape flower
13.	*Pithecellobium dulce*	Leguminosae	*Jungle Jalebi,* Madras thorn, Manila tamarind
14.	*Grewia subinaequalis*	Tiliaceae	*Gangana*, White Crossberry, *Phalsa* Cherry, Raisin Bush
15.	*Morus* spp.	Moraceae	Mulberry, *Sehtoot*
16.	*Ficus* sp.	Moraceae	Fig, *Anjeer*
17.	*Feronia limonia*	Rutaceae	Wood apple, Elephant apple, Organic limonia, *Kaitha*
Some potential exotic underutilized fruit crops Indian arid & semi-arid regions			
S. No.	**Botanical name**	**Family**	**Common name**
1.	*Opuntia ficus indica*	Cactaceae	Cactus pear, Indian fig opuntia, Barbary fig, Spineless cactus and Prickly pear
2.	*Ceratonia siliqua*	Fabaceae	Carob tree or Carob bush. Locust bean
3.	*Spondias tuberosa*	Anacardiaceae	Imbu
4.	*Argania spinosa*	Sapotaceae	Argan tree
5.	*Adansonia digitata*	*Malvaceae*	Baobab, Monkey bread tree, Lemonade tree, Upside down tree
6.	*Cordeanxia edulis*	Fabaceae	Yeb-eb nut, Ehb, Qud
7.	*Sclerocarya birrea*	Anacardiaceae	Marula nut, Mufula, Shea nut
8.	*Santalum acuminatum*	Santalaceae	Quandong, Native peach
9.	*Uapaca kirkiana*	Euphorbiacea	Musuky, Sugar plum or mahobohobo
10.	*Dovyalis caffra*	Salicaceae	Kei apple, Umkokola
11.	*Bosciasenegalensis*	Capparaceae	Kursan, Hemmet,Bokkhelli
12.	*Schinziophyton rautanenii*	Euphorbiacea	Mongongo tree, Mongongo nut or Manketti tree
13.	*Lannea acida*	Anacardiaceae	Bembe

ecologically fragile lands for production of quality horticultural produce has not only opened up scope for providing economic subsistence for the people of these regions, but also for bringing new areas to increase fruits production. The underutilized fruits have a wide scope of export for various processed products.

Bioversity International recommended that underutilized fruits can be used as alternative sources to combat hidden hunger (Khoo *et al.,* 2008).The underutilized fruits are integral part of traditional foods, especially in rural areas and among tribal communities. In ancient times, these underutilized fruits were the main source of food and medicines to rural and tribal people. However in present time, their use in daily life has been reduced, primarily, owing to lack of awareness about their potential. Therefore, it is important to include these fruits in health promotion campaigns. This is the need of the hour to focus on this important and economically rewarding area of horticulture (Nandlal and Bhardwaj, 2014).

SCOPE OF UNDERUTILIZED FRUITS IN ARID & SEMI-ARID REGIONS

1. In arid & semi-arid regions, a large part of land is considered as marginal/problematic/waste lands, which are unfit for cultivation of high input demanding nature crops. Such lands can easily be put to use for growing low input requiring crops like underutilized fruits in order to diversify the present day horticulture, which is so inevitable in view of the increasing population pressure, nutritional security and fast depletion of natural resources as well as the growing and changing consumer's needs.

2. In most of the arid and in a substantial parts of semi-arid region the horticultural crops productivity is less than the desired productivity level. As cultivation of field crops is un-remunerative in such ecosystem due to prevailing environmental constraints and limited irrigation facilities, diversification with the underutilized fruit crops in the conventional cropping system can bridge the gap between increasing demands and supply of food. It is possible to realize the untapped potential of these regions through resorting to cultivation of location specific minor fruit crops. Production of underutilized fruits can further be improved through adoption of modern cultivation practices.

3. Beside nutritional & social security, hitherto untapped export potential, underutilized fruit crops has a vast potential for production of value added products, with high therapeutic, medicinal values and antioxidant properties on one hand and free from the residue of toxic chemicals on the other as such crops are grown with minimum agricultural inputs.

1. **Importance of underutilized fruit crops**

1. Provide variety of products that include food, fodder, fuel wood, gums, resins, fibre, medicine etc.
2. Easier to grow and hardy in nature, producing a crop even under adverse soil and climatic conditions.
3. Most of them are very rich sources of vitamins, minerals, and other nutrients such as carbohydrates, proteins, fats and nutraceuticals.
4. Cheap and readily available.
5. Vital source of genes against biotic and abiotic stresses.
6. Low input requiring crops.
7. Produce higher biomass than field crops per unit area resulting in efficient utilization of natural resources.
8. Can help achieving ecological security through improvement of wastelands by preventing soil erosion, improving fertility of soil and promoting biodiversity.

REINFORCEMENT OF NUTRITIONAL SECURITY

There are several underutilized fruits (*jamun, chriounji, mahua*, *lasoda*) which are very rich in vitamins, minerals, fat, carbohydrates and antioxidant which have not been exploited well. There are some fruits which are rich source of protein also (*chirounji*, wood apple, *ker*) which are otherwise obtained from pulses and vegetables. Strong campaigning is essential to create awareness among producers and consumers about the importance of underutilized fruits, so as to produce in larger quantity for continuous supply of raw materials to the industries. The nutritive value of

Table 2: Nutritive value of some underutilized fruits per 100 g edible portion.

Fruit	Calorie (Kcal)	Protein (g)	Fat (g)	CHO (g)	Fibre (g)	Ca (mg)	P (mg)	Fe (mg)	Vit. A (IU)	B_1 (mg)	B_2 (mg)	Niacin (mg)	Vit. C (mg)
Chirounji	-	19.0	59.1	12.1	3.8	279	528	8.5	-	0.69	6.53	1.5	5
Jamun	83	0.53-0.65	0.1	18.7	0.9-1.2	20	10	100	90	-	-	-	35.0
Karounda	42	1.1	2.9	2.9	1.5	21	38	39.1	-	-	-	-	10.0
Khirni	-	0.48	2.42	27.74	-	83	17	0.92	-	-	-	-	15.62
Mahua- flower	-	-	-	21-25	-	-	-	-	586-890	-	-	-	51-72
Wood apple	-	7.3	0.6	-	-	4	9	0.5	0.17	0.04	-	0.8	3
Jangal jalebi	78.8	2.0-3.3	0.4-0.5	18.2-19.6	1.1-1.2	13	42	0.5	25	-	-	-	138
Ker	100	5.9	1.23	20.87	-	153.8		50.8	2.0	-	-	-	133
Phalsa	72.4	1.3-1.58	0.90-1.82	14.78	1.2-1.77	129	39	3.1	800	-	-	-	22
Lasoda	65	1.8-2.0	1.0	12.2	0.3	40	60	-	-	-	-	-	-
Pilu fruits	-	6.0	2.0	76	2.0	630	167	8.0	-	-	-	-	2.0
Pilu seeds	-	-	45.5	23.5	5.8	-	-	-	-	-	-	-	-
Mulberry	-	0.4-1.5	0.4-0.5	8-9	0.9-1.4	-	-	-	-	-	-	-	12

some underutilized fruits is given in table 2 (Saroj and Prakash, 2012; Singh *et al*., 2018).

The status of germplasm of some underutilized fruits, genetic diversity, nutraceutical values, uses, production and management practices for achieving higher yield and quality of fruits in arid regions are being discussed in the subsequent paragraphs;

1. *Lasoda* (*Cordia myxa* Roxb.)

It is known as Indian cherry, *lehsua* or *goonda*. The other important species are *C. gharaf* (*goondi*), *C. rothii, C. macleodii, C. vestita* and *C. wallichii.* Out of these, goondi (*Cordia gharaf*) is a popularly grown species. Medium size tree having dense foliage with crooked trunk. *Lasora* leaves have sunken stomata and other characters of drought tolerance. Plants are deciduous in nature (Singh *et al.,* 1996).The vegetative growth is very fast in *lasora* plant. New flush comes in spring (March) when plant enters in flowering phase. Bunches are of light yellow colored with hermaphrodite fragrant flowers borne auxiliary on current season growth. Flowering in *lasoda* is reported to change from place to place during the period of March-April in arid region (Pundir, 1987). The duration of flowering varied from 41 to 50 days and the peak flowering reached 16 days after the first flower initiation .The development of flower bud takes about 21-22 days. The fruit is 2.0-3.0 cm long, round in shape and yellowish brown colour at maturity. Immature green fruits are available in April-May while ripe fruits are available during June-July. Fruits are mucilaginous with a stone (Singh and Vishwanath, 1991).

Varieties : A large variability exists in plantation of *lasoda* in relation to morphological characters, particularly, plant height, spread, leaf size, fruit size; fruiting behaviour; quality parameters such as fruit colour (yellow, pink, dark pink), pulp content, sweetness, pickling quality, seed and pulp ratio etc. as a result of seed propagation. There are two identified varieties of *lasoda viz*., Thar Bold and Maru Samridhi.

Thar Bold : A prolific and early bearing *lasoda* has been identified through selection at ICAR-CIAH, Bikaner. It bears bold fruits in cluster with production of 1.5-2.0 q tender fruits/ tree/ year. The

tender fruits are suitable for making vegetable, pickles and for dehydration purpose. Fruits are also utilized as table fruit and for processing purpose. This variety is recommended for commercial cultivation both as block plantation and a component of agro-forestry system in arid and semi-arid regions.

Maru Samridhi : This variety was identified by ICAR-CAZRI, Jodhpur. Growth habits of plants are drooping in nature. It bears on an average 14 fruits per bunch. Each fruit weighs around 10 g and plant yields 90 kg per tree.

Nutraceutical value : Studies conducted at ICAR-CIAH, Bikaner has shown that the *lasoda* fruits are good source of different antioxidants, which are presented hereunder;

Table 3. Antioxidant attributes of *lasoda.*

S. No.	Attributes	Contents
1	Polyphenols (mg/100g)	137.56
2	Flavanol (mg/100g)	14.32
3	Flavonoid (mg/100g)	434.28
4	*0*-dihydric phenol (mg/100g)	45.67
5	Total AOX activity (MTE/100g)	10.67

Uses*:* Green fruits are used for preparing vegetable and delicious mixed pickle. In spite of high nutritive and medicinal value in fruits, leaves and barks are also having medicinal property. Fruit is used as anthelmintic, diuretic demulcent and expectorant. It is used in disease of the chest and urinary passes. The kernels are used in external application for ringworm. A decoction of the bark is used in dyspepsia and fevers. Glue is also prepared from the mucilaginous pulp of *lasora* fruit. Plant gives light timber used for various domestic purposes. However, wood is light in weight and is used for making boat and agricultural implements. Stem barks contain 2% tannin.

2. *Ker* (*Capparis decidua* Forsk.)

It is one of the prominent unexploited plants found in the Indian desert. It is an ancient fruit of Indian subcontinent. In India *ker* is known for its medicinal and religious uses from antiquity. The medicinal and nutritive value of *ker* has been appreciated which is used to prepare various ayurvedic medicine and nutritive dishes (Anon, 1960). In Panchkuta, the important dish of arid region, dehydrated *ker* makes the major component. It is also used for pickle and dehydration. *Ker* is rich source of protein, phosphorus, potash, calcium and magnesium. Besides fresh consumption, it has processed value and therefore, emphasis is required on its large scale cultivation in arid and semi arid regions.

Ker is multipurpose plant species, which every plant part is used by the local people. Fruits are highly nutritious and medicinally important. *Ker* tree is boon for Thar Desert. Stem wood of *ker* is very strong and durable. It is used to make the pivotals of stone mill. Thick wood of *ker* is used to make foundation around the well (Chandra *et al.,* 1994) where as smooth thin wood of light yellow colour is used for making small agricultural implements (Singh, 1993). *Ker* wood resists the termite attack and therefore, thinner branches are used for fencing the field and mulching. It is also used as fuel wood in rural areas. The young twigs serve as a fodder for camels and goats. Immature flower buds and flowers of *ker* are used for vegetable and pickling purpose. The use of immature flowers buds and flowers of *Capparis decidua* as vegetable is described in literature. *Ker* flowers have also been tested for cercaricidal properties.

Varieties*:* Under natural populations, rich genetic diversity with a wide range of variability occurs in *ker* in habit, fruit size, colour of fruits, petals, pulp content, spiny habit, spreading of branches and compactness of canopy, and time of flowering and fruiting. However, no systematic efforts have been made so far to collect and conserve plants representing this diversity or to promote the most desirable variants. There is a need to identify suitable types with the view of selecting plants that are heavy yielding, have large fruit size and high pulp content, are rich in protein; of the proper total soluble solids (TSS), tartness, less acrid, with small and soft seeds, etc. In general two distinct plant types of *ker* occur: a tree form, which is relatively unusual, and a shrub form, in the majority of plants.

Table 4: Antioxidant properties of ripe *ker* fruits.

S. No.	Attributes	*Ker* pulp	*Ker* seed
1	Polyphenols (mg/100g)	106.48	31.87
2	Flavanol (mg/100g)	13.56	14.55
3	Flavonoid (mg/100g)	196.41	81.09
4	*0*-dihydric phenol (mg/100g)	29.0	16.79
5	Total AOX activity (MTE/100g)	6.74	1.74

Nutraceutical value: Studies carried out at ICAR-CIAH, Bikaner has suggested that the *ker* has high contents of different antioxidants, which are presented hereunder;

Uses: Immature tender green as well as pink/ red ripe fruits of *ker* is used in various ways (Chauhan *et al.*, 1986; Chundawat, 1990; Chandra *et al*., 1994; Singh, 1993). It has been mentioned that unripe *ker* fruits are pickled and or cooked as vegetable which forms an integral part of the diet of people in desert and semi-desert areas of the country where as the ripe fleshy fruits are eaten by birds. Chundawat (1990) however, described that *ker* fruits are mainly used in pickling or as vegetable when immature while sweet and acrid fruits are enjoyed by children in natives after ripening. Chandra *et al*. (1994) described the use of *ker* fruits at various stages. They mentioned that unripe green fruits after processing are eaten as vegetable and also used for making pickle, whereas, mature unripe fruit contain high level of glucosinolates and can only be used at limited scale after proper processing. Rai (1987) reported that *ker* seed contains 20% saturated hydrocarbons and ketones with C28 to C32 chain lengths and 0.7% sugar along with 8.6% protein.

3. *Phalsa (Grewia subinaequalis)*

It is a minor fruit crop of sub-tropical region. It is native to India. It is one of the most hardy fruit plant, drought resistant and thus requires little care with low inputs. It can be grown almost in all parts of north India except at higher elevations. It is mainly grown in the states of U.P., Bihar, Rajasthan, Haryana, Punjab, Gujarat, Maharashtra, Andhra Pradesh and Madhya Pradesh. *Phalsa* being very vigorous in growth can be an ideal plant for plugging gullies and ravines and for contours to protect bunds. The plants are multiplied through seeds and stem cuttings. Being a bush, it can be grown as filler plant in *aonla, bael, ber* orchards. It is mainly propagated through seeds and stem cuttings. The small fruits have to be picked from bush several times during the fruiting season and thus the cost of production is increased considerably. It is a small bush and bears many berries like fruits. Fruits ripen by the end of May and beginning of June. Fruits are perishable and keeping quality is very less.

Varieties: In general, no remarkable variability has been found in *phalsa* except erect and bushy type plant habit. Most of the genotypes grown are of local types. However, recently 'Thar Pragati' has been identified for cultivation by ICAR-CIAH, Bikaner.

Thar Pragati: This variety has spreading growth habit, thick stem, dense foliage and drooping branches. Fruit ripens in 60 days from fruit set. It is dwarf, early precocious bearer (bearing in 3rd year), drought tolerant and suitable for high density planting. It is suitable for table and processing purpose.

Nutraceutical value: *Phalsa* has been found to be a very good source of anthocyanin, a strong antioxidant. The mean value of anthocyanin content in *phalsa* was noted to be 10.18 mg/100g.

Uses: Its fruits are eaten as fresh .The fruits are highly perishable and are used in preparation of squash and juice. Ripe fruits are acidic in taste and rich source of vitamins A and C. Its medicinal properties are known since vedic times. Its fruits have cooling effect. Fruits are good source of carbohydrate, proteins, minerals and vitamins. Processed products like jam, squash and pickle can also be prepared from *phalsa* fruits. Bark of plants is used during preparation of jaggary for improvement of the quality. Pruned *phalsa* canes/ shoots can be utilized for making baskets to transport fruit and vegetables to distant market.

4. *Karonda* (*Carissa carandus*)

It is one of the few fruits indigenous to India while 30 species of genus *Carissa* have been reported; many species are found growing wildly in India while other species came from Malaysia and South Africa. It is cultivated throughout India in tropical and sub-tropical areas. In India *Carissa* are found growing most widely in plains and hills and grow wild in Deccan Peninsula, Maharashtra along the west coast, parts of Gujarat, Punjab, lower ranges of J & K, U.P., Uttaranchal and Mount Abu (Rajasthan). It also cultivated in other countries like Bangladesh, South Africa, U.S.A., Denmark, Ghana, Israel and Pakistan. In *karonda* plants, thorns are found. It is most suitable fruits for dry land horticulture. *Karonda* is generally grown on the boundary of orchard, farm, fields as bio-fencing. There is no regular orchard. *Karonda* fruits are mainly used for pickle and jelly preparation.

Varieties :

On the basis of fruit colour, the cultivars of *Karonda* can be classified as: (i) Green fruited, (ii) Pink fruited and (iii) White fruited. There is a quite resemblance in the shape and size of their fruits. However, there is a tremendous scope for improvement using selection force and vegetative method of propagation. A promising variety of *Karonda* 'Thar Kamal' have been identified at CHES, Godhra which are red colour fruit type and high yield potential.

Fast growing, drought tolerance and high yielding genotypes should be identified. More emphasis is needed on its processed products. It is susceptible to frost; hence, frost tolerance types should be identified for arid regions.

Thar Kamal : The variety is developed through selection from existing germplasm. Plant has semi-spreading growth habit, thick trunk, evergreen, dense foliage and drooping branches. Flowering start, in 3rd year, regular bearer, ripens (55-56 days from fruit set) in the month of June and recorded 4.97 g average fruit weight, 93.64% pulp and 9.54^{0}Brix TSS, 0.64% acidity, 30.41 mg/100g vitamin C. Fruit yield 13.00 kg/plant (9th year). It is suitable for processing purpose.

Maru Gaurav : This variety has been identified at ICAR-CAZRI, Jodhpur. Average fruit weight is 3.74 grams, while TSS, acidity, Vitamin C and pulp content has been reported to be 9.4 %, 2.8 %, 35.88/ g 100-1 g and 88.5%, respectively.

Nutraceutical value: Studies at ICAR-CIAH, Bikaner has shown that in red and green type *karonda*, the values of anthocyanin, which is widely hailed as highly beneficial health protective compounds, were 3.85 and 0.35 mg/100g, respectively.

Uses: The fruits are used for making jam, jelly, pickles etc.

5. *Pilu* (*Salvadora* sp.)

It is a drought hardy tree and generally found in saline belts. *Salvadora* is an underutilized tree of arid region having multiple uses. The leaves are eaten by camel. There are two species commonly found in arid region i.e. *S. persica, S. oleoides*. It is multiplied through seeds and root suckers. There is no systematic plantation and its seed oil is very important for industrial uses.

Varieties: Great deal of variability in fruit shape, size and color are found due to seed propagation. There are no identified varieties of *pilu*; however, in nature two distinct types *viz*., red and green fruited types are found.

Table 5: Comparison of antioxidant properties of green and red fruited genotypes of *pilu* (mean values).

S. No.	Attributes	Red fruited	Green fruited
1	TSS (^{0}Brix)	22.9b*	25.3a*
2	Ascorbic acid (mg/ 100g)	29.0a	18.2b
3	Total polyphenols (mg/100g)	619.7a	351.4b
4	Flavanol (mg/100g)	42.5a	36.4b
5	Flavonoid (mg/100g)	118.9a	93.5b
6	*0*-dihydric phenol (mg/100g)	27.35a	26.6a
7	Total AOX activity (CUPRAC; mMTE/100g)	10.38a	7.82b
8	Total AOX activity (FRAP; mMTE/100g)	8.31a	4.95b
9	DPPH inhibition (%)	88.40a	71.66b

*Row values followed by the same letter are not significantly different.

Nutraceutical value: Research carried out at ICAR-CIAH, Bikaner has revealed that red fruited one is richer in terms of different antioxidants at horticultural maturity.

Uses: This plant is gaining phenomenal significance for its oil rich seeds containing 40-50% non-edible fats of industrial use. Fruits are used for making juice and drinks. Fruits mature during summer season. *Pilu* is an underutilized fruit and can be exploited. It is suitable trees for farming system in arid region especially with pasture/ grasses. It is found in the states of Gujarat, Haryana, Punjab, U.P., Rajasthan and M.P. with estimated annual seed production of 47,000 tonne having potential for 15,000 tonnes oil (Singh and Tewari, 1994).

6. Wood apple (*Feronia limonia*)

Wood apple (*Feronia limonia* Linn. Swingle), syn. *Limonia acidissima L. Feronia elephantum* Correa*, Schinus limonia* L. belongs to family Rutaceae. Wood apple is also called *kainth*, elephant apple, monkey fruit, curd fruit, *kathabel* and others name in India.

The wood apple is native to India and common in the wild form in dry plains of India and Ceylon. It is also found growing throughout South East Asia, in Northern Malaya and on Penang Island. In India, the fruit was traditionally a "Poor man's food" until processing techniques were developed in the mid-1950's. It occurs, wild or cultivated, up to an elevation of 1500 ft, in Western Himalayas, but more common in the Deccan; Thane and Chandrapur districts of Maharashtra. It is also reported to occur in parts of Hazaribagh, Palamau and Chhota Nagpur in Jharkhand, in forest of Vidhyan hills of Uttar Pradesh and Chattishgarh. It is often cultivated on borders of fields and as a roadside tree near villages and sometimes planted as orchards. There are no regular plantations however; stray plants along the border of fields, roads, railway lines and banks of the river are the common places where the plants are found.

Varieties: The plants growing so far are of seed origin and found to have lot of variability which can be used for making selection of superior types. There are two forms one with large, sweetish fruits and the other with small, acidic fruit. There are two types of wood apple, one with fruit larger and sweeter than the other and states that the ripe fruit pulp contains 2.3 per cent acid and 7.25 per cent sugars. Fruit is much used in India as a liver and cardiac tonic, and when unripe, as a means of halting diarrhea and dysentery and effective treatment for hiccough, sore throat and diseases of the gums. The pulp is poultice on to bites and stings of venomous insects as is the powdered rind. Juice of young leaves is mixed with milk and sugar candy and given as a remedy for biliousness and intestinal troubles of children. The powdered gum, mixed with honey, is given to overcome dysentery and diarrhea in children. Oil derived from the crushed leaves is applied on itch and the leaf decoction is given to children as an aid to digestion. Leaves, bark, roots and fruit pulp are used against snakebite. The leaves are aromatic, carminative and astringent.

Uses: The pulp constitutes 55-56 percent of the whole fruit. The pectin content of the pulp is 3-5 per cent (16% yields on dry weight basis). The seed contains bland, non-bitter oil with high unsaturated fatty acids. The fruits are so hard that rind be cracked with a hammer. The scooped-out pulp, though sticky, is eaten raw with or without sugar, or is blended with coconut milk and palm-sugar syrup and drunk as a beverage, or frozen as an ice cream. It is also used in chutneys and for making jelly and jam (Gopalan *et al.,* 1971).

7. *Jharber (Ziziphus nummularia*)

This thorny shrub is locally known as *Jharber* and occurs throughout North-west India. Apart from its edible fruits and fodder value, different plant parts of it have medicinal value. This is one of the multipurpose shrubs of arid zone.

Uses: Ripe fruits are eaten as fresh and stored as dried fruits. Dried fruits used in making sweets and drinks, while seeds are eaten in scarcity period.

8. *Kumat* (*Acacia senegal*)

It is a much-branched thorny tree with pale smooth bark. It founds on hillsides and stabilized sand dunes. It is hardy species surviving under harsh edapho-climatic conditions. It is an ideal species for agro forestry systems.

Uses: It is used in *Pachkutta*, a traditional vegetable delicacy of arid regions. It yields the true

gum Arabic, an important commercial product and used in pharmaceuticals. Apart from gum production, its seeds are used as food; leaves and pods as fodder, and wood for fuel wood and charcoal preparation.

9. *Gangana* (*Grewia tenax*)

This winter deciduous shrub naturally occurs in buried pediments, hills and pediplains in arid region. Deep sandy loam is best soil for species, however it can grow in very shallow, skeletal, gravelly or clay soils. It is extremely drought hardy and tolerates frost. Fruits (drupe) are smooth, shinning, yellow orange to red when mature. Fruit production in natural stands varies very much.

Uses: Ripe fruits are eaten as fresh. It also provides excellent leaf fodder.

10. *Khirni* (*Manilkara hexandra* Roxb.)

In India, this species is occasionally cultivated in backyards, homestead gardens, public parts as avenue tree and in farmers' fields near villages due to its economic importance as fruit tree having nutritional and medicinal properties. The production in India is mainly concentrated in the drier states and the produce is collected by the villagers and sold in the local market. Its cultivation may be spread to arid and semi-arid areas, resource-poor areas and wastelands where other crops cannot be grown successfully.

Varieties: States of Rajasthan, Gujarat, Madhya Pradesh, Bihar, Jharkhand, Orissa, Andhra Pradesh and Maharashtra have rich diversity of *khirni*. Recently, an improved variety 'Thar Rituraj' has been developed by ICAR-CIAH, Bikaner, which is semi-dwarf, precocious bearer (4thyear), fruit ripens in 120-125 days from fruit set. It is suitable for table and processing purpose. The fruit yield is 10-16 kg/plant.

Uses: Bark, fresh fruits and extracted seeds have high nutritional and medicinal value. The tree is very well known to rural folk since ages in India.

11. *Mahua* (*Madhuca indica*)

It is a deciduous tree that grows widely under dry climatic conditions. It is very hardy and thrives well on rocky, gravely, saline and sodic soils, even in pockets of soil between crevices of barren rock. It is one of those multipurpose forest tree species that provide an answer for the three major Fs *i.e* food, fodder and fuel. *Mahua* is a tree valued for its fruit, seeds, which are the largest source of natural hard fat commercially known as *mahua* butter or *mowrah* butter.

Varieties: A semi-spreading variety 'Thar Madhu' has been identified by ICAR-CIAH, Bikaner, which starts bearing in 5thyear. Yield has been reported to be 20 kg fruits per plant. Yield of dry flower: 6.30 kg per plant. Fruit ripens in 90-105 days from fruit set.

Uses: Fruits are eaten as raw or cooked. The fruit pulp may be utilized as source of sugar, whereas the dry husk makes a good source of alcoholic fermentation. Seeds are good source of oil. The oil obtained from kernel which is said to be useful for heart patients is used for edible purpose and permitted for preparation of vegetable oil. Amount of oil obtained from seeds of the fruit is higher than many oil seed crops and oil-bearing trees. In *Mahua* oil is used in manufacture of soap, lubricating grease, fatty alcohols and candles. Flowers of the plant are edible. The corolla commonly called as *mahua* flowers is a rich source of sugar containing appreciable amount of vitamins and minerals (Singh and Singh, 2005). The flowers are also used in preparation of distilled liquor, portable spirits, vinegar and feed for livestock (Ghosh, 2015).

12. *Chironji* (*Buchnania lanzan*)

It is a deciduous tree which produces edible seeds. These almond-flavoured seeds are used as a cooking spice primarily in India. It is cultivated across India, primarily in the northwest. After the hard shell is cracked, the stubby seed within is as soft as a pine nut. The *chironji* seed is lentil-sized, is slightly flattened and has an almond-like flavour. Though they can be eaten and used raw they are often toasted or roasted before use, as this intensifies the flavour.

Varieties: Variety 'Thar Priya' has been identified by ICAR-CIAH, Bikaner. It has a semi-spreading growth habit, thick trunk, dense foliage and dropping branches, umbrella shape, fruit ripens in 50-65 days from fruit set. It is comparatively dwarf, precocious bearer (4thyear) and suitable for

high density planting. TSS 23.90 °Brix, 1.24% acidity, 13.06% total sugars, 6.67% reducing sugar, 48.70mg/100g vitamin C and 31.36% kernel protein. The fruit yield is 11.90 kg/tree.

Uses: The *chironji* seeds are commonly used in sweets in India. However, they are also ground into powders for thickening savory sauces and flavoring batters, and stewed into rich, meaty kormas. Seeds are also used in the Ayurveda and Unani systems of medicine.

13. Mulberry (*Morus* spp.)

Mulberry grows throughout India but more extensive in Karnataka particularly Mysore especially for sericulture. In India, there are many species, of which *Morus alba* and *M. indica* are fully domesticated while other important species are *M. laevigata*, *M. rubra*, *M. nigra* and*M. serrata* (Vijayan *et al*., 2011). Mulberry is a fast growing deciduous woody perennial plant, wide-spreading, round-topped, trunk attaining 60 cm in diameter. It has a deep root system. All three mulberry species (*M. alba, M. rubra* and *M. nigra*) are deciduous trees of varying sizes. White mulberries can grow to 24 m and are the most variable in form, including drooping and pyramidal shapes. In the South on rich soils the red mulberry can reach 20 m in height. The black mulberry is the smallest of the three, sometimes growing to 10 m in height, but it tends to be a bush if not trained when it is young. The species vary greatly in longevity. Red mulberry trees rarely live more than 75 years, while black mulberries have been known to bear fruit for hundreds of years. The mulberry makes an attractive tree which bears fruit while still small and young (Krishna *et al.,* 2018).

Uses: The ripe fruit of mulberry is highly appreciated for its delicious taste which is consumed fresh or after extraction of juice. Immature fruits are used for chutney preparation. Mulberry fruit is used to treat weakness, dizziness, tinnitus, fatigue, anemia, and incontinence (Krishna and Chauhan, 2015).

Varieties: Huge diversity exists in available germplasm pool of mulberry in India. Mulberry being perennial and out breeding tree, exhibit high degree of heterozygosis. Till recently, no variety was developed in mulberry for commercial fruit production. However promising selections of mulberry, intended for commercial fruit production, have been identified at ICAR-Central Institute for Arid Horticulture, Bikaner, Rajasthan *viz*., Thar Lohit (red fruited) and Thar Harit (white fruited). Thar Lohit was found to be earliest with respect to maturity period. It took 30-35 days to mature. Upon quality assessment, it was found that mulberry genotype Thar Lohit was better than Thar Harit in terms of antioxidant attributes like polyphenol, flavanol, flavonoid and total antioxidant activity.

14. Cactus pear (*Opuntia ficus india* L.)

Cactus pear (*Opuntia ficus india* (L) Mill.) is known as 'Prickly pear' or Cactus fig or Tuna. It belongs to family Cactaceae. Genus *Opuntia* has nearly 300 species, out of them, 12 species are grown for fruits, vegetable and fodder purpose. Being a succulent xerophytic plant, it is ideally suited to water scarce dry zones of the world. It requires low energy inputs to provide food and fodder for human and livestock. It is a most suitable plant for semi arid and arid regions. In India, it is found in wild state and underutilized fruit. However, it is a National Crop of Mexico. The cactus pear is commercially cultivated in countries like USA, Israel, Chile, Peru, Brazil, Bolivia, Argentina, Italy, Tunisia, Middle East and South Africa. It is a xerophytic spiny or spineless plant. It has shallow, fibrous root system. Roots are developed when the areoles are in contact with soils. The plants have thick succulent stem called 'cladodes'. These cladodes or cactus stems have numerous areoles which function like meristematic buds. The buds develop in to new cladodes and fruits (areal parts) and roots (underground parts) with passage of time (Wessals, 1998). The thornless type cactus pear has introduced from Texas, USA and Israel.

Varieties: There is no indigenously identified variety of cactus pear. However, as a part of an Indo-US collaborative research program on *Opuntia* in India, 33 *Opuntia* clones were introduced at Nimbkar Agricultural Research Institute at Phalton, India, in 1987. All these clones grew well under the semi-arid agroclimate of western Maharashtra and it is reported that some clones also produced fruits (Meghwal and Singh,

Uses

Uses	Forms
Fresh fruit	Fruits and fruit peel fresh
Fruit products	Dried, canned, juice, pulp, alcoholic, beverages, jam, syrup,
Stems	Jellies, pastries, liquid sweetener, seed oil. Fresh processed in brine or vinegar, precooked, frozen, pectin.
Forage	Fodder stems, fruits, seeds and forage shrub
Energy	Biogas (stems, fruits); ethanol (stems, fruits) and firewood.
Medicine	Diarrhoea (stems), diuretic (flower, roots), amoebic dysentery (flowers), diabetes mellitus (stems), hyperlypidemy (stems), obesity (fibres) and anti-inflammatory (stems).
Cosmetics	Shampoo, cream, soaps, astringent and body lotions (stems)
Eco-conservation	Soil binders, hedge, fence, mulching material, windbreak (plants, stems) and organic manure.
Other uses	Adhesives and gum, fibers for handicrafts, paper (stems), dyes (fruits, rearing of *Dactylopius coccus* on stem), mucilages for food industry (stems), anti-transparents (stems) and ornamental plant.

2016). In 1991, Central Soil Salinity Research Institute, Karnal obtained five fruit, forage, and vegetable clones from Dr. Peter Felker's collection in Texas, USA. Again, in January 1997, 51 additional *Opuntia* clones were introduced from Texas A&M University-Kingsville at the ICAR-CIAH, Bikaner. Among them genotype 1269 performed better in terms of survival and cladode production.

15. Marula nut (*Sclerocarya birrea* subsp. caffra)

Marula nut fruit plant (*Sclerocarya birrea* subsp. *caffra*) is a member of Family Anacardiaceae. The plant is tall, dioecious, deciduous tree, which grows naturally in northern South Africa and parts of eastern Botswana. In southern Africa, marula trees are one of the most highly valued indigenous plant species. It has several medicinal properties. It is cultivated for fresh fruit in Arava valley, Israel, where annual average rainfall is about 100 mm and dry climate. In the experimental plots many branches died due to winter temperatures of -7 degrees Celsius. In the spring, however, all plants resumed their growth from the lower parts of the stem. In northern Sotho, marula trees are not cut down when land is cleared for planting and cultivation because of its high value. Marula tree bears male and female flowers on separately. It is a dioecious fruit tree and flowering takes place during summer season. Fruits are ripened during September-October month. The fruit yield depends on growing site, age of tree and management practices employed. Marula fruits abscise when mature but ripen only a few days later. In western arid part of India, it has introduced from Israel and evaluated for growth and development of plant. It is a fast growing fruit tree but it is susceptible to low temperature and frost during winter season in arid region. Marula fruit is very sweet, juicy and aromatic. It looks like a small yellow plum. It is eaten fresh and the flesh has extremely high vitamin C content. The TSS of fruit is 13.2^{o} brix at full ripen stage.

Uses: Besides its consumption as fresh fruits, it is used to prepare jam, juices and alcoholic beverages. Inside the flesh, one or two small tasty nuts are available which are rich in protein. Its seed oil is used as a skin cosmetic.

Value addition: If exploited properly, these underutilized fruits have the potential of transforming the economy of rural and tribal areas because such crops are, usually, of explicit quality with great nutritional, medicinal, organoleptic, economic and traditional importance; however, they are available for a very short period during the growing season. Therefore, the value added products will definitely help to provide taste throughout the year if processed during the season. It will not only help the growers to get good returns for these under-utilized wild fruits but also provide nutritionally and medicinally rich value added products for the consumers. Some underutilized fruits, though they are not utilized as table fruit (ker, lasoda, Karonda, tamarind, wood apple) because high acidity, strong astringent taste and also difficulty in eating can be converted into value added processed products like pickles, chutney,

Table 6: Potential value added products from different underutilised fruits.

Fruits	Processed / Value added products
Ker	Dehydrated fruits, pickle
Lasoda	Dehydrated fruits, pickle
Mulberry	RTS, Squash, Jam, vinegar
Jharber	Dehydrated fruits, Dry fruit powder as acidulant
Karonda	Jelly, pickle, candy, chutney
Cactus pear	Pickle
Jangal jalebi	Juice, various home preparation
Chirounjee	Dried nut and various nut based products
Mahua	Juice, squash, nectar, RTS from fresh flower, dehydrated flowers and various home scale products, Jam, juice etc. from ripe fruit
Phalsa	Juice, syrup and other fruit beverages
Tamarind	Kernel powder, Juice concentrate, Pulp powder, Pickle, jam, syrup, candy
Jamun	Vinegar, cider, syrup, Nectar, RTS
Woodapple	Chutney, pickle, jelly, fruit beverages
Pilu	RTS, nectar, squash

squash, jam, dehydrated products etc.. There is good demand not only in domestic market but also in international trade for new food products, especially, which are highly nutritious and delicately flavoured. Some processed fruits like tamarind, ker, lasoda and khejri products are now being marketed in those parts of the world where Asian particularly Indians are settling in large population.

Constraints in expansion of area under cultivation of underutilized fruits

Exploitation underutilized fruits is delimited by a gamut of factors such as technical, socio-economic and institutional. The main constraints are as followed;

- Poor awareness about the nutritional and medicinal value of underutilized fruit crops.
- Less emphasis in researches for exploitation of potential underutilized fruits.
- Lack of standardized propagation techniques in many such fruits and non- availability of quality planting materials (seed and vegetative parts).
- Limited application of modern cultivation practices e.g. negligible use of innovative and novel technologies such as biotechnology, plasticulture for enhancement of productivity.
- Lack of proper transportation facilities for an efficient supply of production inputs and timely disposal of produced in the market.
- Lack of knowledge about suitable postharvest management practices.
- Under-developed marketing channels and infrastructure like storage facilities.
- Non-competitive prices of produce of underutilized fruits.
- Inadequate extension services for promotion of cultivation underutilized fruits.
- Negligible set up of agro-industrial units.

Strategies for the development of arid underutilized horticultural crops

- Creation of awareness about the nutritional importance of unexploited fruits through organization of special awareness camps/ campaigns, exhibition, etc., at micro and macro level, use of mass media like radio, TV, newspaper and distribution of other printed literature.
- Emphasis on sustainable collection and use of various fruits from forests and domestication of potential wild species for avoiding over-exploitation from natural sources.
- More crop-specific systematic research and development efforts entailing conservation of genetics resources, improvement, production technology advancement, postharvest management, value addition etc., keeping in view the agro-climatic suitability of the region.
- Independent tailor-made research for crops important for subsistence farming and those exhibiting potential to become commodity crops.

- Development of trait-specific varieties from the available gene pool to cater the intended demand.
- Mass multiplication of planting materials and their distribution.
- Increased focus to document indigenous knowledge through ethno-botanical studies to tap multipurpose uses of such crops.
- Emphasis on development of processing units in rural areas.
- Expansion of infrastructure facilities with priority on market development, transport and communication.
- Promotion of export oriented production programmes of targeted crops.

A number of underutilized fruits are available in arid parts of the country. The less known fruit crops should be popularised and improved cultural practices should be developed for different agro-climatic regions. These plants are not only yields fruits but also provide firewood, leaf fodder and serve as wind breaks in arid regions. Owing to its multiple uses, it can be used in different farming systems to meet the basic needs of local inhabitants.

Thus, it can be concluded that more attention is needed on exploitation of genetic resources of underutilized fruits. There is a tremendous scope of underutilized fruits cultivation in water scarce areas of the country. Under drought conditions, using underutilized plants in horti-pasture and agro-horticultural system are suitable to fulfil the local demand of food, fodder and fuel besides several products of economic uses. The genetic resources may be utilized for crop improvement as a source of resistance, hardiness and vigour. The post harvest management of underutilized fruits is essential for value addition.

REFERENCES :

Anonymous.2017. Horticultural Statistics at a Glance 2017. Horticulture Statistics Division, Department of Agriculture Cooperation & Farmers Welfare, Ministry of Agriculture & Farmers Welfare, Government of India. Pp. 481.

Anonymous. 1960.*Capparis decidua*, Wealth of India, Raw Material-II, C.S.I.R., New Delhi Pp.210-215.

Anonymous. 1993. Final Report of the Project "Genetic selection and improvement of *Opuntia* cultivars for human and animal food on semi arid lands". Nimbkar Agricultural Research Institute, Phaltan, Maharasthra, India.

Bhandari, M.M. 1995. Flora of Indian desert, Scientific Publisher, Jodhpur, India.

Bhardwaj, R.L. and Pandey, S. 2011. Juice Blends—A Way of Utilization of Under-Utilized Fruits, Vegetables, and Spices: A Review. *Crit. Rev. Food Sci. Nutr*., **51**: (6): 563-570.

Bhargava, R. and Saroj, P.L. 2003. Standardization of protocol for micro-propagation of Capparis decidua. CIAH, Annual Report 2002-2003, pp. 125-126.

Chauhan, B.M., Duhan, A., and Bhat, C.M. 1986. Nutritional value of *ker* Capparis decidua fruit.*J. Food Sci. Technol.*, **23:** (2): 106-108.

Chandra, A., Chandra, A. and Gupta, I.C. 1994. *Lasoda*, In Arid Fruit Research, Scientific Pub., Jodhpur, pp. 235-239.

Chundawat, B.S. 1990. Arid Fruit Culture, Oxford IBH Pub., New Delhi.

Ghosh, S.N. 2015. Breeding ofunderutilized fruit crops. Jaya Publishing House, Delhi. Pp. 530.

Gopalan, C.B.N., Ramasastri, B.V. and Balasubramanium, S.C. 1971. Nutritive Value of Indian Foods. National Institute of Nutrition, ICMR, Hyderabad.

Gupta, I.C. Harsh, L.N. Shankarnarayan, K.A. and Sharma, B.D. 1987. Note on *Capparis decidua* (*Kair*) from waterlands. *Curr. Agric.*, **11**: 87-89.

Joshi, G.D., Prabhudesai, V.G. and Salvi, M.J. 1986. Physicochemical characteristics of *Karonda* (*Carissa carandas* L.) fruits. *Maharashtra J. Hort*., **3:** (1) : 39-44.

Karale, A.R., Keskar, B.G., Shete, M.B., Dhawale, B.C., Kale, P.N. and Chaudhari, K.G. 1989. Seedling selections of *Karonda* (*Carissa carandas* L.). *Maharashtra J. Hort*., **4** : 125-29.

Khoo H.E., Ismail A., Mohd-Esa, N., Idris, S. 2008. Carotenoid content of underutilized tropical fruits. *Plant Foods Hum Nutr*., 63:170–175.

Krishna, H. and Chauhan, N. 2015. Mulberry. *In.* Ghosh, S.N. (ed.). *Breeding of Underutilized Fruit Crops*. Jaya Publishing House, Delhi, India. pp. 339-349.

Krishna, H., Singh, D., Singh, R.S., Kumar, L., Sharma, B.D. and Saroj, P.L. 2018. Morphological and antioxidant characteristics of mulberry (*Morus* spp.) genotypes. *J. Saudi Soc. Agric. Sci*., https://doi.org/10.1016/j.jssas.2018.08.002

Krishna, H., Singh, D., Singh, R.S., Meena, R.K. and Kumar, L. 2019. Phyllotaxic diversity as a means of assessing variations in mulberry (*Morus* spp.). *Intl. J. Minor Fruits Med. Arom. Plants*, **5**: (1): 38-43.

Kumar, S., Rani, C. and Mangal, M. 2012. A Critical review on *Salvadora persica*: An important medicinal plant of arid. *Intl. J. Phytomed*., **4**: 292–303.

Meghwal, P.R. and Singh, A. 2016. Underutilized Fruits Research in Arid Regions: A Review. *Ann. Arid Zone*, **56:** (1&2): 23-36.

Meghwal, P.R. and Vashishtha, B.B. 1998. Effect of time of planting and auxins on rooting of cuttings of *ker* (*Capparis decidua* Forsk). *Ann. Arid Zone*, **37:** (4): 401-404.

Nandal, U. and Bhardwaj, R.L. 2014. The role of underutilized fruits in nutritional and economic security of tribals: a review. *Crit. Rev. Food Sci. Nutr*., **54:** (7): 880-90.

Pundir, J.P.S. 1987. Studies on Growth. Flowering and fruiting behaviour of *Lehsua* (*Cordia dichotoma* Forst.) Ph.D. Thesis, Sukhadia Univ., Udaipur.

Pareek, O.P. 1978. Development of horticulture in arid region. Indian Horticulture, **23:** (2) : 23-30.

Pareek, O.P. and Sharma, S. 1993. Under-utilized Fruits, *Indian Hortic.*, **38:** (1): 47-56.

Rai, S. 1987. Chemical examination of edible plants in Rajasthan desert with special reference to *Capparis decidua* L., *TSDT*, **1**: (1-2):15-23.

Saini, R.S., Kaushik, R.A. and Singh, S. 2002. Research note on the evaluation of *Lasora* (*Cordia myxa*) germplasm for vegetative growth under semi-arid conditions. Haryana *J. Hort. Sci*., **31**: 62-63.

Saúco, G.V. 2013. Potential of Minor Tropical Fruits To Become Important Fruit Crops. *Acta Hortic*., **975**: 581-591.

Saroj, P.L. and Prakash, J. 2012. Prospects and potential of underutilized fruits in India. *In.*: Sharma, S.K., Singh, R.S., Krishna, H., Bhargava, R. and Sharma, B.D. (eds.). *Compendium of Winter School on Exploitation of Underutilized Horticultural Crops for Sustainable Production* held on 5-25 September, 2012 at ICAR-CIAH, Bikaner, Rajasthan. pp. 19-28.

Singh, R.S. and Singh, V. 2001. Performance of vegetable types Cactus under Indian conditions. *Curr. Agric*., **25**: 97-100

Singh, G.B. and Felker, P. 1998. Cacti: A new world food. *Indian Hort*., 43 :26-31.

Singh, R.S. and Vishwanath 1991. Shushka Kshetra mein labhkari *lasoda* lagayein. Phal-Phool, April-June issue, p. 8-9.

Singh, R.S., Nath, V. and Tewari, J.C. 1996. *Lasora*- a promising fruit tree for arid eco-system. *Deco Mirror*, **3**: (2): 5-11.

Singh, R.S. and Tewari, J.C. .1994. *Salvadora*: A multipurpose tree in arid traits. *Deco Mirror*, **2**: (2): 129-22.

Singh R.S., Bhargava, R., Sharma, B.D. and Pareek, O.P. 2002. Effect of depth and directions of cladodes planting on growth in cactus pear. *Curr. Agric*., **26**: 119-121.

Singh, R.S.1993. Maru kshetra ka Upyyogi Phal kair (in Hindi). *Udyan Lok,* **5**: (4) : 1-2.

Singh, S. and Singh, A.K. 2005. Genetic diversity in *mahua* (*Bassia latifolia*) under semi-aridecosystem of Gujarat. *Indian J. Agric. Sci*., **75:** (8): 519–523.

Singh, D., Kumar, C., Choudhary, MK, Mahla, HR. 2018. Indian arid zone miracle plants for food and livelihood security. *Intl. J. Minor Fruits Med. Arom. Plants*, **4**: (1): 1-12.

Vijayan, K., Tikader, A., Weiguo, Z., Nair, C.V., Ercisli, S., Tsou, C.H. 2011. *Morus*. *In.* Kole, C. (ed.) *Wild Crop Relatives: Genomic and Breeding Resources*. Springer, Berlin Heidelberg, pp. 75-95.

Wessels, A.B. 1988. Spineless Prickly pear. Perskor Publication, Johanesburg, South Africa. Pp. 61.

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INVITED ARTICLE

Spilanthes acmella- an important medicinal plant

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ABSTRACT

Spilanthes acmella Murr., commonly known as toothache plant, an important medicinal plant belonging to family Asteraceae. It has been reported to posses various biological activities like antipyretic, antidiuretic, antiinflammatory, antioxidant, immunomodulatory, hepatoprotective, anticancer and antitoothache etc. The plant has been found to produce important secondary metabolites like spilanthol, scopoletin, myrecene, á amyrin, â amyrin etc. Among all, the bioactive chemical component is spilanthol, an alkamide which is present in roots and all aerial parts of the plant. Spilanthol has high industrial demand for its use in pharmaceutical, cosmetic and toothpaste industry. S.acmella is quickly getting depleted from its natural habitat, because of its wider applications for commercial use. The plant is not meeting the industrial demand due to less commercial cultivation. In this context, the present review will throw light on its medicinal importance and pharmacological applications, cultivation practices and mass propagation through tissue culture techniques.

Key Words: *Spilanthes acmella*, phytochemical constituents, traditional and medicinal uses, cultivation

INTRODUCTION

Spilanthes acmella Murr., commonly known as toothache plant or Paracress or Eyeball plant is an important medicinal plant belonging to family Asteraceae. It has been reported to posses various biological activities like antipyretic, antidiuretic, antiinflammatory, antioxidant, immunomodulatory, hepatoprotective, anticancer and anti-toothache etc. The plant has been found to produce important secondary metabolites like spilanthol, scopoletin, myrecene, á amyrin, â amyrin etc. Among all, the bioactive chemical component is spilanthol, an alkamide which is present in roots and all aerial parts of the plant. Spilanthol has high industrial demand for its use in pharmaceutical, cosmetic and toothpaste industry. *S.acmella* is one of such important medicinal plants that quickly getting depleted from its natural habitat, because of its wider applications for commercial use. The plant is not meeting the industrial demand due to less commercial cultivation. The other major limiting factor in large scale propagation of *S.acmella* is low germination and viability of the seed (Pati *et al.,* 2006).

MEDICINAL PROPERTIES

Spilanthes acmella Murr. is an important medicinal plant, popularly known as toothache plant which reduces the pain associated with toothaches and induce saliva secretion. For centuries *S. acmella* has been widely cultivated for horticultural, medicinal, insecticidal, and culinary purposes and application for this purpose is still widespread in different parts of the world. Whole plant of *S. acmella* is rich in secondary metabolites, which impart a plethora of medicinal uses to the plant. Different parts of this plant possess multiple pharmacological activities, which include antimicrobial, antipyretic, local anaesthetic, bio-insecticide, anticonvulsant, antioxidant, aphrodisiac, analgesic, diuretic, toothache relieve and anti-inflammatory effects (Dubey *et al.,* 2013).

ACTIVE PRINCIPLE AND PHYTOCHEMICAL CONSTITUENTS

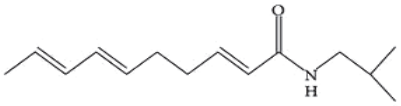
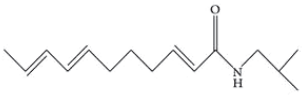
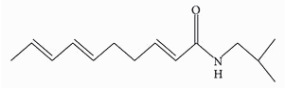
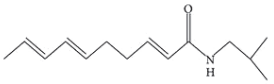
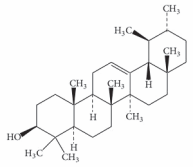
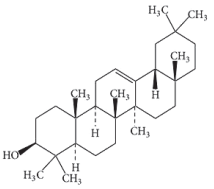
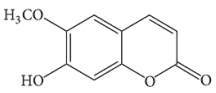
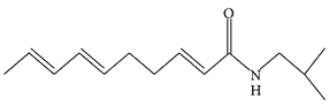
The medicinal properties of *S. acmella* are mainly due to the presence of a wide array of compounds with varying structural patterns, such as alkylamides (spilanthol), phenolics (ferulic acid and vanillic acid), coumarin (scopoletin) and triterpenoids, like â-sitostenone and stigmasterol (Prachayasittikul *et al*., 2009). Of these, the most abundant principle is Spilanthol, an antiseptic alkylamide, (2E, 6Z, 8E)-deca-2,6,8-trienoic acid N-isobutyl amide The analgesic activity of spilanthol has been attributed to an increased

gamma-aminobutyric acid (GABA) release in the temporal cerebral cortex. Spilanthol is bitter, strong pungent taste and produce local anaesthetic effects.

The flower head and root part of the plant have been reported to be the rich source of active principles. Antioxidant, Butylatedhydroxytoluene (BHT) and fatty acids (n-Hexadecanoic acid and tetradecanoic acid) have been obtained from extracts of flower heads. The leaves contain alkaloids, carbohydrates, pungent amides, tannins, steroids, carotenoids, essential oil, amino acids etc. (Savadi *et al.,* 2010). Besides the alkamides, pungent nonvolatile sesquiterpenoids have been found, such as polygodial and eudesmanolide II. Essential oils were isolated from the flowers of *S. acmella*, which contain limonenes, â-caryophyllene, Z-â-ocimene, ã-cadinen, thymol, germacrene D, Triterpenoids and myrecene (Dubey *et al.,* 2013).

The various chemical constituents of *Spilanthes acmella* and their structures are summarised in Table 1.

Table 1: Chemical structures of important secondary metabolites of *Spilanthes acmella*.

Names	Structures
Spilanthol	
deca-2E,7Z,9E-trienoic acid isobutylamide	
β-Sitosterol	
Vanillic acid	
α-Amyrin	
α-Amyrin	
Scopoletin	
Limonene	

TRADITIONAL USES

S.acmella is a well-known anti-toothache plant and is used in traditional medicine for many purposes. The different plant parts of *S.acmella* like flowers heads, leaves, roots, stem and other aerial parts have been used in various health care systems (Prachayasittikul *et al.,* 2013). The important traditional uses and applications of different parts of *Spilanthes acmella* in different healthcare systems are provided in the Table 2.

Table 2: Traditional uses and applications of different parts of *Spilanthes acmella* plant

Health Care	Treatment	Plant part Used
Medical	Rheumatism, fever Diuretics Flu, cough, rabies diseases, Tuberculosis, antimalarials, Antibacterial	Leaves, flowers
	Antifungals, skin diseases Immunomodulatory Antiscorbutic Local anesthetics Digestive , Obesity control (lipase inhibitor)	Leaves
	Snakebite	Whole plant
Dental	Toothache	Leaves, Flower
	Toothpaste	Leaves
	Pridontal disease	Flower heads, Roots
Beauty care cosmetics	Fast acting muscle relaxantAntiwrinkle	Whole plant

In the tropics and subtropics, this plant is widely used in traditional medicine. The major use in medicine is for toothache where the fresh flower head and leaves are chewed or placed in tooth cavities to relieve pain. Traditionally, *Spilanthes* plants are used to treat stammering in children, fungal skin diseases and remedy for snakebite.

In India, juice of inflorescence of *S. acmella* is used to treat mouth ulcers (Pushpangadan and Atal, 1986). Ethiopian traditional healers use the crushed aerial parts in a paste dressing for external injuries (Teklehaymanot *et al*., 2007). In Nigeria and Sri Lanka, *S. acmella* is used as a sialagogue (Jayaweer *et al*., 1981).

PHARMACOLOGICAL APPLICATIONS

Different parts of *Spilanthes acmella* plant shows various pharmacological activities. *S.acmella* leaves and flowers extract exhibits antimalarial, antiseptic, anti-bacterial properties. The flower heads of *S.acmella* can be chewed to relieve toothache and also as an analgesic (Leng *et al.,* 2011). Ayurvedic system of medicine, flower heads and roots are used in treatment of scabies, psoriasis, scurvy, infections of gums. The leaves are used as immune-modulatory, anti-scorbitic, ailagogine and digestive. Spilanthol, the most active antiseptic alkaloid extracted from this plant, is found effective against blood parasites (Yadav and Singh, 2010). The other bioactive compounds, scopoletin (coumarin) and ferulic acid (phenolics) found in this plant are reported to be of immense pharmacological interests (Prachayasittikul *et al*., 2009). Scopoletin is a phytoalexin, its production mainly seen upon pathogenic infection. It is considered as an important defence agent against bacteria and fungi (Smith, 1996). It has attracted the most attention because of its use in cardiovascular disease, antitumor and anti-thyroid treatment. In addition to this, scopoletin also possesses antioxidant, antimicrobial, anti-inflammatory, antipyretic and hepatoprotective properties. Ferulic acid is most highly regarded for its antioxidant property. Additionally, it exhibited a wide range of therapeutic effects against cancer, diabetes, cardiovascular and neurodegenerative diseases (Singh and Chaturvedi, 2015). The important pharmacological actions of *S.acmella* have been summarized in Table 3 and are listed below.

Table 3: Summary of pharmacological actions of *Spilanthes acmella.*

SL. no.	Pharmacological activity	Parts of plant used	Experimental models	Animals used
1	Local anaesthetic	Whole plant	Intracutaneous wheal in guinea pigs and plexus anaesthesia in frog	Guinea pig, frog
2	Antipyretic activity	Whole plant	Yeast induced pyrexia	Albino rats
3	Anti-inflammatory activity	Whole plant, leaves	Carrageenan induced paw oedema	Albino rats
4	Analgesic activity	Whole plant	Tail flick method, acetic acid induced abdominal constriction	Albino rats
5	Diuretic activity	Flowers (cold water extract), whole plant	Induction of dieresis using cold water extract	Albino rats
6	Vasorelaxant activity	Flowers	Partially endothelium induced nitric oxide and PGI_2	Albino rats
7	Antioxidant activity	Leaves & whole plant	DPPH Assay, TBARs and SOD method	*Invitro,* no animal
8	Antimalarial & larvicidal activity	Spilanthol extracted from whole plant	—	Eggs & pupae of vector
9	Aphrodisiac activity	Whole plant	—	Male rats
10	Antinociceptive activity	Whole plant	Acetic acid induced writhing	Mice
11	Immunomodulatory activity	Whole plant	—	Rats
12	Bioinsecticidal	Whole plant, leaves	—	—
13	Convulsant	Whole plant	Electroencephalogram (EEG) analysis	Albino rat

ANAESTHETIC ACTIVITY

The local anaesthetic activity of *Spilanthes acmella* has been carried out using two different animal models: (i) intracutaneous application in guinea pigs using nupercaine as standard (suitable for determining degree of anaesthesia) and (ii) plexus anaesthesia in frog using cocaine as standard (used for determining onset of anaesthesia) (Chakraborthy *et al.,* 2002). The mean onset of local anaesthetic action was very potent which could be attributed to the presence of alkylamides.

ANTIPYRETIC EFFECTS

Chakraborty *et al.* (2010) studied the antipyretic activity of *Spilanthes acmella* which was carried out by yeast induced method as yeast is commonly used for the induction of pyrexia. The antipyretic activity of *Spilanthes acmella* demonstrated in the study is attributed to the presence of flavonoids which are predominant inhibitors of either cyclo-oxygenase or lipo-oxygenase.

ANTI-INFLAMMATORY AND ANALGESIC ACTIVITY

The antiinflammatory activity of *Spilanthes acmella* has been carried out by the researchers using carrageenan induced hind paw oedema (Chakraborty *et al*., 2010). The extract was found to produce considerable dose-dependent inhibition of paw oedema which was less than the standard drug. They also demonstrated the analgesic activity of *Spilanthes acmella* using acetic acid induced abdominal constriction and tail flick method. The aqueous extract produced better results as compared to tail flick method which meant that the plant can be explored as peripherally acting

analgesic. The activity was attributed to the presence of flavonoids which are potent inhibitors of prostaglandins at later stages of acute inflammation.

ANTIBACTERIAL ACTIVITY

The different fractions were isolated from crude ethyl acetate extract of *S. acmella* and were studied against 27 strains of microorganisms (Prachayasittikul *et al*., 2009). The results showed that fraction E3 completely inhibited the growth of *Corynebacterium diphtheriae* with MIC value of 128 µg/mL. The antibacterial activity is also reported from the flower head extract of *S.acmella* (Sabitha and Murty, 2005).

ANTIFUNGAL ACTIVITY

The effect of different concentrations of *Spilanthes acmella* flower head extract against four different fungi: *Aspergillus niger, Aspergillus parasiticus, Fusarium oxysporum, and Fusarium moniliformi* was evaluated by Sabitha and Murty (2006). All the concentrations of the test solution inhibited the fungal species with varying degree of sensitivity. The maximum zone of inhibition was found at highest concentration (2 mg/l) and increased proportionally with the dose. Among the test organisms, high inhibition zones were observed in *F. oxysporium and F. moniliformis* followed by *A. niger and A. parasiticus.*

DIURETIC EFFECT

The diuretic potential of *Spilanthes acmella* whole plant as well as fresh flowers, extracted using cold water extract method showed strong diuretic activity when given orally in a single dose (Ratnasoorya *et al.,* 2004). The dieresis induced by the *Spilanthes acmella* flowers was found to be strong with intensity similar to that of furosemide and accompanied by marked increases in both urinary Na+ and K+ levels. The onset of the diuretic action of the aqueous extract was extremely rapid, and it also had a fairly long duration of action.

PANCREATIC LIPASE INHIBITION

Ethanolic extracts of the flowers of *Spilanthes acmella* are demonstrated to inhibit pancreatic lipase activity (40% at 2 mg/mL concentration *in vitro*) (Ekanem *et al*., 2007).

VASORELAXANT AND ANTIOXIDANT ACTIVITY

The plant extracts elicited vasorelaxations via partially endothelium induced nitric oxide and prostaglandin-I2 in a dose-dependent manner (Hossain *et al.,* 2012). Significantly, the ethyl acetate extract exhibited immediate vasorelaxation in nanogram levels and is the most potent antioxidant in the diphenylpicryl hydrazine assay. The chloroform extract displays the highest vasorelaxation with the highest antioxidant concentration. Antioxidant potential of leaves of *Spilanthes acmella* was also studied recently by the researchers and they found that the potent antioxidant activity in the crude ethanol extract of the leaves of the plant was attributed to the presence of tannins, flavonoids and phenolic compounds **(**Hajera *et al.,* 2014**).**

ANTIMALARIAL AND LARVICIDAL EFFECTS

Spilanthol is more effective even at low doses against eggs and pupae. In pupae, it seems to work on nervous system as evident by abnormal movement like jerks, spinning and uncoordinated muscular activity. This suggested that the drug disturbed the nerve conduction somewhere. The mortality of pupae in short span of time upon exposure to the drug also indicated that spilanthol greatly disturbs the ongoing processes of histolysis and histogenesis. Many researchers also reported spilanthol as a potent larvicidal agent (Sabitha *et al.,* 2005).

APHRODISIAC ACTION (INTERACTION WITH TESTOSTERONE AND SEXUALITY).

Aphrodisiac effect of the plant extract has been studied in male rats by Sharma *et al*. (2011). They stated that mount latency, intromission latency, ejaculation frequency and postejaculatory interval were increased in a dose-dependent manner after oral administration of extract.

IMMUNOMODULATORY ACTIVITY

Hexane and chloroform extracts of *Spilanthes acmella* were found to suppress nitric oxide production in stimulated macrophages at 80 mcg/mL by 72% and 85%, respectively (Wu *et al.,* 2008). Isolated spilanthol demonstrated dose-

dependent prevention of macrophage activation with 60% and 20% production of nitric oxide at 90 and 360 5ØßM concentrations, respectively. These inhibitory properties were accompanied by less nitric oxide synthetase and cyclooxygenase-2 mRNA and protein content, less cytokine production from macrsophages, and less nF-kB activation in the nucleus.

BIOINSECTICIDE AND CONVULSANT ACTIVITY

Several insecticidal compounds have been reported in *Spilanthes acmella* (Ramsewak *et al.,* 1999). Extract of *S. acmella* plant in rats was reported to induce full convulsions accompanied by typical electrographic seizures in the electroencephalogram (Mondal *et al.,* 1998).

INSECTICIDAL TOXICITY OF SPILANTHOL

Extract of Spilanthol from the flower heads of *Spilanthes acmella* was found to be active against *P. xylostella* (Sharma *et al*., 2012). The extracts from *Spilanthes* were most toxic against different mosquito species (i.e., Anopheles, Culex, and Aedes). The insecticidal property was attributed to spilanthol and alkamides. Besides, non-volatile sesquiterpenoids, saponins were also reported (Krishnaswamy *et al.,* 1975). Ethanol extract of flower heads of *Spilanthes* has shown a potent ovicidal, insecticidal and pupacidal activity at dose of 7.5 ppm concentration against Anopheles, Culex, and *Aedes* mosquito (Saraf and Dixit., 2002). The hexane extract of dried flower buds of *Spilanthes acmella* (3 N-isobutylamides: spilanthol, undeca-2E,7Z,9E-trienoic acid isobutylamide and undeca2E-en-8,10-diynoic acid isobutylamide) was found active against *Aedes aegypti* larvae. Ethanolic extracts of *Spilanthes acmella* (whole plants) were screened against early 4th instar larvae of *Culex quinquefasciatus* (Pitasawat *et al*., 1998). Spilanthol was shown to be toxic against adults of *P. americana*. It is one of the most potent compound when compared with conventional insecticides such as carbaryl, lindane, and bioresmethrin (Sharma *et al*., 2012). The *S. acmella* flower head extract also found to be effective in controlling the *Spodoptera litura,* an polyphagous, serious agriculture pest (Sabitha and Murty, 2009).

MUSCLE RELAXANT

The plant's extract is an active component used in beauty care cosmetics as a fast acting muscle relaxant to accelerate repair of functional wrinkles (Belfer, 2007). The *S. acmella* extract was also used for stimulating, reorganizing and strengthening the collagen network in anti-age applications (Schubnel, 2007).

ANTICANCER ACTIVITY

Spilanthol has been demonstrated to inhibit nitric oxide (NO) production in a murine macrophage cell line, to efficiently down regulate the production of inflammatory mediators interleukin (IL)-1â, IL-6 and tumor necrosis factor (TNF-á), and to attenuate the expression of cyclooxygenase-2 (COX-2) and inducible NO synthase (iNOS) (Wu *et al.,* 2008). Other investigations have also confirmed the down regulation of some pro-inflammatory cytokines by bioactive alkylamides under various experimental conditions (Cech *et al*., 2006). These findings suggest that spilanthol can be a useful inhibitor of inflammatory mediators and is a potential new lead compound for COX-2 selective non-steroidal anti-inflammatory drugs (NSAIDs).

CULTIVATION

Spilanthes acmella can be grown as an annual in most climates. It is frost-sensitive but perennial in warmer climates. Commercial *Spilanthes* plantations have been established to address the need for sustainable supplies of standardized, high quality raw materials. *S. acmella* grows well in full sun to partial shade reaching a height of 12 to 15 inches with a spread of 24 to 30 inches. It prefers rich, moist, well-drained soil with a pH of 6.1 to 6.5. It is easily established started from seeds directly sown in the garden or indoors pots. Seed should be sown in flats. *Spilanthes* can also propagate through stem cuttings. It needs regular watering and thrives well in high humidity in well-drained soils.

The optimal temperature for germinating the seeds is 20-24°C (68-75°F). It is important to sow the seeds by burrowing them to about only 1/4 inch

***Spilanthes acmella* Plant**

deep as they require light to stimulate germination. Germination takes approximately 1-2 weeks. For the best germination results, it is recommended to grow indoors in sterilized potting soil. A black earth and peat moss mixture works well. Always keep soil moist but never soggy. Once the seedlings have at least 2 sets of leaves they can be transplanted when the danger of frost has passed.

For utilizing the leaves and flowers of *Spilanthes acmella*, the whole plant can be harvested by cutting the plant to about 6". It will grow back and can be harvested again during the season. For harvesting the roots of the plant, the entire plant is plucked out and the roots are cut and separated from the plant. The harvested plant parts can be shade dried and stored in a dry place to avoid moisture and contamination.

PROPAGATION

Spilanthes acmella seeds have low rates of germination and moreover, propagation by seeds is also limited because of the highly heterozygous nature of the plant due to protandry, which prevents self-pollination (Reddy *et al.,* 2004). Field gene banks offer easy access to conserved material but they have risk of destruction by natural calamities, pests and diseases. Hence, *in vitro* conservation through plant tissue culture is the safest and efficient alternative for medicinal plant conservation. Tissue culture offers an opportunity to utilize plant cell, tissue or organ by growing them *in vitro* to get large number of plants and desired medicinal metabolites. *In S. acmella,* there are few reports on successful micropropagation through various explants.

MICROPROAGATION THROUGH HYPOCOTYL EXPLANTS

Saritha *et al.* (2002) were the first to report the successful tissue culture of *Spilanthes*. They reported multiple shoot proliferation from hypocotyl explants of 1-week-old seedlings on MS medium supplemented with BAP (2.2 mM) and NAA (0.54 mM). About 95% of the *in vitro* developed shoots rooted on half strength (½) MS medium containing IBA (4.9 mM).

MICROPROPAGATION THROUGH AXILLARY SHOOT PROLIFERATION

Haw and Keng (2003) attempted *in vitro* clonal propagation of *Spilanthes* by axillary shoot proliferation. The aseptic axillary buds formed multiple shoots within five weeks when cultured on MS medium supplemented with BAP (8.8 mM) and NAA (0.54 mM). However, the study lack crucial information on percent culture response, the rate of proliferation in recurrent cycles of shoot multiplication, frequency of rooting and transplantation was not attempted. *S. acmella* was *in vitro* multiplied using axillary buds as explants on MS medium supplemented with various

concentrations of BAP and NAA (Nelofar *et al*., 2015). In a similar study, shoot induction was observed from axillary and apical meristems as explants on MS medium supplemented with various auxins and cytokinins individually and in various combinations (Hajera and Sabitha Rani, 2017).

MICROPROPAGATION THROUGH NODAL SEGMENTS

Multiple shoots were induced from nodal explants on media supplemented with BAP and IAA (Yadav and Singh 2010). A report (Singh and Chaturvedi, 2010) on systematic clonal propagation by nodal segment culture is published whereby, detailed description on *in vitro* shoot multiplication, rooting and hardening are described. In this study, nodal explants of *S. acmella* bearing two opposite axillary buds were cultured on MS basal medium, supplemented with BAP and high rate of shoot multiplication was observed. A single shoot with long internodes was developed from axillary buds in 100% cultures when NAA (1.0 or 5.0 mM) was added to BAP containing medium.

Singh *et al*. (2009) established *in vitro* propagation system of *Spilanthes* using nodal segment transverse thin cell layer (tTCL) culture system. MS medium fortified with BAP (5.0 mM) was optimal for shoot regeneration from tTCL. On this medium, the explants inoculated in the upright orientation exhibited a high frequency (97%) of shoot regeneration from the edge of the explants, and the highest number of shoots (an average of 31.5) per explant.

DIRECT REGENERATION THROUGH LEAF EXPLANTS

Saritha and Naidu (2008) reported shoot regeneration from leaf explants. Maximum number of shoots per explants was recorded on MS medium containing BAP (13.2 mM) and IAA (5.7 mM). An anatomical study confirmed that shoot regeneration was via direct organogenesis. Micropropagation of *Spilanthes* by leaf-disc culture was also reported by Pandey and Agrarwal (2009). They obtained green and compact callus on MS medium supplemented with BAP (10.0 mM) and NAA (1.0 mM) in 15 days. Shoots were rooted on ½ MS + IBA (0.1 mM) within 2 weeks. The plantlets were successfully hardened and established in soil where they flowered and set viable seeds. Direct shoot regeneration and callus production was also observed from the leaf explants, supplemented with different concentrations of IAA (Tanwer *et al*., 2010). Recently, Singh and Chaturvedi (2012a) reported morphogenesis from leaf disc cultures. They cultured leaf-disc explants of 5 mm size on a range of media. At its optimal concentration of 5.0 mM, BAP showed highest percentage (100%) of shoot organogenesis with an average of 3.5 adventitious shoots, directly from the explants, without an intervening callus phase. In comparison to BAP alone and BAP + NAA, addition of IAA to MS + BAP medium enhanced the number of shoot-buds per explant significantly.

CROP IMPROVEMENT INCLUDING BIOTECHNOLOGY

In a previous study, an effective method for rapid and large scale multiplication of the plant was developed through tissue culture with a protocol for effective organic farming to boost the vigour and other quantitative traits of the plant.

HAIRY ROOT INDUCTION IN *SPILANTHES ACMELLA*

Hairy root cultures offer a promise for high production of valuable secondary metabolites used as pharmaceuticals, pigments and flavors. Genetically transformed hairy roots obtained by infection of plants with *Agrobacterium rhizogenes* are suitable source for production of bioactive molecules due to their genetic stability and fast growth in culture media devoid of growth hormones (Shanks and Morgan, 1999). Integration of plasmid into host plant genome is stable which accounts for genetic stability of transformed root cultures.

Research on hairy root production in the genus *Spilanthes* is still in its infancy. There is one report on the production of hairy roots of *Spilanthes paniculata* by infecting the cotyledons and hypocotyl segments with *A. rhizogenes* strains MTCC 2364 and MTCC 532 (Sheela *et al.,* 2008). In case of *A. rhizogenes* MTCC 532, the best frequency explant infection percent for hypocotyl and cotyledon explants were 75% and 76%. The values for *A. rhizogenes* MTCC 2364 were 78% and 76%.

A significant observation has been made in a recent study (Hajera Sana, 2018) in which hairy roots were induced from nodal segments and leaves of *S.acmella* by transfecting with *A.rhizogenes* MTCC 532. The hairy roots were multiplied and their spilanthol content was quantified using HPLC. This study reported the presence of high amount spilanthol in hairy roots (0.134%) compared to the other types of roots i.e *in vitro* produced roots (0.066%) and roots from field grown plants (0.056%). Hence hairy root induction can be employed as an alternative and sustainable source for spilanthol production, which holds immense potential for pharmaceutical applications.

UTILIZATION

Spilanthes acmella plant parts are predominantly used as extracts in personal care products, traditional medicines, pharmaceutical and culinary areas. There is a significant advances in all aspects of *Spilanthes* research and an increasing number of commercial *Spilanthes* products have appeared in the market place as personal care products, health care products and for culinary use. Most people find the spilanthol-induced tingling of the tongue unpleasant, but when cooked, the plants lose their strong flavor and may be used as a green leafy vegetable. For culinary purposes, a small amount of shredded fresh leaves adds unique flavors to salads. In addition, both fresh and cooked leaves are used in dishes such as stews and soups.

For medicinal use, worldwide the flower heads are used either fresh or dried and powdered, but the use of roots and leaves has been recommended as well. Infusions and decoctions are prepared from the aerial parts or roots and administered either orally or topically as compresses or baths.

PLANT EXTRACTION PROCEDURE

To extract the active principles and useful chemical compounds from *S.acmella* plant parts, the common techniques employed are basically maceration, infusion, percolation, digestion, decoction. The aqueous-alcoholic extraction are done by fermentation, counter current extraction, microwave assisted extraction, phytonic extraction (with hydrofluorocarbon solvents), ultrasound extraction (sonication), hot continuous extraction (Soxhlet), supercritical fluid extraction etc. The spilanthol can be extracted from *S. acmella* using simple maceration, supercritical fluid extraction, solid phase extraction and microwave assisted methods (Dias *et al*., 2012; Costa *et al*., 2014). In most of the studies hexane, ethanol, methanol and hydroethanolic solvents were used for spilanthol extraction.

ANALYTICAL TECHNIQUES FOR QUANTITATIVE AND QUALITATIVE ESTIMATION OF SPILANTHOL AND OTHER CHEMICAL COMPONENTS FROM *S.ACMELLA*

For spilanthol detection and quantification, so far, various analytical techniques such as High-Performance Liquid Chromatography (HPLC), Nuclear Magnetic Resonance (NMR), Gas Chromatography- Mass spectrometry (GC-MS) and Liquid Chromatography-Mass spectrometry were used. The NMR (Nuclear Magnetic Resonance) and High pressure liquid chromatography-Mass spectrometry (HPLCMS) were employed to determine structure of spilanthol in extracts of *S.acmella* (Nakatani and Nagashima (1992). Bae *et al*. (2010) used high pressure liquid chromatography-electrospray ionization-mass spectrometry (HPLC-ESI-MS) for rapid identification and quantification of spilanthol from *S. acmella*. Mbeunkui *et al.,* (2011) identified *Spilanthes* alkylamide by electrospray ionization-ion trap-time of flight mass spectrometry (ESI-IT-TOFMS) and validated by 1H-and13C-NMR analysis. Leng *et al*., (2011) employed GC-MS to detect spilanthol present in mother plant, flower heads and *in vitro* plantlets of *S. acmella.* Recently, Singh and Chaturvedi, (2012b) used HPLC and then MS I for identification and quantification of spilanthol present in *in vivo* and *in vitro* plants. Centrifugal partition chromatography (CPC) is another technique used for quantitative isolation of N-alkylamides from *S. acmella* methanolic flower extract.

IN VITRO PRODUCTION OF SECONDARY METABOLITES FROM *S.ACMELLA*

In *Spilanthe*s, so far, only two reports are available on *in vitro* metabolite production. First of all, Singh and Chaturvedi (2010) reported scopoletin accumulation in *in vitro* nodal segment

derived plant. They have developed a novel HPLC method with fluorescence detector for the quantitative estimation of scopoletin in *S.acmella*. The results of this study showed that the scopoletin content of the nodal segment derived plants was 0.104 mg/g DW of leaves which was comparable to that of the mother plant (0.101 mg/g DW of leaves). Scopoletin biosynthesis was induced in several plant species upon infection by different pathogens (Matros and Mock, 2004) and played an important role in defence mechanism against bacteria and fungi (Smith, 1996). However, no quantification studies were performed in either of these reports. This is the first report on detection and quantification of scopoletin in *S. acmella.* The study revealed that even the uninfected leaves of *Spilanthes* could accumulate the scopoletin. The same authors, after two year, observed spilanthol production from leaf of leaf disc derived plants. Interestingly, they noticed significantly higher spilanthol production (3294.3 mg/g DW) from leaf disc derived plants than from field grown plants. In the same study, callus cultures established from leaf disc accumulated low amount of spilanthol (998.03mg/g DW) (Singh and Chaturvedi 2012).The study confirms the earlier reports which suggested that differentiated (organized and dedifferentiated) cells and specialized organs generally produce most secondary products compared to dedifferentiated (unorganized) cells in cultures.

REFERENCES :

Bae, S.S., Ehrmann, B.M., Ettefagh, K.A. and Cech, N.B**.** 2010. A validated liquid chromatography-electrospray ionization-mass spectrometry method for quantification of spilanthol in *Spilanthes acmella* (L.) Murr. *Phytochem Analysis,* **21**:438–443.

Belfer, W.A. 2007. Cosmetic compositions comprising peptides and *Acmella oleracea* extract to accelerate repair of functional wrinkles, US Pat. 2007048245.

Cech, N.B., Tutor, K., Doty, B.A., Spelman, K., Sasagawa, M., Raner, G.M. and Wenner, C.A. 2006. Liver enzyme-mediated oxidation of *Echinacea purpurea* alkylamides: production of novel metabolites and changes in immunomodulatory activity. *Planta Med.,* **72**: 1372–1377.

Chakraborty A., Devi B. R. K., Rita S., and Singh I.T. 2002. "Local anaesthetic effect of *Spilanthes acmella* in experimental animal models," *Indian Journal of Pharmacology*, **34**: 144–145.

Chakraborty, A., Devi, B.R.K., Sanjebam, R., Khumbong, S. and Thokchom, I.S., 2010. Priliminary studies on local anesthetic and antipyretic activities of *Spilanthes acmella* Murr. in experimental animals models. *Indian Journal of Pharmacology*, **42**(5): 277-279.

Costa S.S., Gariepy Y., Rocha S.C.S. and Raghavan V., 2014. Microwave extraction of mint essential oil – temperature calibration for the oven. *J. Food Eng.,* **126**:1–6.

Dias, A. M. A., Santos, P., Seabra, I. J., Júnior, R. N. C. and Braga, M. E .M., 2012. De Sousa HC. Spilanthol from *Spilanthes acmella* flowers, leaves and stems obtained by selective supercritical carbon dioxide extraction. *J Supercrit Fluids*, **61**:62–70.

Dubey, S., Maity, S., Singh, M., Saraf, S. A. and Saha, S**.** 2013. Phytochemistry, pharmacology and toxicology of *Spilanthes acmella*: A review. *Ad Pharmacol Sci*., 423750 (on line journal): 1-9.

Ekanem, A., P., Wang, M., Simon, J. E., and Moreno, D. A. 2007. Antiobesity properties of two African plants (*Afromomum meleguetta* and *Spilanthes acmella*) by pancreatic lipase inhibition, *Phytotherapy Research*, **21**: (12):1253–1255.

Hajera Sana , Sabitha Rani, A. and G.Sulakshana. 2014. Determination of antioxidant potential *Spilanthes acmella* using DPPH Assay. *International Journal of Current Microbiology and Applied Sciences*, **4** (7): 219-223.

Hajera Sana and Sabitha Rani, A. 2017. Micropropagation of *Spilanthes acmella* Murr. from nodal segment and apical shoot tip cultures, *Indian J.Sci.Res.,* **13** (1): 92-98.

Hajera Sana. 2018. Tissue culture studies and production of secondary metabolites by hairy root induction in *Spilanthes acmella* Murr. Ph.D. Thesis, Department of Botany, Osmania University, Hyderabad, T.S.

Haw, A. B. and Keng, C. L. 2003. Micropropagation of *Spilanthes acmella* L. a bio-insecticide plant, through proliferation of multiple shoots. *J Appl Hort.*, **5**:65–68.

Hossain, H., Shahid-Ud-Daula, A. F. M, Jahan, I.A., Nimmi, I, Hasan K., and Haq, M. M, 2012. "Evaluation of antinociceptive and antioxidant potential from the leaves of *Spilanthes paniculata* growing in Bangladesh," *International Journal of Pharmacy and Phytopharmacology Research*, **1**: (4): 178–186.

Jayaweer, D. M. A. 1981. *Medicinal Plants. Part III*. Columbo, Sri Lanka: National Science Council of Sri Lanka.

Krishnaswami, N.R, Prasanna, S., Seahadri, T.R., Vedantham, T.N.C., 1975. á- and â-Amyrin esters and sitosterol glucoside from *Spilanthes acmella*. *Phytochemistry*., **14**: 1666–1667.

Leng T.C., Ping N.S., Lim B.P. and Keng C.L. 2011. Detection of bioactive compounds from *Spilanthes acmella* (L.) plants and its various *in vitro* culture products. *J Med Plant Res*., **5**:371–378.

Matros, A., and Mock, H.P. 2004. Ectopic expression of UDP glucose: phenylpropanoid glucosyltransferase leads to increased resistance of transgenic tobacco plants against infection with Potato Virus Y. *Plant Cell Physiol.*, **45**: 1185–1193.

Mbeunkui, F., Grace, M.H., Lategan C., Smith, P.J., Raskin, I. and Lila, M.A., 2011. Isolation and identification of antiplasmodial N-alkylamides from *Spilanthes acmella* flowers using centrifugal partition chromatography and ESI-IT-TOF-MS. *J. Chromatogr.,* **879**: 1886–1892.

Mondal, A.K., Parui, S. and Mandal S., 1998. Analysis of the free amino acid content in pollen of nine Asteraceae species of known allergenic activity. *Annals of Agricultural and Environ- mental Medicine*, **5**: (1): 17–20.

Nakatani, N. and Nagashima, M., 1992. LC-MS analysis and structure determination of pungent alkamides from *Spilanthes acmella* L. flowers. *Lebens Wiss Technol*., **25**:417–421.

Nelofar Gulam Nabi and Mukta Shrivastava. 2015. *Spilanthes acmella* Murr. An important endangered medicinal plant and its conservation through Tissue culture techniques Indian J. Applied & Pure Bio. Vol. 30(2), 159-163.

Pandey, V. and Agrawal, V., 2009. Efficient micropropagation protocol of *Spilanthes acmella* L. possessing strong antimalarial activity. *In Vitro Cell Dev Biol Plant,* **45**: 491–499.

Pati, P. K., Rath, S. P., Sharma, M., Sood A. and Ahuja P. S**.** 2006. *In vitro* propagation of Rose- A review. *Biotechnol. Adv.,* **24**: 94–114.

Pitasawat, B., Choochote, W., Kanjanapothi, D., Panthong, A., Jitpakdi, A. and Chaithong, U. 1998. "Screening for larvicidal activity of ten carminative plants," Southeast Asian Journal of *Tropical Medicine and Public Health*, **29**: (3): 660-662.

Prachayasittikul, S., Ruchirawat, S. and Prachayasittikul, V**.** 2013. High therapeutic potential of *Spilanthes acmella: A Review* / Veda / *EXCLI Journal*, **12**:291-312.

Prachayasittikul, S., Suphapong, S., Worachartcheewan, A., Lawung, R., Ruchirawat, S. and Prachayasittikul, V. 2009. Bioactive metabolites from *Spilanthes acmella Murr. Molecules*, **4** (12) :850-867.

Pushpangadan, P and Atal, C.K. 1986. Ethnomedical and ethnobotanical investigations among some scheduled caste communities of travancore, Kerala, India. *Journal of Ethnopharmacology*, **16**(2-3):175–190.

Ramsewak R.S., Erickson A.J. and Nair M.G**.**, 1999: Bioactive N-isobutylamides from the flower buds of *Spilanthes acmella*. *Phytochemistry*, **51**:729-73.

Ratnasooriya, W. D., Pieris K. P. P., Samaratunga U., and Jayakody, J. R. A. C. 2004. Diuretic activity of *Spilanthes acmella* flowers in rats, *Journal of Ethnopharmacology*, **91** (2-3): 317–320.

Reddy, S. M., Rao, M. M., Reddy, A. S., Reddy, M. M. and Chary, S .J. 2004. University Botany-iii: (Plant Taxonomy, Plant Embryology, Plant Physiology). New Age International (P) Publishers, New Delhi, pp. 95.

Sabitha Rani , A. and Murty U .S.N. 2005. Evaluation of antoimicrobial activity of *Spilanthes acmella* flower head extract. *Journl of Natural Remedies*, **5**(2) 170-171.

Sabitha Rani , A. and Murty, U .S.N. 2009. Antifeedant activity *of Spilanthes acmella* flower head extract against *Spodoptera litura* (Fabricus). *J.Ent Res*., **33** (1)-55-57.

Sabitha Rani , A., Srinivas Rao.M. and Murty, U.S.N. 2005. Evaluation of three medicinal plants of India against the larvae of *Culex quinquefasiatus*. Nig. J. Nat. Prod. and Med., **9**: 44-45.

Sabitha Rani, A and Murty, U.S,N. 2006. Antifungal potential of flower head extract of *Spilanthes acmella*. *Afr J Biomed Res*. **9**: 67-69.

Saraf, D. K. and Dixit, V.K. 2002. "*Spilanthes acmella* Murr. ; study on its extract spilanthol as larvicidal compound", *Asian Journal Experimental Science,* **16**: (1-2): 9-19.

Saritha K. V. and Naidu, C.V.2008. Direct shoot regeneration from leaf explants of *Spilanthes acmella. Biologia Plantarum,* **52**(2):33:334-338.

Saritha, K. V., Prakash, E., Ramamurthy, N. and Naidu, C. V. 2002. Micropropagation of *Spilanthes acmella* Murr. *Biol Plant.,* **45**:581–584.

Savadi R.V., Yadav R. and Yadav N. 2010. Study on immunomodulatory activity of ethanolic extract Spilanthes acmella Murr. Leaves. *Indian Journal of Natural Products and Resources*, **1**(2): 204-207.

Schubnel, L. 2007. A different approach to lifting efficacy based on a natural active ingredient. *SOFW J,* **133**:34-39.

Shanks, J. V. and Morgan, M. 1999. Plant 'hairy root' culture. *Current Opinion Biotechnology,* **10**: 151- 155.

Sharma V., Boonen, J., N. Chauhan, S.N., Thakur, M., de Spiegeleer, B., and Dixit, V.K., 2011. *Spilanthes acmella* ethanolic flower extract: LC-MS alkylamide profiling and its effects on sexual behavior in male rats. *Phytomedicine*, **18:** (13), 1161– 1169.

Sharma, A., Kumar, V., and Singh B. 2012. Insecticidal toxicity of spilnthol from *Spilanthes acmella* Murr. against *Plutella xylostella*. *American journal of Plant Sciences,* **3**: 1568-1572.

Sheela, C., Sharma H. P. , Ramesh C. and Jha S. 2008. *Agrobacterium rhizogenes* mediated genetic transformation of *Spilanthes paniculata* (DC.) Jansen. *International Journal of Plant Sciences*, **3**(2): 471-476.

Singh, M. and Chaturvedi, R. 2012a. Screening and quantification of an antiseptic alkylamide, spilanthol from *in vitro* cell and tissue cultures of *Spilanthes acmella* Murr. *Industrial Crops and Products*, **36**: 321-8.

Singh, M. and Chaturvedi, R. 2012b. Evaluation of nutrient uptake and physical parameters on cell biomass growth and production of spilanthol in suspension cultures of *Spilanthes acmella* Murr. *Bioprocess Biosyst Eng*, **35**:943-951.

Singh, M. and Chaturvedi, R. 2015. An appraisal on *in vitro* conservation and biotechnological interventions in *Spilanthes acmella* Mur. In : Plant Reproductive Biology and Conservation, Publisher: I.K. International, Delhi, pp.299-319.

Singh, M. and Chaturvedi, R., 2010. Optimization of *Spilanthes acmella* L. cultivation by *in vitro* nodal segment culture. *Acta Hort.,* **865**: 109-114.

Singh, S. K., Rai, M .K., Asthana, P. and Sahoo, L. 2009. An improved micropropagation of *Spilanthes acmella* L. through transverse thin cell layer culture. *Acta Physiol. Plant,* **31**: 693–698.

Smith, C. J. 1996. Accumulation of phytoalexins: Defence mechanism and stimulus response system. *New Phytol.*, **132**: 1–45.

Tanwer, B.S, Choudhary, R. K. and Vijayvergia, R**.** 2010. *In vitro* and *in vivo* comparative study of primary metabolites and Antioxidant activity in *Spilanthes acmella* Murr. *International Journal of Biotechnology and Biochemistry*, **6** (5): 819– 825.

Teklehaymanot, T., Giday, M., Medhin, G and Mekonnen, Y. 2007. Knowledge and use of medicinal plants by people around Debre Libanos monastery in Ethiopia. *Journal of Ethnopharmacology*, **111**(2):271–283.

Wu, L.C., Fan, N.C., Lin, M.H., Chu, I.R., Huang, S.J., Hu, C.Y., Han and S.Y. 2008. Anti-inûammatory effect of spilanthol from *Spilanthes acmella* on murine macrophage by down-regulating LPS-induced inûammatory mediators. *J. Agric. Food Chem.*, **56**: 2341–2349.

Yadav, K. and Singh, B. 2010. Micropropagation of *Spilanthes acmella* Murr. – An important medicinal plant. *Nature and Science,* **8**(9):5–11.

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Leaf Morphology and Stomatal Anatomy Indicates Inter-Varietal Variability in Water Chestnut (*Trapa natans* var. *bispinosa* Roxb.)

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ABSTRACT

Water chestnut (Trapa natans var. bispinosa Roxb.) is a commercially important yet underutilized aquatic, annual herb grown for its valuable fruit but it has not been documented for germplasm variability in India. Thus, 20 morphotypes of Trapa, collected from various blocks of district Lucknow (Uttar Pradesh) and maintained in artificial pit created as experimental pond at the Vocational Research Farm of our department. Significant differences were recorded in Selection – 6 among the collected genotypes for leaf characters with highest number of leaves per plant (29.67), maximum length of leaves (19.78cm), length (5.65cm) and width of lamina (8.78cm), petiole length (13.34cm) and stomatal pore width (5.16ìm) while, maximum pulvinus diameter (15.94 mm) and fruit yield (255.07 g plant^{-1}) were recorded for Selection- 12 and similarly pulvinus: petiole ratio (0.29), stomatal width (8.05ìm) and stomatal density (50ìm^{-2}) were observed maximum in Selection-14 and maximum pulvinus length (3.17cm) recorded in Selection- 10. Minimal environmental influence on the morphological expression of the characters under study is indicated by similar genotypic coefficient of variance (GCV) andphenotypic coefficient of variance (PCV) values. The highest PCV (35.44), GCV (35.07), h^2% (97.90) and genetic advance as percent of mean (147.42%) was observed for width of stomatal pore, while highest genetic advance (26.01) was observed for stomatal density. Thus, phenotypic expression of these characters was governed at the genetic level since they show high heritability contributing to genetic advance over mean and thus, these selected characters could be useful for selection traits for future crop improvement programs.

Key words: Phenotypic, Stomata, *Trapa natans* var. *bispinosa*, Variability, Water chestnut

INTRODUCTION

Water chestnut (*Trapa natans* var. *bispinosa* Roxb.) is a commercially important aquatic, angiospermic, annual, warm season herb grown for its valuable fruit but variation in its germplasm has not been documented in India. *Trapa natans* var. *bispinosa* Roxb has two forms, one is red (leaf, petiole and fruit) and the other is green (leaf, petiole and fruit) each bearing fruit large in size having two dull spines (Faruk *et al*., 2012). It is basically a tropical crop, cultivated commercially in tropical, subtropical and temperate zones of the world (Arima *et al.,* 1999). In India, it is cultivated in waterlogged areas in shallow ponds and catchment areas of irrigation canals etc. in most north Indian states (Chakor, 1974). The water chestnut fruits are nutritive and possess medicinal importance and are used in the traditional ayurvedic system of medicine, yet it is highly neglected for study of its inter variability in Indian agro-climatic situation (Babu *et al.,* 2011). This research has focussed on diversity in water chestnut on the basis of leaf morphological and stomatal characters since success of any breeding program depends upon the quantum of genetic variability available for exploitation and the extent to which the desirable characters are heritable (Tiwari *et al*., 2011) contributing to genetic advance.

MATERIALS AND METHODS

Twenty germplasm of water chestnut from the various blocks of district Lucknow of Uttar Pradesh, were collected during end of June to July, 2016 and established in ponds $2\times1\times1m^3$ in dimension at Vocational Research Farm, Department of Horticulture, Babasaheb Bhimrao Ambedkar University, Lucknow following standard management practices (Chattopadhyay, 1996).

Leaf Morphology Studies

Leaves of uniform age and physiological maturity at 6-8 internode from the apex of rosette were collected as per leaf sampling technique (Wolf, 1982). Length of leaves and lamina, width of lamina, petiole and pulvinus length (cm) was measured using measuring scale while pulvinus diameter was measured using digital vernier callipers (Mitutoyo, Japan). The experiment was laid out in randomized block design. Observed data was analyzed using Windows-based computer software ICAR-SPAR (Statistical Package for Agricultural Research) as per procedure for analysis of variance at 5% level of significance, PCV and GCV was estimated as per procedure by Burton and De Vane (1953) whereas, heritability in broad sense (h^2) and genetic advance were calculated following the method of Allard (1960).

Stomatal Anatomy Study through Scanning Electron Microscopy (SEM)

Variations in the anatomical characters of stomata were studied by scanning electron microscope (JSM-6490LV, JEOL, Japan) at University Scientific Instrumentation Centre of the university. Leaf samples were prepared as per procedure given by Fischer *et al.* (2013) with slight modifications (Fig.1).Stomatal density (μm^{-2}) was measured at 500X magnificence while, all stomatal dimensions were measured at 5000X magnificence.

RESULTS AND DISCUSSION

Variability Study by Leaf Morphology Analysis

A statistical significant variability was observed in leaf morphological characteristics of water chestnut (Table 1). The maximum values were observed for leaf number (29.67), leaf length (19.78cm), lamina length (5.65cm), lamina width (8.78cm) and petiole length (13.34cm) in Selection-6, while, maximum pulvinus diameter (15.94mm) and fruit yield (255.07g) were recorded for Selection-12 and pulvinus length (3.17cm) and pulvinus: petiole ratio (0.29) were observed in Selection-10 and 14, respectively. These leaf morphological characters helped to identify primarily the inter-varietal variability of water chestnut as also described by other scientific workers who narrated morphological characterisation is one of the simple, rapid and inexpensive methods which was conventionally applied in mango (Begum *et al*., 2014; Kishor *et al.,* 2019), in jamun (Swamy *et al*., 2017), in banana (Kundu *et al.,* 2018 and in other horticultural crops Salparni (Manivel *et al.,* 2019) and in *Gingko biloba* (Klimko *et al.,* 2015) which even facilitating the identification and classification of fragments of *Gingko* fossil leaves. But, number of these traits is limited, unstable and unable to establish variations in closely related accessions (Konarev, 2000). These may however, be controlled by epistatic and pleiotropic gene effects and face heritability problems (Begum *et al*., 2014). Thus, prime advantages of genotyping on the basis of morphological traits are simplicity and rapid, inexpensive assays, even from herbarium specimens and other dead tissues (Begum *et al.,* 2014). However, it is limited and lack decisiveness because environmental variations also affect expression of these characteristics. Thus, these morphological characters may not adequately represent the genetic variability among accessions of a single cultivar. Hence, characterization of inter-varietal variability based on morphological traits was complemented with stomatal studies through scanning electron microscopy (SEM) since stomatal initiation is controlled by both environmental and genetic factors (Casson and Hetherington, 2010) and is indicative of clonal variability.

Study on Stomatal Characters

The maximum stomatal density ($50\mu m^{-2}$) and stomatal width (8.05 µm) were recorded in Selection- 14. However, the highest stomatal length (17.43 µm) and stomatal pore length (13.52 µm) were recorded in Selection-19 and maximum stomatal pore width (5.16 µm) was recorded for Selection-6 (Table 1). Stomatal density is reported to vary within leaves, plants and individuals even of a single species (Afas, 2006) which may be due to environmental factors (Woodward and Kelly, 1995) but, is also genetically controlled by additive genes (Gailing *et al*., 2008) which indicates that selection of these stomatal characters would be more effective for crop improvement.

Table. 1 Vegetative performance and scanning electron microscopy of leaves of water chestnut (*Trapa natans* var. *bispinosa* Roxb.)

Morpho types	Number of leaves	Length of leaves (cm)	Length of lamina (cm)	Widths of lamina (cm)	Petiole length (cm)	Pulvinus length (cm)	Pulvinus diameter (mm)	Pulvinus: petiole ratio	Stomatal Density (μm^{-2})	Stomatal length (µm)	Stomatal widths (µm)	Stomatal pore size (µm)		Yield g/plant
												Length	Width	
Sel-1	22.50	16.40	5.62	7.50	11.60	2.77	6.58	0.25	25	13.73	7.36	9.12	2.48	201.60
Sel-2	24.34	12.87	4.55	5.09	7.65	1.80	5.34	0.25	38	13.88	6.04	9.91	3.44	101.44
Sel-3	29.67	13.49	4.55	5.45	9.47	2.29	7.34	0.26	47	12.95	4.68	8.68	1.40	76.67
Sel-4	27.17	12.50	4.20	4.22	7.02	1.60	3.84	0.19	31	15.24	6.56	8.68	2.20	97.67
Sel-5	23.50	16.90	4.74	5.82	12.29	2.32	8.30	0.24	29	17.00	6.28	12.81	3.44	119.54
Sel-6	29.67	19.78	6.44	8.78	13.34	2.88	7.80	0.22	39	16.00	6.68	12.78	5.16	139.77
Sel-7	25.34	18.44	5.14	6.87	13.18	3.05	7.86	0.23	46	12.55	6.85	6.94	1.84	105.80
Sel-8	24.84	17.04	5.12	6.80	12.95	2.97	7.39	0.23	44	11.53	6.4	8.08	3.72	103.67
Sel-9	26.00	17.22	5.55	5.65	12.35	2.74	11.13	0.24	40	14.88	6.76	8.42	3.04	139.00
Sel-10	21.67	17.30	5.29	7.69	12.67	3.17	8.49	0.27	39	14.28	5.29	8.54	1.92	129.04
Sel-11	22.00	16.20	5.15	5.77	10.28	2.42	10.97	0.24	38	14.44	4.76	10.78	1.76	104.37
Sel-12	22.67	16.79	5.53	8.53	12.53	2.92	15.94	0.27	35	15.44	6.76	11.27	1.60	255.07
Sel-13	24.50	13.30	4.22	5.25	9.29	2.20	9.27	0.24	48	11.80	5.44	8.24	2.72	80.67
Sel-14	27.67	13.79	4.99	5.67	9.23	2.53	10.58	0.29	50	13.33	8.05	8.22	3.44	113.40
Sel-15	27.17	13.14	4.69	5.83	9.35	2.40	9.18	0.28	42	15.73	5.48	10.61	2.56	133.80
Sel-16	26.67	11.93	4.30	5.43	7.47	1.68	5.33	0.23	42	13.20	6.52	8.59	3.64	82.60
Sel-17	24.50	14.87	4.55	5.45	9.33	2.07	7.92	0.22	44	13.40	6.56	9.36	6.56	93.04
Sel-18	23.84	16.17	4.70	5.82	10.67	2.37	8.75	0.23	44	14.16	7.52	10.28	3.83	145.22
Sel-19	23.34	17.09	4.78	6.38	12.10	2.53	9.80	0.22	42	17.43	5.53	13.52	1.84	191.43
Sel-20	23.67	17.40	4.52	6.10	12.85	2.35	8.47	0.20	46	11.48	5.92	6.64	2.36	246.60
SEM	1.461	1.050	0.333	0.342	0.464	0.143	0.478	0.013	1.559	0.756	0.363	0.763	1.559	5.260
CD	6.399	4.599	1.458	1.497	2.032	0.626	2.093	0.060	2.067	1.353	0.649	1.365	2.790	23.038

Table 2 Estimates of PCV, GCV, heritability, genetic advance and genetic advance as percent of mean in water chestnut (*Trapa natans* var. *bispinosa* Roxb.)

Characters		Grand Means	Minimum	Maximum	PCV	GCV	h^2 (%)	GA	GAM (%)
No. of leaves		25.03	21.67	29.67	10.11	0.13	0.00*	0.00*	0.00*
Length of leaves (cm)		15.62	11.93	19.78	17.70	13.34	56.80	6.67	42.70
Length of lamina (cm)		4.92	4.20	5.62	15.37	9.96	42.00	1.33	27.03
Widths of lamina (cm)		6.20	4.22	8.78	20.70	18.35	78.60	4.28	69.03
Petiole length (cm)		10.78	7.02	13.34	19.17	17.65	84.80	7.43	68.92
Pulvinus length (cm)		2.45	3.84	15.94	20.01	17.26	74.40	1.54	62.85
Pulvinus: Petiole ratio		0.23	1.60	3.17	10.65	3.22	9.10	0.00*	0.00*
Pulvinus diameter (mm)		8.51	0.19	0.29	21.02	18.64	78.60	5.97	70.15
Stomatal density (μm^{-2})		40.43	25.00	50.00	16.51	15.82	91.8	26.01	64.33
Stomatal length (µm)		14.12	11.48	17.43	13.10	11.34	74.9	5.89	41.71
Stomatal widths (µm)		6.25	4.68	8.05	15.23	13.47	78.2	3.15	50.40
Stomatal pore size (µm)	**Length**	9.55	6.64	13.52	21.55	19.20	79.4	6.94	72.67
	Width	2.72	1.40	5.16	35.44	35.07	97.9	4.01	147.42
Yield g/plant		133.01	76.67	255.07	6.86	0.34	0.30	0.10	0.077

*Very negligible

The extent of variability among genotypes was further determined in terms of PCV and GCV estimates which were found very close (Table 2) and reveal that most of the stomatal characters expressed appear to be independent of the environmental effect in their phenotypic expression (Majumder *et al*., 2012). The characters having high genotypic coefficient of variation, phenotypic coefficient of variation, heritability and genetic advance indicate predominance of additive gene action for these characters and these characters would have possibilities of selection towards desired direction (Ogunniyan and Olakojo, 2014) for further breeding programme. In the present experiment it was observed that the highest PCV (35.44), GCV (35.07) and heritability (97.9) were recorded for stomatal pore size (width). While, the highest genetic advance (26.01) was observed for stomatal density. So, stomatal pore size had very good distinguished parameter to specify and characterise the inter variability of water chestnut.

Genetic variability was recorded based on morphological studies which was further elucidated with the help of stomatal studies through SEM. Similar values for PCV and GCV for morphological as well as stomatal characters indicated genetic control of their phenotypic expression since the influence of the environment was minimal in case of water chestnut. Significantly high values for PCV, GCV heritability and genetic advance were recorded for stomatal characters as well as some morphological traits *viz*., stomatal density, petiole length indicating that these traits would have possibilities of selection in desired direction. Present study has significance since development of superior varieties in this hitherto, underutilised crop like water chestnut could have far reaching impact on developing an alternative crop which has the capacity to grow in waterlogged, degraded lands.

REFERENCES :

Afas AN, Marron N and Ceulemans R. 2006. Clonal variation in stomatal characteristics related to biomass production of 12 poplar (*Populus*) clones in a short rotation coppice culture. Environ. *Exp. Botany*, **58**: 279-286.

Allard RW. 1960. In: Principles of plant breeding. New York, NY, USA: John Wiley and Sons.

Arima S, Hoque MA and Agarie S. 1999. Comparison of growth and yield performance of several water chestnut species collected from south western Japan and middle China. *Plant prod. Sci.,* **2**(4): 273-278.

Babu M, Dwivedi DH, Yogita and Ram BR 2011. Studies on physico- chemical traits on local water chestnut (*Trapa natans* var. *bispinosa* Rox.) germplasm under central Uttrar Pradesh India. *Plant Archiv.,* **11**(2): 949-951.

Begum H, Reddy MT, Malathi S, Reddy BP, Narshimulu G, Nagaraju J and Siddiq EA. 2014. Morphological and microsatellite analysis of intravarietal heterogeneity in 'Beneshan' Mango (*Mangifera indica* L.). *In. J. of Agri. and Food Res*., **3**(2): 16-33.

Burton GW and De Vane EH. 1953. Estimating heritability in tall fesscusce from Replicated clone natural materials. *Agro. J.,* **45**:171-181.

Casson SA and Hetherington AM. 2010. Environmental regulation of stomatal development. *Curr. Opin. Plant Biol.,* **13**:90–95

Chakor IS 1974. Improved practices of nursery raising for water chestnut. *Indian Far. Dig.,* **7**:37-38.

Chattopadhyay TK 1996. A textbook on Pomology. Vol. II. Kalyani Publishers, Calcutta, India.

Faruk MO, Amin MZ, Sana NK, Shaha RK and Kamal KB 2012. Biochemical analysis of water chestnut (*Trapa spp*.). *Paki. J. Biol. Sci.,* **15**(21): 1019-1026.

Fischer ER, Hansen BT, Nair V, Hoyt FH, Dorward DW. 2013. Scanning Electron Microscopy. NIH Public Access. 02-04

Gailing O, Langenfeld-Heyser R, Polle A and Finkeldey R 2008. Quantitative trait loci affecting stomatal density and growth in a Quercusrobur progeny: implications for the adaptation to changing environments. *Global Change Biol*., **14**:1934–1946.

Kishor S, Dwivedi DH, Singh N, Maji S and Sharma MK. 2019. Analysis of intra-varietal variability in mango (*Mangifera indica* L.) cv. Dashehari. *Annals of Plant and Soil Res.*, **21**(2): 193-199.

Klimko M, Korszun S and Bykowska J. 2015. Comparative morphology and anatomy of the leaves of *Ginkgo biloba* L. Cultivars. *Acta Sci. Pol. Hortorum Cultus,* **14**(4):169-189.

Konarev VG. 2000. Cultivar identification and gene pool registration by seed protein in cultivated plant St. Petersburg: Vses. Inst. Restenievod, Russia

Kundu P, Kumar F, Bauri and Maji S. 2018. Morphological study of genetic variability of banana genotypes for crop improvement. *Indian J. Eco.,* **45** (3): 615-622.

Majumder DAN, Hassan L, Rahim MA and Kabir MM 2012. Genotypic and phenotypic variability in mango (*Mangifera indica* L.). *Bangladesh J. Agri. Res*., **37**(4): 683-690.

Manivel, P., Reddy RN, Saravanan R, Thondaiman V and Ganvit RS. 2019. Exploration and collection of genetic resources of Salparni (*Desmodium gangeticum* L.) in India. *In. J. Minor Fruits, Med.and Aro. Plants*., **5** (1): 21-28.

Ogunniyan DJ and Olakojo SA. 2014. Genetic variation, heritability, genetic advance and agronomic character association of yellow elite inbred lines of maize (*Zea mays* L.). *Nigerian J. Genetics*, **28(**2): 24-28.

Swamy GSK, Anushma PL and Jagadeesha RC. 2017. Morphological characterization of elite Jamun (*Syzigium cuminii* Skeels) genotypes. *Int. J. Minor Fruits, Med. and Aro. Plants.,* **3** (1): 09-15.

Tiwari R, Suresh BG, Mishra VK and Kumar A 2011. Genetic variability and character association in direct seeded upland rice (*Oryza sativa* L.). *Envir. and Ecol.,* **29**(4A):2132-21.

Wolf B. 1982. A comprehensive system of leaf analyses and its use for diagnosing crop nutrient status. *Comm. soil sci. and plant analysis,* **13**(12): 1035-1059.

Woodward FI and Kelly CK. 1995. The influence of CO_2 concentration on stomatal density. *New Phytol*., **131**:311-327.

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Growth and yield responses of papaya *(Carica Papaya L.)* intercropped with herbaceous weeds

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ABSTRACT

Organic production of medicinally important crop is substantial to ensure food quality. Papaya is medicinally important fruit crop all over the world. A field experiment was conducted to test both growth and yield responses of papaya (Carica Papaya L.) cover cropped with different herbaceous weed species possess in allelopathic effect with the purpose of reduction of herbicide application and cost for weed management. Four herbaceous weeds namely Cleome viscosa, Andrographis paniculata, Ocimum sanctum and Celosia argentea were used with papaya var. Red Lady. Papaya was planted with 2.5x 2.5m spacing. Treatments included cultivation of four herbaceous weeds and hoe weeding (control) in between papaya rows. Mowing of cover crops was practiced at the blooming stage to ensure addition of maximum bio mass to the cultivation. A varity of data was collected throughout the trial, such as growth and yield parameters of papaya, weed survey and soil analysis. Results indicated that herbaceous weed cover did not significantly affected on vegetative growth and yield of papaya and exerted good control over weeds. However, Cleome viscose significantly reduced the number of flowers and fruits per plant. There was a long term effect of herbaceous weed cover on soil nutrient contents. Although further research is needed, it is possible to conclude that there is a possibility to use some weed species as a cover crop in papaya orchards to suppress other weed growth.

Key words: *Andrographis paniculata, Celosia argentea, Cleome viscosa, Cover crop, Herbaceous weeds, Ocimum sanctum*

INTRODUCTION

Papaya (*Carica papaya* L.) is one of the important fruit crop cultivated in Sri Lanka. It is short-lived perennial plant in the family Caricaceae. Papaya is a rich source of nutrient and use as remedy against a variety of diseases. Moreover, it contains vitamin A, C, E and minerals. Additionally, the different plant parts including leaf, ripped and unripe fruit, seed, root, bark and latex contain variety of chemicals. Papain is a digestive enzyme contains in milky juice present in papaya plant parts. Hence, it is used to treat trauma, allergies and patients with inflammatory disorders of intestine, liver and eye (Vij and Prashar, 2015; Ayoola and Adeyeye, 2010). Furthermore, leaf, seed and fruit juice have been used to treat cancers, dyspepsia, digestive disorders and chronic ulcers as well (Workneh *et al*., 2012).

However, weed management of papaya orchards in Sri Lanka become a major and costly operation due to labor scarcity and banding of herbicide glyphosate which is widely used for weed management in orchards. Nevertheless, indiscriminate use of potentially harmful agrochemicals may affect food quality and food safety, environmental pollution and health of famers (Linares *et al*., 2008). It has also increased resistance of weeds to the herbicides. Finally all these create agro ecologically unbalanced, high cost agricultural systems with irregular and reduced yield. Cover crops suppress weed by means of competition and inhibiting weed growth via allelopathy (allelochemicals) while providing multiple potential benefits to soil health and crop productivity.

Life span of papaya orchard is comparatively shorter than other perennials. Generally, it should be replaced after 2-3 years to obtain economic yield. In Sri Lanka, there are recommended cover crops for weed suppression in long term plantation crops such as tea, rubber, coconut. But for short term perennial fruit orchards, there are no

recommended cover crops for the purpose of weed suppression. Intercropping with short term crops like medicinal plants and vegetables is also a recommended method for weed management in orchards in the world. As an example the intercropping experiment conducted by Nandi and Ghosh (2016) in 8 year old Mosambi Sweet orange orchard with short term medicinal plants showed one year growing of medicinal plants namely *Menthaspicata* and *Bacopamonnieria* has no adverse effect on Mosambi, but results also indicated that *Aloevera* plant should not be grown in the orchard while growing of *Withania somnifera*and *Rouwolfia serpentine* need to be investigated further due to their high mortality rate. In spite of several benefits of intercropping, commercial orchard owners have little interest to follow this due to several issues such as higher capital investments, wider spacing, need specific attentions on managing both crops, lack of information on suitable crops, etc.

All the cover crops recommended in long term perennials are creepers. Frequent slashing and adding biomass to the soil is not practiced. Therefore, addition of biomass to the soil is not considerably higher in growing these recommended cover crops. Considering all these facts from this study we tested the effectiveness of growing some common weeds as a cover crop. These weeds can suppress the growth of other weeds due to higher competitive ability. Further they produce large amount of biomass within short period of time and resistant to various pests and diseases. Therefore, 4 weed species namely *Cleome viscose, Andrographis paniculata, Ocimum sanctum* and *Celosia argentea* were selected for the experiment.

Cleome viscosa, belongs to the family *Capparaceae*, commonly known as wild mustard. The plant is sticky herb which grows up to 30– 90 cm high and is branched. It is characterized by its yellow flowers with long slender pods with strong penetrating odour. Seeds look like mustard seeds. *C. viscosa* possess ethnobotanical, phytochemical and pharmacological importance. Hence it has been used as a remedy for various therapeutic purposes. Jana and Biswas (2011) reported that root exudates of *C.viscosa* showed inhibitory activity on rice, mustard and gram seeds germination and growth. Moreover, aqueous extracts of *C. viscosa* was significantly inhibited seed germination as well as growth and biomass production of *Sesamum indicum* L (Natarajan *et al*., 2014).

Andrographis paniculata (Acanthaceae) is commonly known as King of Bitter. Plant height ranging from 50- 100 cm, profusely branched and erect stem. This plant is used as a remedy for various diseases in most of Asian countries (Niranjan *et al*., 2010). Except medicinal properties *A. paniculata* possess allelopathic effect. Nagaraja and Deshmukh, (2009) investigated allelopathic effect of *A. paniculata* residue on growth and physiology of *P. hysterophorus*. Mandal *et al*. (2016) also reported aqueous leaf extracts of *A. paniculata* reduced seed germination and seedling growth of wheat (*Triticum aestivum* L.).

Ocimum sanctum L., (Lamiaceae) commonly known as Basil. The plant characterized by 0.5-1.5 m tall, much branched and leaves are rich in secondary metabolites (Singh and Singh, 2009, Purohit and Pandya, 2013). It is also rich in pharmacological properties thus used as a medicinal plant in India (Islam and Kato-Noguchi, 2014). Other than the medicinal properties of *O. sanctum* some researchers have investigated phytotoxic activity of *O. sanctum* on different weed species and common legume species (Singh and Singh, 2009; Islam and Kato-Noguchi, 2014; Purohit and Pandya, 2013).

Celosia argentea L. (Amaranthaceae) show erect growth to a height up to1.0 to 1.6 m. It has greater reproductive capacity, thus produces large number of seeds creating huge seed banks in the soil. Saritha and Sreeramulu, (2013) investigated allelopathic effect of *C. Argentea* for agricultural crops such as inhibitory effects on seed germination and seedling growth of *Sorghum bicolor*, *Phaseolous aureus*, *Arachis hypogaea*, *Dolichos lab lab* and *Vigna unguiculata*. Moreover, it has been reported presence of phytochemicals namely, hyaluronic acid, celosianin, betanin and isocelosianin affected on seed germination and plant growth of above crop plant.

Cleome viscose, Andrographis paniculata, Ocimum sanctum L. and *Celosia argentea* L. are commonly grown herbaceous plant in Sri Lankan

orchards. In this study mainly focused to assess the possibility of use of those herbaceous plants for papaya orchard floor management. Effects on soil nutrients, papaya plant growth, yield and weed control efficacy were investigated

MATERIALS AND METHODS

The study was conducted in Faculty of Agriculture, University of Ruhuna Sri Lanka (Low country wet zone) during 2016 to 2018. Before establishing papaya, selected weed species ie, *Cleome viscose* (T1), *Andrographis paniculata* (T2), *Ocimum sanctum* L. (T3) and *Celosia argentea* L. (T4) seedlings were established in the field. After having uniform dense weed population in each plot, seedlings of papaya variety "Red lady" were transplanted in March 2017 at a spacing of 2.5 x 2.5 m. Each plot contained 4 papaya plants and in between papaya plants, there was previously established weed species as cover crops. Hoe weeding (T5) was used as the control. Weeds were moved using a grass cutter at their blooming stage while keeping few plants for the seed production for next generation. Each treatment was repeated in three plots in a randomized block design. Plant height, and number of leaves per plant were measured at 50% flowering (50%FI) and first fruit ripening (1stFR) stages of papaya. Number of flowers per plant and number of fruits per plant were also recorded in weekly intervals. Total yield of papaya were also taken one year after planting. Number of weeds and number of weed species were also counted by using 20 cm x 20 cm quadrate at 6 month after planting. Composite soil samples were randomly collected from the top 20 cm depth of soil from each plot except manure circle of papaya plant before cover crop establishment and at 6 months (6 MAP) and 12 months (12 MAP) after planting. Soil samples were air dried, grounded and sieved in 2 mm mesh. Total nitrogen (N), available prosperous (P), extractable potassium (K) and total organic carbon (TOC) were analyzed at plant nutrient laboratory, Tea Research Institute, Walahanduwa, Sri Lanka.

The analysis of variance for all data was measured using the ANOVA procedure of the statistical analysis system (SAS). The mean values were separated by using Duncan's Multiple Range Test (DMRT) at the 0.05 probability level.

RESULTS AND DISCUSSION

Intercropping cover crops along with other cash crops can have some unique benefits, such as improving soil fertility, reduction of soil erosion, water evaporation, stimulate pollinators, increase soil organic matter content *etc*. Therefore integration with cover crops is an important agricultural practice in sustainable crop production systems. Some weeds can also be used as a cost effective cover crop in crop fields as there is no cost for seeds and establishment in the field. Those weeds can frequently and easily mow down using a grass cutter which reduces the cost for herbicide application. In this study, the suitability of four herbaceous weed species as a cover crop in papaya orchards was investigated as an organic weed control method.

It was observed that cover cropping of *Ocimum sanctum*, *Celosia argentea*, *Cleome viscose* and *Andrographis paniculata* did not significantly affect on plant height and number of leaves of papaya (Table 1) with respect to hoe weeding. However, papaya plants which intercropped with *Cleome viscose* showed significant (P = 0.05) reduction in number of number of fruits per plant (Table 1) at 50% fruiting stage (Table 1) and it continued up to 12 months after planting (Figure 1). All the plots intercropped with herbaceous weeds gave lower yield compare to the control plots. The reason for the lower yield might be the allelopathic effect and competition for growth resources between herbaceous weeds and papaya. However, all cover crops except *Cleome viscose*, did not significantly affect on average yield of papaya (kg/plant). The control (hoe weeding) showed maximum fruit yield (25.81 kg/plant) (Figure 1).

Significant difference was not observed in number of weeds and number of weed species among treatments (Table 1). Linares *et al*., (2008) reported cover cropping of Sun hemp (*Crotalaria juncea* L.), hairy indigo (*Indigo ferahirsuta* L.), cowpea (*Vigna unguiculata* L. Walp.) and alyceclover (*Alysicarpus vaginalis* L.) in organic citrus orchards provide better weed control by means of weed suppression and cover crops dry matter accumulation. Cheema and Khaliq, (2000) investigated that sorghum stalks soil incorporation

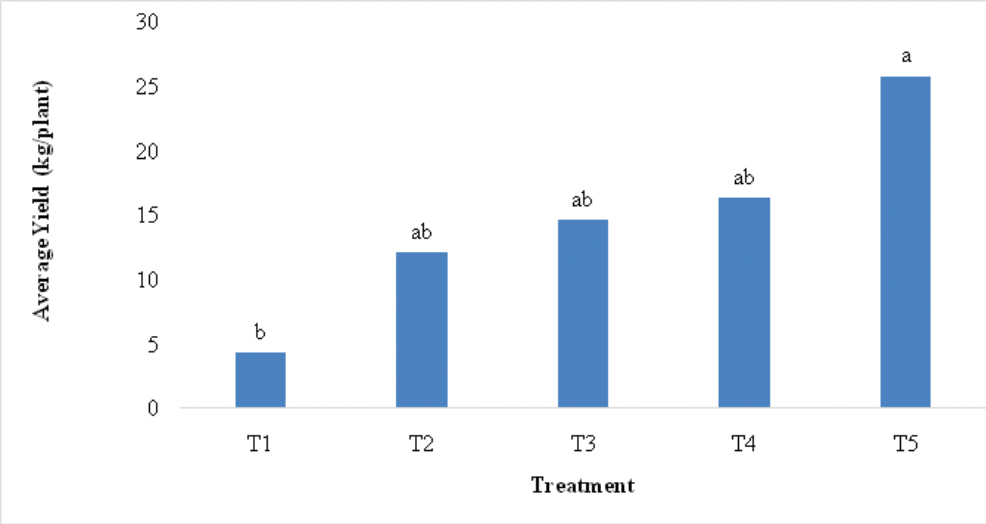

Figure 1: **Effect of herbaceous weed cover crop on average yield of papaya**. (Means with identical letters within the graph do not differ significantly based on the Duncan's Multiple Range test ($p < 0.05$), T1-*Cleome viscose*, T2-*Andrographis paniculata*, T3-*Ocimum sanctum* L., T4-*Celosia argentea* L. and T5- *hoe weedi*

Table 1. Effects of cultivation of different herbaceous weeds as a cover crop in papaya orchards on growth and yield of papaya and weed population of the field.

Treatment	Plant height (cm)		No. of leaves		No. of flowers	No. of fruits	No. of weeds/400 cm^2	No. of weed species/400 cm^2
	50% FI	1st FR	50% FI	1st FR				
C. viscosa	85.3 a	157.8 a	13.0 a	16.5 a	2.22 b	6.3 b	49.7 a	4.0 a
A.paniculata	106.3 a	187.0 a	14.5 a	19.1 a	4.02 ab	12.3 a	41.7 a	4.0 a
O. sanctum L	100.3 a	184.2 a	14.3 a	18.7 a	6.06 a	13.2 a	50.8 a	3.3 a
C. argentea	110.4 a	203.1 a	15.0 a	21.8 a	4.46 ab	15.5 a	71.8 a	3.8 a
Hoe weeding (control)	101.2 a	200.8 a	15.3 a	21.3 a	4.34 ab	19.6 a	95.8 a	4.2 a

in to the wheat field, controlled weed by 40-50% and increased grain yield by 15%. It was observed that weed suppression occurred due to the release of sorghum allelochemicals in to the soil. Moreover it has been reported that the use of cover crops in developing countries reduces input costs while improving soil productivity and crop yields (Akemo *et al*., 2000). A research conducted by Tursun *et al*. (2018) on soil management in apricot orchards reported mowing or soil incorporation of living cover crop can increase weed suppression efficacy.

The effect of herbaceous weeds on soil chemical properties at 6 and 12 month after establishment (MAE) is shown in figure 2. Total available N content 6 MAE was greater in control treatment, probably as consequence of use of N by both herbaceous weeds and papaya plants. 12 MAP increased amount of total available N was observed in all treatments except control, possibly as a consequence of incorporating mowed herbaceous weed materials with the soil. But there was no significant increment compare to the control where also hoe weeded biomass was incorporated with soil. It is well known phenomenon that the N fertilizer can easily loss from leaching or denitrification from soil profile. Similarly rapid release of N from decaying plant parts can also happen at field condition with tropical environmental condition. Therefore, measuring increment of N levels after decomposing moved herbaceous weeds at field level is a difficult task.

A significant influence of herbaceous weed cover on available P, extractable K and total organic

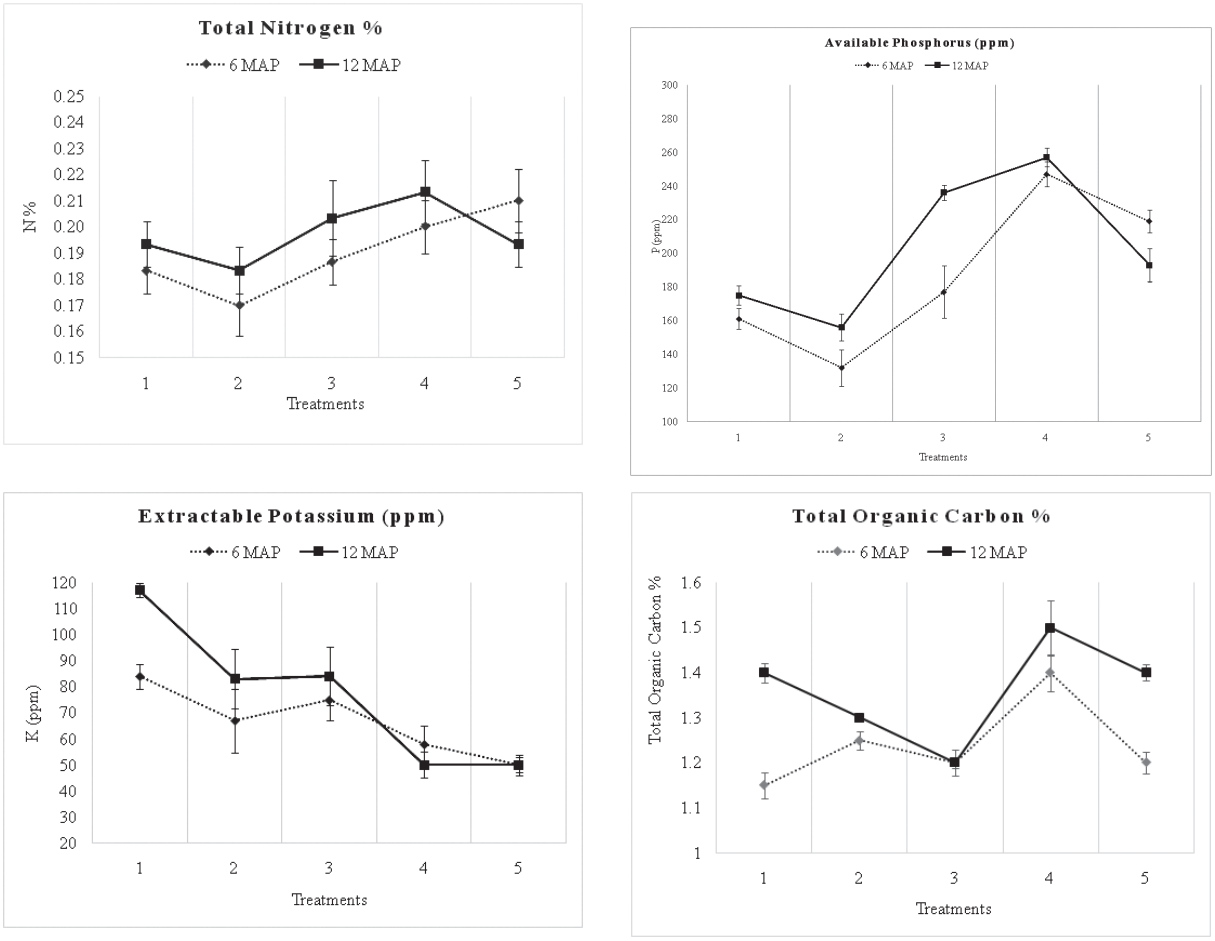

Figure 2: Soil total Nitrogen , available Posperous , extractable Potassium and total organic carbon levels as affected by different cover crops at 6 and 12 month after cover crop establishment. P <0.05 . Vertical bars show standard errors of the means. T1-*Cleome viscose*, T2-*Andrographis paniculata*, T3-*Ocimum sanctum* L., T4-*Celosia argentea* L. and T5- *hoe weeding*)

C contents of the soil was observed in this study. *Celosia argentea* (T4) and control treatments showed significantly higher values for available P in 6 MAE. *Celosia argentea* and Ocimum *sanctum* showed significantly higher amount of available P. Available P contents were increased in 12 MAE in all treatments except control than the valued observed in 6 MAE. Similar trend was observed in extractable K and total organic C % also. This indicates that there is a long term effect on this practice for soil nutrient contents (figure 2). Higher biomass production by herbaceous weeds and residue application by slashing can increase the soil properties long term. This result also agreement with the study conducted by Sainju *et al*. (2002). They reported increased soil organic carbon and nitrogen concentration in no tillage system with the application of cover crop residues of hairy vetch and winter weeds. And also Diacono and Montemurro, (2011) reviewed that decomposition of organic matter is done by heterotrophic microorganisms and this process is affected by temperature, moisture and ambient soil conditions and leads to the release and cycling of plant nutrients. According to the observations, cover cropping of *C. argentea* (T4) showed maximum performance in increment of soil nutrient except soil extractable potassium level.

CONCLUSION

The hoe weeding method is labour intensive method than intercropping of herbaceous weeds.

Thus intercropping of *Celosia argentea* was nearly as productive as the hoe weeding methods by means of economicall advantage and organic weed management method. Similarly keeping orchard floor green in throughout the period and adding weed trashes time to time can improve soil nutrient status and structure. This practise is supported more sustainable orchard floor management.

REFERENCES :

Akemo, M.C., Bennett, M.A., and Regnier, E.E. 2000. Tomato Growth in Spring-sown Cover Crops. *Hortscience,* **35(**5):843–848.

Ayoola, P. and Adeyeye, A. 2010. Phytochemical and nutrient evaluation of *Carica papaya* (pawpaw) leaves. *Ijrras,* **5**: 325-328.

Cheema, Z. and Khaliq, A. 2000. Use of sorghum allelopathic properties to control weeds in irrigated wheat in a semi arid region of Punjab. *Agriculture, Ecosystems & Environment*, **79**: 105-112.

Diacono, M. and Montemurroo, F. 2011. Long term effect of organic amendmends on soil fertility. *Sustainable Agriculture*, **2**: 761-786.

Islam, A. and Kato-Noguchi, H. 2014. Phytotoxic activity of *Ocimum tenuiflorum* extracts on germination and seedling growth of different plant species. *The Scientific World Journal*, : 1-8.

Jana, A. and Biswas, S.M. 2011. Lactam nonanic acid, a new substance from *Cleome viscosa* with allelopathic and antimicrobial properties. *Journal of Biosciences*, **36**: 27–35.

Linares, J., Scholberg, J., Boote, K., Chase, C.A., Ferguson, J.J. and Mcsorley, R. 2008. Use of the cover crop weed index to evaluate weed suppression by cover crops in organic citrus orchards. *Hort. Science,* **43:** 27-34.

Mandal, M.P., Pal, V., Kumar, S. and Mandal, S.K., 2016. Allelopathic Effects of Leaf Extracts of Kalmegh on Seed Germination and Seedling Growth of Wheat (*Triticum aestivum* L.). Research and Reviews: *Journal of Botanical Sciences*, **5**: 50-53.

Nandi, P. and Ghosh S.N. 2016. Effect of medicinal plants as intercrop on plant and soil of Mosambi sweet orange gown in laterite oil. *International Journal of Minor Fruits, Medicinal and Aromatic Plants*, **2**(2): 11-13.

Nagaraja, T. and Deshmukh, S. 2009. Phytotoxic effect of *Andrographis paniculata* Nees on metabolism of *Parthenium hysterophorus* L. *Journal of Biopesticides*, **2**: 165-167.

Natarajan, A., Elavazhagan, P. and Prabhakaran, J. 2014. Allelopathic Potential of Billy Goat Weed *Ageratum Conyzoides* L. and *Cleome Viscosa* L. on Germination and Growth of *Sesamum Indicum* L. *International Journal of Current Biotechnolog.*, **2**: 21-24.

Niranjan, A., Tewari, S.K. and Lehri, A. 2010. Biological activities of kalmegh (*Andrographis paniculata* Nees) and its active principles: A review. *Indian Journal of Natural Products and Resources*, **1**(2):125-135

Purohit, S. and Pandya, N. 2013. Allelopathic activity of *Ocimum sanctum* L. And *Tephrosia purpurea* L. Pers. Leaf extracts on few common legumes and weeds. *International Journal of Research in Plant Science*, **3**: 5-9.

Sainju, U.M., B.P. Singh, and W.F. Whitehead. 2002. Long-term eff ects of tillage, cover crops, and nitrogen fertilization on organic carbon and nitrogen concentrations in sandy loam soils in Georgia, USA. *Soil Tillage Res*., **63**:167–179.

Saritha, P. and Sreeramulu, A. 2013. Allelopathic effects of *Celosia argentea* L. root extracts on crop plant seed germination. *International Journal of Life Sciences Biotechnology and Pharma Research,* **2**: 142-154.

Singh, S. and Singh, M. 2009. Interactions of basil (*Ocimum sanctum* L.) with some weed species-competition or allelopathy? *Indian Journal of Weed Science*, **41**: 12-22.

Tursun, N., Isik, D., Demir, Z. and Jabran, K. 2018. Use of living, mowed, and soil incorporated cover crops fro weed control in apricot orchards. *Agronomy*, **8** (150):1-10

Vij, T. and Prashar, Y. 2015. A review on medicinal properties of *Carica papaya* Linn. *Asian Pacific Journal of Tropical Disease,* **5**:1-6.

Workneh, T., Azene, M. and Tesfay, S. 2012. A review on the integrated agro-technology of papaya fruit. *African Journal of Biotechnology,* 11:15098-15110.

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Studies on the effect of organic and integrated sources of nutrients on yield and economics of Bottle Gourd

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ABSTRACT

A field experiment was conducted during the summer in 2009 and 2010 to study the effects of integrated nutrient management on bottle gourd growth, yield, and economics. During both the years, the benefit: cost ratio was found highest for recommended NPK only (T_1) followed by FYM @ 10 t /ha + half of recommended FYM (T_3) and T_5 i.e. for vermicompost @ 0.25 t /ha + half of recommended NPK. In both years, average individual fruit weight was highest in the recommended N-P-K only. In 2009, highest fruit yield was highest for all the treatments except FYM at 20 t/ha, neem cake at 0.50 t/ha and poultry manure at 5.0 t/ha. In 2010, all treatments were similar except for vermicompost at 5 t/ha which had reduced fruit yield.

Key words: Bottle gourd, nutrients, yield, economics, B: C ratio

INTRODUCTION

Bottle gourd (*Lagenaria siceraria*) is an important cucurbitaceous vegetable crop cultivated in several tropical and subtropical countries for its edible fruit. Immature, tender bottle gourd fruits are used as a fresh vegetable and in preparation of pickles and other products. Bottle gourd can provide multiple medicinal benefits (Harika *et al*., 2012). Soil fertility and nutrient management is one of the important factors that have a direct impact on vegetable and fruit yield and quality. Managing optimum soil nutrient levels is the key in maintaining a sustainable and productive vegetable production enterprise. Sharath *et al.* (2016) conducted an experiment on integrated nutrient management in beal and obtained highest fruit yield from the plant received with combined application of FYM and mustard cake while the yield was lowest from the control plants. Vegetable production using organic methods has beneficial effects on the environment, soil health and sustainability of crop production (Panda *et al*., 2012). Integrated nutrient management is a concept easily applied in production of bottle gourd. Research has been done by several researchers on integrated nutrient management in bottle gourd. Till date information on integrated nutrient management in bottle gourd is meager in our country. A study was therefore conducted to determine the influence of inorganic fertilizer alone or in combination with organic fertilizers on bottle gourd for yield and economics.

MATERIALS AND METHODS

The experiment on "Studies on the response of organic and integrated sources of nutrients on yield and economics of bottle gourd" was conducted in the field under the Department of Botany, Utkal University, Bhubaneswar, during the summer seasons of 2009 and 2010. It comes under East and South Eastern Coastal Plain Agro climatic Zone of the state. The place is characterized by warm and moist climate with hot and humid summer and mild winter. The mean annual rainfall of Bhubaneswar is 1660 mm, out of which about 90 per cent is received during June to October. The soil of the experimental plot was low in organic carbon, low in total nitrogen, medium in phosphorus and low in potassium status. The soil was acidic in reaction with pH 6.0. The experiment was laid out in the randomized block design with 3 replications and conducted for 2 consecutive summer seasons (January to May) of 2009 and 2010.

The treatments consisted of nine levels of nutrient management.

Sl.No.	Treatment	Symbol used
1	Recommended dose of fertilizer (RDF) @50-30-50 kg N-P_2O_5- K_2O / ha.	T_1
2	FYM@20 t/ha.	T_2
3	FYM@10t/ha + half recommended N-P-K.	T_3
4	Neem cake @ 0.50t/ha	T_4
5	Neem cake @ 0.25 t/ha + half recommended N-P-K.	T_5
6	Vermicompost @ 5 t/ha	T_6
7	Vermicompost @ 2.5 t/ha + half recommended N-P-K.	T_7
8	Poultry manure @ 5t/ha	T_8
9	Poultry manure @ 2.5 t/ha + half recommended N-P-K.	T_9

The plot size is 3.00m x 2.70 m and plants were maintained at a spacing of 1.00 m x 0.90 m. The experimental plot was ploughed thrice followed by laddering in order to break the clods and level the field. Organic amendments were applied before sowing of seed and inorganic fertlizers were applied in splits. Inorganic fertilizers like Urea (1/4 rate) + single super phosphate (full rate) + muriate of potash (1/4 rate) were applied at the time of sowing to treatments T_1, T_3, T_5, T_7 and T_9. The first top dressing of urea (1/4 rate) + muriate of potash (1/4 rate) were applied at 15 days after sowing. The second top dressing with the remaining urea and muriate of potash was done at 30 days after sowing. Five seeds of bottle gourd variety BBOG 3-2 were sown in each pit at a depth of 2-3 cm on 21st January, 2009 and 22nd January, 2010 at a spacing of 100 cm x 90 cm. After the emergence, plants were thinned to three per pit, keeping in view the uniformity in growth for the trial. Hoeing, weeding, thinning and 1st top dressing were done after 15 days of sowing. The weeds present in intra row spaces were uprooted manually. A second hoeing, weeding, thinning and second top dressing was also done at 30 DAS. Irrigation was given after sowing of seeds, first top dressing and second top dressing of fertilizers and also as and when needed. The crop was sprayed 2 to 3 times with Triazophos @ 2ml/l and Sulfex @3 g/l in each growing season during both the years for management of red pumpkin beetle and powdery mildew respectively. Harvesting was done 61 days after sowing in both the years. Plot yields were recorded at 4 days interval starting from 61 days of sowing of seed. Just after plucking, the fruit weights were recorded plot wise and date wise. The fruit yields were expressed in quintal per hectare. The date on which the first fruit was harvested in each plot was recorded and the days taken were calculated from the date of sowing. The length of randomly selected five fruits from five sample plants in each plot was measured at harvest and the average was worked out by means of a piece of thread and a graduated scale and expressed in cm. The diameter of five fruits selected randomly from each sub plot was recorded in cm with the help of a measuring tape and the average was worked out. The fruit weight of the above randomly selected five fruits from the five sample plants in each plot was recorded (in g) and the average worked out. The fruits were harvested at an interval of 4 days and were weighed. The cumulative yields of each plot were multiplied by the hectare factor to get the fruit yield per hectare. The return was worked out from the total output of all enterprises before deducting the cost of cultivation.Net return was computed from the total output of the enterprise after deducting the total variable costs, which also included the wages of manual labour. Return per rupee invested was computed by dividing the gross return with total cost. Analysis of variance method as suggested by Panse and Sukhatme (1978) was used for statistical analysis for Randomized Block Design (RBD).

RESULTS AND DISCUSSION

From the data presented in the Table 1, it is obvious that fruit length was affected by year, in 2009 fruits being shorter than in 2010. The highest fruit length was obtained with the application of

recommended NPK only (T_1) (10.61 cm) followed by FYM @10t/ha + half recommended NPK (T_3)(10.06 cm) and vermicompost @ 2.5 t/ha + half recommended NPK (T_7)(10.0cm) which were similar, but greater than the rest of the treatments. Treatment neem cake @ 0.50 t /ha (T_4) produced significantly shortest (6.79 cm) fruit as compared to other treatments in bottle gourd. Similarly, greater fruit diameter was found in 2009 than in 2010 except neem cake @ 0.50 t /ha (T_4). The widest fruits were in recommended NPK (T_1)(15.84cm) followed by FYM@10t/ha + half recommended NPK (T_3)(15.08 cm) which were similar, but higher than rest of the treatments. The minimum fruit diameter was recorded in neem cake @ 0.50 t /ha (T_4) (9.41 cm).The treatment T_4 (neem cake @ 0.50 t /ha) produced significantly the lowest fruit diameter (9.41cm) as compared to other treatments (Table 1).

Table 1. Effect of organics and inorganics on fruit length (cm) of bottle gourd

Treatment	Fruit length (cm)			Fruit diameter (cm)		
	2009	2010	Pooled	2009	2010	Pooled
T_1 Full NPK (50:30:50 kg /ha)	8.910	12.300	10.610	16.660	15.030	15.840
T_2 FYM @ 20 t/ ha	7.210	10.000	8.610	12.930	11.140	12.030
T_3 FYM @ 10 t/ ha + 1/2 NPK	8.210	11.900	10.060	15.850	14.330	15.080
T_4 NC @ 0.5 t/ ha	5.080	8.500	6.790	8.850	9.960	9.410
T_5 NC @0 .25 t/ ha +1/2 NPK	8.170	11.000	9.590	15.280	12.290	13.780
T_6 VC @ 5 t/ ha	7.970	8.700	8.340	14.430	10.410	12.420
T_7 VC @ 2.5 t/ ha +1/2 NPK	8.490	11.500	10.000	15.710	12.830	14.260
T_8 PM @ 5 t/ ha	7.470	9.200	8.340	13.490	10.630	12.050
T_9 PM @ 2.5 t/ ha + 1/2 NPK	7.850	10.400	9.130	14.210	11.680	12.940
S.Em.(+)	**0.379**	**0.507**	**0.317**	**0.775**	**0.629**	**0.499**
C D at 5 %	**1.135**	**1.521**	**0.912**	**2.323**	**1.886**	**1.437**
C D (Y x T)			NS			NS

NS = Non – significant

From the data presented in Table 2, it was found that the average individual fruit weight was highest in the recommended NPK (T_1) during both years. In the first year, fruit weight was second highest in vermicompost @ 2.5 t/ha + half recommended NPK(T_7)(1.0 kg) followed by FYM@10t/ha + half recommended NPK (T_3) (0.99 kg), which were at par but significantly higher than vermicompost @ 5 t/ha (T_6), NC @ 0.25 t/ha + half recommended NPK (T_5), PM @ 2.5t/ha + half recommended NPK (T_9), FYM @ 20 t/ha (T_2), PM @ 5 t/ha (T_8) and neem cake @ 0.50 t /ha (T_4). The treatment neem cake @ 0.50 t /ha (T_4) recorded significantly lowest fruit weight (0.22 kg per plant) than all other treatments. In the second year, the second highest treatment was obtained from the treatment T_3 *i.e.* FYM@10t/ha + half recommended NPK (1.0 kg) followed by (T_7) i.e. vermicompost @ 2.5 t/ha + half recommended NPK (0.977kg). T_4 *i.e.*, neem cake @ 0.50 t /ha) produced the lowest (0.44 kg) fruit weight. In the present study, high fruit length and diameter were recorded with FYM @ 10 t/ha + half recommended NPK which is in agreement with the findings of Nirmala *et al*. (1999), Subbarao and Ravisankar (2001) and Das *et al*. (2015) who observed similar beneficial effects of integrated nutrient management on cucumber, brinjal and bottle gourd respectively. The treatment FYM @ 10 t/ha + half recommended NPK (T_3) also resulted in high fruit weight of bottle gourd which conforms to the findings of Sreenivas *et al*. (2000).

Perusal of data presented in the Table 2, revealed that during 2009, fruit yield was highest in T_1 (318.28 q/ha) followed by T_3 (314.82 q/ha) which were *at par* with each other and were significantly superior to other treatments. The lowest yield was obtained in T_4 (49.63 q/ha) which was similar to T_2 (61.61). Similarly, during 2010, T_1 was at top (330.62 q/ha) followed by T_3 (319.51 q/ha) which were at par with each other but

significantly higher than other treatments. Again the treatment T_4 obtained lowest (59.14 q/ha) fruit yield which was inferior to all treatments. Integrated nutrient management with FYM can maintain high productivity in bottle gourd and the rate of inorganic fertilizer can be halved without sacrificing productivity. This is in agreement with the findings of Dass *et al.* (2008) and Jahromi and Aboutalebi (2012) using other crops.

Table 2.Effect of organics and inorganics on fruit weight(kg) of bottle gourd

Treatment	Fruit weight (kg)			Fruit yield (q/ha)		
	2009	2010	Pooled	2009	2010	Pooled
T_1 Full NPK (50:30:50 kg /ha)	1.177	1.213	1.200	318.280	330.620	324.450
T_2 FYM @ 20 t/ ha	0.620	0.810	0.720	61.610	175.810	118.710
T_3 FYM @ 10 t/ ha + 1/2 NPK	0.990	1.000	1.000	314.820	319.510	317.170
T_4 NC @ 0.5 t/ ha	0.220	0.440	0.330	49.630	59.140	54.390
T_5 NC @0 .25 t/ ha +1/2 NPK	0.813	0.883	0.850	186.430	233.460	209.950
T_6 VC @ 5 t/ ha	0.843	0.490	0.670	113.090	106.050	109.570
T_7 VC @ 2.5 t/ ha +1/2 NPK	1.000	0.977	0.990	211.120	242.110	226.620
T_8 PM @ 5 t/ ha	0.587	0.610	0.600	95.680	135.070	115.380
T_9 PM @ 2.5 t/ ha + 1/2 NPK	0.710	0.843	0.780	128.150	201.240	164.700
S.Em.(+)	**0.040**	**0.035**	**0.027**	**4.051**	**7.323**	**4.185**
C D at 5 %	**0.121**	**0.105**	**0.077**	**12.145**	**21.952**	**12.052**
C D (Y x T)			0.127			26.718

Table 3. Economics of treatments in bottle gourd (during 1st year i.e. 2009)

Treatment	Yield (q/ha)	Gross income (Rs/ha)	Total cost of cultivation (Rs/ha)	Net income (Rs/ha)	Benefit: Cost ratio
T_1 Full NPK (50:30:50 kg /ha)	318.28	187149.00	23716.00	163433.00	7.89
T_2 FYM @ 20 t/ ha	61.61	36227.00	33810.00	2417.00	1.07
T_3 FYM @ 10 t/ ha + 1/2 NPK	314.82	185114.00	28763.00	156351.00	6.43
T_4 NC @ 0.5 t/ ha	49.63	29182.00	26950.00	2232.00	1.08
T_5 NC @ .25 t/ ha +1/2 NPK	186.43	109621.00	25333.00	84288.00	4.32
T_6 VC @ 5 t/ ha	113.09	66497.00	46550.00	19947.00	1.43
T_7 VC @ 2.5 t/ ha +1/2 NPK	211.12	124139.00	35133.00	89006.00	3.53
T_8 PM @ 5 t/ ha	95.68	56260.00	41650.00	14610.00	1.35
T_9 PM @ 2.5 t/ ha + 1/2 NPK	128.15	75352.00	32683.00	42669.00	2.31

Sale price – Rs588/q

Table 4. Economics of treatments in bottle gourd (during 2nd year i.e. 2010)

Treatment	Yield (q/ha)	Gross income (Rs/ha)	Total cost of cultivation (Rs/ha)	Net income (Rs/ha)	Benefit: Cost ratio
T_1 Full NPK (50:30:50 kg /ha)	330.62	210605.00	24941.00	185664.00	8.45
T_2 FYM @ 20 t/ ha	175.81	111991.00	35525.00	76466.00	3.15
T_3 FYM @ 10 t/ ha + 1/2 NPK	319.51	203528.00	30233.00	173295.00	6.74
T_4 NC @ 0.5 t/ ha	59.14	37672.00	28322.00	9350.00	1.33
T_5 NC @ .25 t/ ha +1/2 NPK	233.46	148714.00	26607.00	122107.00	5.59
T_6 VC @ 5 t/ ha	106.05	67554.00	48902.00	18652.00	1.38
T_7 VC @ 2.5 t/ ha +1/2 NPK	242.11	154224.00	36897.00	117327.00	4.18
T_8 PM @ 5 t/ ha	135.07	86040.00	43757.00	42283.00	1.97
T_9 PM @ 2.5 t/ ha + 1/2 NPK	201.24	128190.00	34349.00	93841.00	3.73

Sale price- Rs 637/q

ECONOMICS ANALYSIS

The data presented in the table 3 indicated that the gross income per ha in the first year(during 2009) was highest in T_1 (Rs. 1,87,149.00) followed by T_3 (Rs. 1,85,114.00) and T_7 (Rs. 1,24,139.00). The lowest gross income was obtained in T_4 (Rs. 29,182.00).During second year (2010), also T_1 recorded the highest (Rs. 2,10,605.00) income followed by T_3 (Rs. 2,03,528.00), T_7 (Rs.1,54,224.00) and T_5 (Rs.1,48,714.00), while T_4 was the lowest (Rs. 37,672.00). (Table 4).Thus, in both years the gross income was highest for the recommended NPK only followed by FYM @10t/ ha + half of the recommended NPK and lowest in neem cake @ 0.5 t/ha. During 2009, total cost of cultivation per ha was highest with T_6 (Rs. 46,550.00) followed by T_8 (Rs. 41,650.00) and T2 (Rs. 33,810.00). It was lowest in T_1 (Rs, 23,716.00 per ha) (Table 3). During 2010, also total cost of cultivation per ha was highest with T_6 (Rs. 48,902.00) followed by T_8 (Rs. 43,757.00) and T_7 (Rs.36,897.00) while it was lowest in T_1 (Rs, 24,941.00 per ha) (Table 4). Thus, in both the years the total cost of cultivation was highest for the treatment with vermicompost @ 5 t /ha (T_6) and lowest in treatment with recommended NPK only (T_1).

During 2009, net income per ha obtained from T_1 was highest (Rs.1,63,433.00) followed by T_3 (Rs. 1,56,351.00)and T_4 was lowest (Rs. 2,232.00).(Table 3).During 2010, highest net income per ha was obtained from T_1 (Rs.1,85,664.00) followed by T_3 (Rs. 1,73,295.00) while lowest net income per ha was obtained from T_4 was lowest (Rs. 9,350.00).(Table4). Hence, in both the years the net incomes per ha were highest for T_1 i.e. for the recommended NPK only followed by T_3 i.e. FYM @ 10 t/ha + half of recommended NPK. The lowest net income per ha was obtained from T_4 i.e. for neem cake @ 0.5 t/ha only.In case of Benefit: Cost (B.C.) ratio during 2009, T_1 recorded the highest (7.89) followed by T_3 (6.43) and T_5 (4.32) while T_2 was the lowest (1.07) (Table 3).During 2010, this economic parameter was also found to be highest with T_1 (8.45) followed by T_3 (6.74) and T_5 (5.59) and lowest in T_4 (1.33)(Table 4). During both the years 2009 and 2010, the benefit: cost ratio was found best for recommended NPK only (T_1) followed by FYM @ 10 t /ha + half of recommended FYM (T_3) and T_5 i.e. for vermicompost @ 0.25 t /ha + half of recommended NPK. The results are in conformity with the findings of Kumar *et al*. (2012) indicating that the plant responses can be extrapolated to differing environmental conditions.

CONCLUSION

Integrated nutrient management with FYM can maintain high productivity in bottle gourd and the rate of inorganic fertilizer can be halved without sacrificing productivity.

REFERENCES :

Das, R., Mandal, A. R., Priya, A., Das, S. P. and Kabiraj, J. 2015. Evaluation of integrated nutrient management on the performance of bottle gourd (*Lagenaria siceraria (Molina) Standl.*). *Journal of Applied and Natural Science,* **7**(1): 18-25.

Das, R., Mandal, A.R. and Anuj, P. 2015. Performance of bottle gourd (*Lagenaria siceraria*) under different nutrient management. *Progressive Horticulture,* **47** (2) : 307-313.

Dass Anchal, N., Lenka, K., Patnaik, U.S. and Sudhishi, S. 2008. Integrated nutrient management for production, economics, and soil improvement in winter vegetables. *International Journal of Vegetable Science,* **14**(2): 104-120.

Harika, M., Gasti, V.D., Shantappa, T., Mulge, R., Shirol, A.M., Mastiholi, A.B. and Kulkarni, M.S. 2012. Evaluation of bottle gourd genotypes [*Lagenaria siceraria*(mol.) Standl.] for various horticultural characters. *Karnataka Journal of Agricultural Science,* **25** (2): 241-244.

Jahromi, M.G. and Aboutalebi,A. 2012. Influence of different levels of garden compost (garden waste and cow manure) on growth and establishment of tomato and cucumber in greenhouse condition. *African Journal of Biotechnology,* **11**(37): 9036-9039.

Kumar, V., Singh, V.K. and Teena, R. 2012. Effect of integrated nutrient management on economics in bottle-gourd (*Lagenaria siceraria* L.). *Environment and Ecology,* **30** (4A): 1410-1412.

Nirmala, R., Vadivel, E. and Azakiamanavalan, R. S. 1999. Influence of organic manures on fruit characters and yield of cucumber (*Cucumis sativus* Linn.) cv. Local. *South Indian Horticulture,* **47**(1-6) : 65-68.

Panda, P.K., Nandi, A., Swain, P.K., Patnaik, S.K. and Patnaik, M. 2012. Soil amendment in growth, nodulation, yield, soil health and economics of cowpea. *International Journal of Vegetable Science,* **18**(3): 284-297.

Panse, V.G. and Sukhatme, P.V. 1978. *Statistical Method for Agricultural Workers (3rd Edition). Indian Council of Agricultural Research, New Delhi* p. 351.

Sharath, A.A, Ghosh, S.N. and Das, B.C. 2016. Integrated nutrient management in Bael in new alluvial soil. *International Journal of Minor fruits, Medicinal and Aromatic Plants*, **2** (1): 41-46.

Sreenivas, C. H., Muralidhar, S. and Singarao, M. 2000. Yield and quality of ridge gourd fruits as influenced by different levels of inorganic fertilizer and vermicompost. *Annals of Agricultural Research,* **21**(2) :262-266.

Subbarao, T. S. S. and Ravisankar, C. 2001. Effect of organic manures on growth and yield of brinjal. *South Indian Horticulture,* **49**: 288-291.

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Study on rooting behaviour of different types of cutting of Dragon fruit at different period of year

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ABSTRACT

A study was conducted on Red Fruit type of dragon fruit in a private farm at Onda block of Bankura district of West Bengal with the view to find out best propagation period in a year and which part of the stems are suitable to give higher plant stand. Results of one year of investigation revealed that maximum number alive cuttings were obtained when cuttings were collected from middle part of three angled main stem in the month of November and December. Besides, the cuttings can be taken from the shoots which were arisen from three angled main stem at 90 ^{0} angle in November also resulted in maximum percentage of alive cuttings with maximum root length.

Keywords: Dragon fruit, Month, Cuttings, Root length, 3-angle stem

INTRODUCTION

Dragon fruit is a member of the family Cactaceae and perennial, climbing cactus with triangular (3- sided), green, fleshy, jointed, many-branched stem. It is a long day plant with beautiful night blooming flower that is nicknamed as "Noble Woman" or "Queen of the Night". Dragon fruit is considered a promising crop to be grown commercially in dry regions (Vaillant*et al*., 2005). It is one of the newly introduced exotic fruit crop in India and is being cultivated mainly in the states of Maharashtra, Gujarat, Andhra Pradesh, Karnataka and Tamil Nadu.Aerial roots grow from the base of the stems, providing anchorage for the plants (Zee *et al.*, 2004). Dragon fruit is valuable for treating different types of diseases and has significant economic value (Suryono, 2006). It is usually propagated by seeds or cuttings. Seed propagation method is very simple, but seeds are not true to type due to cross pollination and seeds are stored for about 28 days without losing viability (Andrade *et al.*, 2005). So, it is generally propagated by stem cuttings which may be planted directly in the field or in pots (Zee *et al.,* 2004). Due to heterozygous nature of fruit crops, use of vegetative propagated planting material is the scientific practices (Singh and Singh, 2006; Singh and Singh 2007). Therefore, large number of plantlets with healthy shoot and root system can be produced to meet the demand of increasing commercial cultivation through vegetative propagation methods. According to Ghosh and Bera, 2015 different season influence propagation methods like grafting and air layering for different crop. The stem section of pitaya forms aerial roots which adhere to the surface upon which they grow or climb. Healthy mature stem segments of 6 - 15 inches are used. A slanted cut is made at the stem base, this is left in a shaded area for about 5-7 days to dry and heal before being planted out directly in the field. Successful cutting propagation has been associated with the ideal collection date of cuttings (Sharma and Aier 1989; Howard 1996; Rosier *et al.,* 2004).A study was conducted mainly to know about which month will give maximum successful cutting and which plant part exert better rooting.

MATERIALS AND METHODS

The present investigation was carried out in a private farm at Onda block of Bankura district of West Bengal in 2018-19.The experimental site was located at an altitude of 74m (243ft) above mean sea level and geographically situated at 23°082 N latitude 87°122 E longitude. The *climate* is *tropical* savannah and is comparatively quite *dry*

from other parts of the state. Drought is a common occurrence. The cuttings are taken in every month of the year and from different parts of three angle stem. Four replications were taken for each treatment.In each replication 20-cuttings were used. Top soil, sand, cow dung at the rate of 1:2:1 were mixed thoroughly and soil mixture was filled in each polythene bag (25 cm long and 12 cm width) upto three fourth of its length. Water was applied over the cuttings daily morning and evening. The study was conducted on Red Fruit type of dragon fruit. Cuttings were collected from 10-12 months old shoot of 3- years' old plant. Cuttings were shade dried for two day prior to planting to dry the ooze coming from the fresh cuttings. Cuttings (20cm length) are planted every month using 3-types of cuttings viz., (i) the shoots which were arisen from three angled main stem at 90 ^{0} angle; (ii) Last part of three angled main stem and (iii) Middle part of three angled main stem. Depth of planting of cuttings was 7-8cm.

Observations were recorded at 90 days after planting of cuttings.Ten sprouted cuttings were randomly selected for recording the observations from each replication of every treatment throughout the study. The observations included were, average number of roots formed, percentage of cuttings alive 90 days after planting in polybag (calculated using the formula, number of cuttings alive /total number of cuttings planted x 100), length of roots (measured with the help of measuring scale from the base to the tip of root and the mean length was calculated and expressed in centimetres). Percentage of success of cuttings was considered on the basis of cuttings were alive. The data obtained were statistically analysed by adopting the factorial Randomized Block Design method as suggested by Panse and Sukhatme (1978).Critical difference values were calculated where ever F-test was found to be significant at 5 per cent level of probability.

RESULTS AND DISCUSSION

The results on rooting behaviour of cuttings taken in different months from three- types of stem have been presented in Table 1, 2 and 3 respectively. The statistical analysis indicated that there were significant differences between the different plant parts for all the root parameters.It was found that cuttings taken from middle part of three angled main stem (T3) produced significantly maximum percentage of alive cuttings (100%) for five months (November, December, January, February and March). In general, it was noted that the months of September and October resulted in lowest survival percentage of cuttings irrespective of types of cuttings. T1 (The shoots which were arisen from three angled main stem at 90 0 angle) also exert better result than T2 (Last part of three angled main stem) incase of rooting % mentioned in Table1.According to the Le Bellec, (2003) also suggested that if cuttings are at least 50 to 70 cm in length and are regularly watered gives satisfactory rooting. If all these conditions are provided around 90% of the cuttings ensure rooting. All the treatment showed 100% rooting success in November, December and February. According to the previous worker (Wang and Zhao, 2012) it was stated that cuttings taken in the month of February having more C:N ratio. Total carbohydrate and total nitrogen levels, and C/N ratio (Druege*et al.,* 2004; Rapaka*et al.*, 2005) have been reported to influence the adventitious rooting of plant species. It was also supported by Kumar, 2016. Cuttings taken from many deciduous plants and narrow-leaved evergreens from late fall to early winter are likely to root well. At this stage, shoot growth has slowed down and the stem has begun to harden, resulting in the accumulation of adequate carbohydrate reserves to support root growth. The relatively lower nitrogen levels also make cuttings less susceptible to rotting. Many studies showed that rooting response also correlates with the interactions between endogenous plant hormones (Guo *et al.*, 2004; Tsipouridis*et al.,* 2006). Auxin is believed to play a central role in the formation of adventitious root (Weigel et al. 1984). Maximum root length was observed 30.00 cm by T1 in the month of November mentioned in Table2. Seran and Thiresh, (2015) also revealed that the average value of longest root length ranged from 11.0 cm to 22.0 cm. All treatment showed maximum root length in the month of November (T1-30.00cm, T2-25.00cm and T3- 20.00cm). Maximum number of root observed in T3 (3.0) in July month than T1 and T2 respectively.

Table 1: Success percentage of cuttings (from different parts of stem) planted in different months

Date of propagation (M)	T_1 (% of success)	T_2 (% of success)	T_3 (% of success)
Nov., 2017	100	50	100
Dec., 2017	100	100	100
Jan., 2018	50	90	100
Feb., 2018	100	100	100
March, 2018	90	70	100
April, 2018	80	70	60
May, 2018	80	70	50
June, 2018	80	80	90
July, 2018	60	40	50
Aug., 2018	50	30	50
Sept., 2018	40	30	20
Octo., 2018	30	30	10
SE(d)	**1.23**	**2.46**	**4.25**
CD	**2.43**	**4.87**	**8.43**

*T_1: The shoots which were arisen from three angled main stem at 90 ^{0} angle, T_2: Last part of three angled main stem and T_3: Middle part of three angled main stem

Table 2: Average length of roots of cuttings (from different parts of stem) planted in different months

Date of propagation (M)	T_1 Average length of roots (cm)	T_2 Average length of roots (cm)	T_3 Average length of roots (cm)
Nov., 2017	30	25	15
Dec., 2017	16	17	20
Jan., 2018	9	16	18
Feb., 2018	15	13	12
March, 2018	14	19	12
April, 2018	20	0	12
May, 2018	15	13	0
June, 2018	20	17	19
July, 2018	18	0	13
Aug., 2018	16	0	13
Sept., 2018	16	0	0
Octo., 2018	14	0	0
SE(d)	**0.56**	**1.12**	**1.94**
CD	**1.11**	**2.22**	**3.85**

*T_1: The shoots which were arisen from three angled main stem at 90 ^{0} angle, T_2: Last part of three angled main stem and T_3: Middle part of three angled main stem

Table 3: Average number of roots per cuttings (from different parts of stem) planted in different months

Date of propagation (M)	T1 Average number of roots per cutting	T2 Average number of roots per cutting	T3 Average number of roots per cutting
Nov., 2017	1	1	1
Dec., 2017	1	1	1
Jan., 2018	1	2	1
Feb., 2018	1	1	1
March, 2018	1	2	1
April, 2018	2	0	1
May, 2018	2	2	0
June, 2018	1	1	1
July, 2018	2	0	3
Aug., 2018	1	0	2
Sept., 2018	1	0	0
Octo., 2018	1	0	0
SE(d)	**0.04**	**0.07**	**0.12**
CD	**0.07**	**0.14**	**0.24**

*T_1: The shoots which were arisen from three angled main stem at 90 ^{0} angle, T_2: Last part of three angled main stem and T_3: Middle part of three angled main stem

CONCLUSION

From this present investigation it is concluded that to get maximum number of planting material for vegetative propagation cuttings should be taken from middle part of three angled main stem in the month of November and December. Beside this cutting also can be taken from the shoots which were arisen from three angled main stem at 90^0 angle in November to get maximum % successful rooted cuttings with maximum root length.

REFERENCES :

Andrade, R.A. de, Oliveira, I.V. de M. and Martins, A.B.G. 2005. Influence of condition and storage period in germination of red pitaya seeds. *Revista-Brasileira-deFruticultura,* **27**(1): 168-170.

Druege U., Zerche S. and Kandner R. 2004. Nitrogen and storage-affected carbohydrate partitioning in high-light-adapted pelargonium cuttings in relation to survival and adventitious root formation under low light. *Ann Bot*., **94**: 831-832.

Ghosh, S. N. and Bera, B. 2015.Studies on standardization of propagation methods of some minor fruit crops in India. *International Journal of Minor Fruits, Medicinal and Aromatic Plants*, **1**(1) 2015:31-36.

Guo S.J., Ling H.Q. and Li F.L. 2004. Physiological and biochemical basis of rooting of Pinus bungeana cuttings. *J. Beijing For Univ.,* **26**: 43-47.

Kumar, M.G.N. 2016.Propagating shrubs, vines, and trees from stem cuttings, pnw publication, Department of Horticulture, Washington State University, Pp. 1-8.

Le Bellec F., Vaillant, F. and Imbert, E. 2006.Pitahaya (*Hylocereus* spp.): a new fruit crop, a market with a future. *Fruits*, **61**: 237–250.

Panse, V.G. and Sukhatme, P.V. 1978. *Statistical methods for agricultural workers.*ICAR, New Delhi, pp.145-52.

Rapaka V.K., Bessler B., Schreiner M. and Druege U. 2005 Interplay between initial carbohydrate availability, current photosynthesis, and adventitious root formation in Pelargonium cuttings. *Plant Sci.,* **168**: 1547-1560.

Rosier, C. L., Frampton, J., Goldfarb, B., Blazich, F. A., and Wise, F.C. 2004. Growth stage, auxin type, and concentration influence rooting of stem cuttings of Fraser fir. *Hort. Science.,* **39**: 1392-1396.

Seran, H. T. and Thiresh, A. 2015. Root and Shoot Growth of Dragon Fruit (*Hylocereusundatus*) Stem Cutting as Influenced by Indole Butytic

Acid, *Agric. and Biologic. Sci. J.,* **1**(2) 2015: 27-30.

Sharma, S. D. and Aier, N. B. 1989. Seasonal rooting behaviour of cuttings of plum cultivars as influenced by IBA treatments. *Sci. Hortic.,* **40**: 297-303.

Singh, S. and Singh, A. K. 2006. Standardization of method and time of propagation in jamun (*Syzygium cuminii)* under semi arid environment of western India. *Indian Journal of Agricultural Sciences*, **76**:142-45.

Singh, S. and Singh, A. K. 2007. Standardization of method and time of propagation in Tamarind (Tamarindusindica L) under semi-arid environment of western India. *Indian Journal of Horticulture*, **64** (1): 45-49.

Suryono, J. 2006. Consuming dragon fruit to treat various diseases. *IndonesiaSinarTani,* 15-21pp.

Tsipouridis C., Thomidis T., Bladenopoulou S. 2006. Rhizogenesis of GF677, Early Crest May Crest and Arm king stem cuttings during the year in relation to carbohydrate and natural hormone content. *Sci Hortic.,* **108**: 200-204.

Vaillant, F., Perez, A., Davila I., Dornier, M. and Reynes, M. 2005. Colorant and antioxidant properties of red-purple pitahaya (*Hylocereus* sp.), *Fruits*, **60**: 3–12.

Wang, X. L. and Zhao, Z. 2012. Seasonal variation in rooting of the cuttings from Tetraploid Locust in relation to nutrients and endogenous plant hormones of the shoot, *Turk J Agric For,* **36**: 257-266.

Weigel U., Horn W. and Hock B. 1984. Endogenous auxin levels in terminal stem cuttings of Chrysanthemum morifolium during adventitious rooting. *Physiol Plant*, **61**: 422-428.

Zee, F., Yen, C.R. and Nishina, M. 2004. Pitaya (Dragon fruit, Strawberry pear).Fruit and Nuts 9.Cooperative Extension Service, College of Tropical Agriculture and Human Resources, University of Hawaii at Manoa, Honolulu, Hawaii.

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Effect of shoot pruning on yield and fruit quality of custard apple cv. Balanagar

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ABSTRACT

With a view to sustainable production of quality fruits in 7 years old custard apple plants cv. Balanagar grown in laterite soil at Jhargram, Paschim Medinipur, a pruning trial was conducted for two consecutive years. The treatments included viz.,: T_1: Shoot pruning in February; T_2: Shoot pruning in March; T_3: Shoot pruning in April; T_4: Shoot pruning in May; T_5: Shoot pruning in June; T_6: Control (un- pruned) following randomized block design with five replications. Shoot pruning consisted of heading back of all secondary and tertiary branches at 50% of their length on 15th of each month as per treatment. Results indicated that fruit production was improved due to pruning practices. Significantly highest fruit number (45) and fruit weight (174g) was observed from May-pruned plants. Fruit quality was improved due to different pruning treatments and maximum TSS (21.6^{0}B) and sugar content (19.5%) was obtained from May-pruned plants. Harvesting date did not varied due to pruning at different months.

Key words: Custard apple, pruning time, fruit yield, fruit quality,

INTRODUCTION

Custard apple (*Annona squamosa* L) is one of the important tropical fruit crops in India. It is mainly used as dessert fruit however both the pulp and seeds are also used for medicinal purposes. It is considered as one of the important minor fruits and possesses high nutritional properties like other underutilized fruits (Kalkame *et al.,* 2018) which are grown in waste land with least care. In laterite tract of West Bengal where the soil is porous and less fertile, in that Balanagar variety of custard apple found to perform well (Nandi *et al*., 2018). The custard apple is generally planted at 3.0-5.0 m spacing depending on the soil fertility and economic orchard life of custard apple is declined after 15 years (Raut and Ghosh, 2017).

Among different management practices followed in different fruit crops, canopy management is considered is one of them. In custard apple, selective and mild removal of deadwood and very old branches is carried out to avoid congestion and encourage well spaced branching. Severe removal is detrimental for the plant growth (Raut and Ghosh, 2017). The custard apple and the other annonas bear mostly on the current season's growth and to a lesser extent on old wood. Therefore, severe pruning of bearing branches will cause reduction in tree size, flowering, fruiting and yield. Moderate annual selective pruning, however, keeps the tree smaller without seriously affecting yield and increases the size of the fruits. Few reports are available suggesting removal of branches at different intensity in different months for sustainable production of custard apple (Choudhari, 2012; Dahapute *et al.*, 2018). Considering beneficial effect of pruning, an investigation was carried out to find out the best time of pruning for production of quality custard apple in laterite zone of West Bengal where such attempt did not made earlier.

MATERIALS AND METHODS

The experiment was conducted in a private orchard at the Jhargram, Paschim Medinipur, West Bengal on 7 years old custard apple plant cv. Balanagar which were planted at a spacing of 3 x 3 m for two consecutive years (2014 and 2015). Before pruning, the plants were over-crowded and had excessive growth of leaders and laterals. The pruning treatment comprised of: T_1: Shoot pruning in February; T_2: Shoot pruning in March; T_3: Shoot

Table 1. Effect of shoot pruning on yield and physic-chemical composition of fruit of custard apple cv. Balanagar (Average of two years)

Month of pruning	Number of fruits/ plant	Number of fruits born on secondary shoots	Number of fruits born on tertiary shoots	Fruit weight (g)	Pulp content (%)	TSS (0Brix)	Acidity (%)	Total sugars (%)	Date of 1st harvest	Date of last harvest
February	30	24	6	145	87.1	21.5	0.18	16.8	25/8	15/10
March	26	20	6	170	84.1	21.0	0.21	19.4	25/8	15/10
April	24	18	6	168	85.3	20.8	0.19	17.6	25/8	15/10
May	45	35	10	174	86.2	21.6	0.17	19.5	25/8	15/10
June	20	18	2	134	82.6	20.0	0.17	17.4	25/8	15/10
Control	**22**	**20**	**2**	**140**	**85.0**	**19.2**	**0.14**	**16.4**	**25/8**	**15/10**
C.D. at 5%	**1.8**	**1.6**	**0.3**	**3.6**	**N.S.**	**0.3**	**N.S.**	**0.2**	**-**	**-**

pruning in April; T_4: Shoot pruning in May; T_5: Shoot pruning in June; T_6: Control (un- pruned).

All root suckers, unproductive shoots and dried branches were removed as per treatment (at different months). Shoot pruning consisted of heading back of all secondary and tertiary branches at 50% of their length on 15th of each month as per treatment. The experiment was laid down in randomized block design, replicated five times taking two plants as a unit. The plants were fertilized with 15.0 kg FYM, 200 g Nitrogen, 200 g P_2O_5 and 200 g K_2O plant^{-1} year^{-1} in two splits viz., June and September. Observations on fruit yield (both by number and weight) were recorded in each year. Physico-chemical characteristics of mature fruits were observed in each year following standard method (A.O.A.C, 1990).

RESULTS AND DISCUSSION

Practised of shoot pruning in custard apple has been found beneficial as appeared from data in Table 1. Shoot pruning in different months resulted in different degree of fruit production with highest in May-pruned shoots (45) followed by February (30) and lowest in June pruned shoots (20). It is clear from the data that shoot pruning in May gave double production as compared to un-pruned plants (control). One interesting results was noted that pruning of secondary shoots produced highest number of fruits as compared to tertiary shoots irrespective of month of pruning. From this observation it is appeared that fruit production in custard apple is mainly happened on secondary shoots and there is little need to prune the tertiary shoots when we considered for management of big orchard. There are several reports on beneficial effect of pruning on fruit production and quality improvement in custard apple (Choudhari, 2012; Dahapute *et al.* 2018; Choudhary and Dhakare, 2018) due to pruning but they did not mention the type of shoots to be pruned (secondary or tertiary) and the suitable month when pruning should be done. Most of the works was on severity of pruning and recommended 25% pruning intensity in all the cases. Highest fruit production in May-pruned shoots might be due to more number of new shoot growth which start flowering and fruiting when natural rain (monsoon is generally appeared from 10th June and onward in the zone) is started i.e., better availability of moisture and nutrients from June and onwards. Raut and Ghosh (2017) stated that high humidity and adequate nutrition results better fruit set and yield.

Better sizeable fruits always fetch higher market value. All the pruning treatments resulted better fruit size as compared to control except June-pruned shoots. Highest fruit weight was obtained from the tree with May-pruned shoots (174g) and lowest from June-pruned shoots (134 g) followed by control (140g). Improvement in fruit weight in custard apple due to pruning was also noted by Choudhary and Dhakare (2018) in custard apple, Ghosh and B. Bera (2014) in sweet orange, Mohamed *et al.* (2010) in custard apple.

Pulp content did not significantly varied due to different pruning treatment however; maximum pulp content (87.1%) was recorded from February pruned shoots followed by May pruned shoots(86.2%). Choudhary and Dhakare (2018)

observed maximum pulp percentage in fruits of custard apple from plants with pruning at 90cm.

Fruit quality in respect of TSS and total sugar content was significantly improved in all pruned treated plants as compared to control. Highest TSS (21.6^0B) and sugar content (19.5%) was measured from May-pruned plants and lowest in control (19.2^0B and 16.4% respectively). This finding was agreement with the results of Dahapute *et al.* (2018) in custard apple who found significantly maximum total soluble solids (TSS) from the fruits of plants with 30 cm pruning of shoots.

Regarding harvesting time i.e., 1st date of harvesting and last date of harvesting did not varied among different pruning treatments including control which indicated that time of pruning for the purpose of fruit production is more important in red laterite zone of West Bengal as compared to severity of pruning as reported by several workers from Maharashtra (Choudhari, 2012; Dahapute *et al.* 2018; Choudhary and Dhakare, 2018).

REFERENCES :

A.O.A.C. 1990. *Official methods of Analysis* (15th ed.) Association of official Agricultural Chemists, Washington, D.C.

Choudhari, Seema B. 2012. Effect of time and pruning intensity on growth, yield and quality in custard apple (Annona squamosa L.) cv. Balanagar. M.Sc. thesis submitted to Mahatma Phule Krishi Vidyapeeth, Rahuri.

Choudhary Kalpana and B. B. Dhakare. 2018. Influence of Pruning Intensities on Growth, Yield and Fruit Attributes of Custard Apple. *Int. J. Curr. Microbiol. App. Sci*., Special Issue-7: 5311-5315

Dahapute VM, Joshi PS, Tayade SA and Nagre PK. 2018. Effect of severity of pruning on growth, yield and quality of custard apple. *International Journal of Chemical Studies*, **6**(2): 1606-1609.

Ghosh, S.N. and Bera, B. 2014. Effect of pruning on productivity of sweet orange. *J. Hortl. Sci.,* **9**(2):206-208.

Kalkame Ch. Momin, Achume N. Sangma, C. P. Suresh, Y. S. Singh and S. R. Rao. 2018. Blood fruit [*Haematocarpus validus* (Miers) Bakh. f. ex Forman] – A potential nutraceutical and therapeutic fruit plant. *International Journal of Minor Fruits, Medicinal and Aromatic Plants,* **4** (1): 44-49.

Mohamed FM, Shahein, Abd El-Motty EZ, Fawzi MIF. 2010. Effect of pruning, defoliation and nitrogen fertilization on growth, fruit set and quality of Abdel-Razik Annona cultivar. *Nature and Science*, **8**(12):281-287.

Nandi Priyanka, Tarai, Ranjan Kumar and Ghosh. S.N. 2018. Studies on performance of different custard apple (*Annona squamosa* Linn) grown in red laterite zone of West Bengal. *International Journal of Minor Fruits, Medicinal and Aromatic Plants,* **4** (1)*:* 20-22.

Raut Ujwal Ajabrao and Ghosh. S.N.2017. Custard apple: *In:* Minor Fruits: Nutraceutical Importance and Cultivation (Part-I). 2017. Editor: S.N.Ghosh. Published by: Jaya Publishing House, 27-B, Pocket-B, Dilshad Garden, Delhi-110095. Pp:287-324.

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SHORT COMMUNICATION

Sohphlang–a potential indigenous leguminous tuber crop of Meghalaya

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ABSTRACT

Flemingia vestita locally called as 'Soh-phlang' belongs to the family Fabaceae. It is an underutilized minor tuber crop domesticated in Indian subcontinent and restricted to its cultivation in Khasi and Jaintia Hills of Meghalaya, Northeast India. Being a leguminous crop, it is known to improve soil quality. The edible tuberous roots are consumed after peeling off the outer yellowish skin and have been an indigenous vermifuge drug among the Khasi and Jaintia tribals. The crop is also known to possess high market value, i.e., Rs. 100-300 per Kg in the local markets.This leguminous tuber crops can serve as a key to future food and nutritional security for small and marginal farmers of Meghalaya.

Keywords: *sohphlang*, tuber, legume, indigenous

INTRODUCTION

Meghalaya is a fascinating state, situated in the North- Eastern region of India and endowed with a rich biodiversity of tuber crops, both wild and cultivated. "*Sohphlang*" botanically known as *Flemingia vestita* (synonyms *Flemingia procumbens* Roxb.; *Moghania vestita* (Benth.) ex Baker Kuntze; *Moghania procumbens* (Roxb.) Mukerjee) is one of the unique tuber crops found in Meghalaya. It is a small trailing legume with crisp, white edible root tubers, which are usually eaten raw and have a nutty flavour. Although, the tuber is rich in phosphorus and protein, this pale white shapeless tuber crop is not very attractive to look at, however it is regarded as a powerhouse of medicinal and nutritional value.It is also a rich source of bioactive isoflavones such as genistein, daidzein, formononetin and pseudobaptigenin (Rao and Reddy, 1991). It is further reported that, consumption of *Sohphlang* helps in getting rid of soft-bodied intestinal worms. In Meghalaya it is usually consumed raw with powdered perilla (*Nei lieh* in khasi) after peeling the outer skin. While the plant can be found growing in the wild, its recent demand has turned it into a profitable cash crop for the small and marginal farmers of Meghalaya. Being a legume crop, its might also has the property of nitrogen fixation. It has been reported that mixed cropping with *Flemingia vestita* gave better economic returns, which was mainly due to improved soil fertility with a net gain in nitrogen up to 250 kg/ha/year (Gangwar and Ramkrishnan, 1989). In spite of huge prospects, it full potential is yet to be realized amongst the farming community. The present article will provide an insight into the nutritional value and cultural practices for the cultivation of this crop. This information will pave the ways for prospecting this underutilized leguminous tuber crop towards it commercial and nutritional potential.

BOTANY

Sohphlang is a perennial herb, having a prostrate but weak stem, measuring about 60 cm. It is highly branched with hirsute stems and tuberous roots. Leaves are pinnately compound with obovate-cuneate leaflets; 3-foliolate; and also pubescent like the stem. Lateral leaflets are obliquely elliptic and slightly smaller. Inflorescence is a raceme either axillary or terminal, about 2–10 cm and densely pubescent; bracts lanceolate. Calyx is 5-lobed; lobes are linear-lanceolate, lower one is longest, longer than the tube. Corolla is slightly longer than calyx and elliptical. Fruits are hairy sub-cylindrical pods. Seed is globose, brown or black in colour. Flowers are bright-red. Flowering usually occurs after the monsoon season, August and September, sometime in the autumn, which suggests that day length sensitivity could be an issue if seed production is required (Chaudhri, 2005; Ren and Gilbert, 2010).

***Fig. 1 Sohphlang* plants**

CHEMICAL CONSTITUENTS

The tuber of sohphlang has been an indigenous vermifuge drug among the tribal populace of Meghalaya. The raw tuber is directly consumed for the treatment of soft-bodied intestinal worms (Hrckova and Velebny, 2013). Experimental investigation started in 1996 when the in-vitro activity of tuber peel extract was tested against different helminth parasites, including the nematodes such as *Ascaris suum*, *Ascaris lumbricoides*, *Ascaris diagalli*, *Heterakis gallinarum*, a cestode *Raillietina echinobothrida* and trematodes such as *Paramphi stomum* sp., (Tandon *et al*., 1997) *Artyfechinostomum sufrartyfex* and *Fasciolopsis buski* (Roy and Tandon, 1996). Result suggested the vermifugal activity of this plant extract against trematodes and cestodes. Isoflavone and genistein extracted from tuber are the major anti-helmintic principle, highly potent against trematodes and cestodes (Rao and Reddy, 1991). This compound were also found to be effective against the sheep liver fluke *Fasciola hepatica* (Toner *et al*., 2008) and human tapeworms such as *Echinococcus multilocularis* and *E. granulosus metacestodes* (Naguleswaran *et al*., 2006).

***Fig. 2: Sohphlang* tuber**

USES

Raw *Sohphlang* is eaten raw with salt, powdered perilla (*nei lieh*) and chilli. The best way to enjoy sohphlang is with *nei lieh* that has been roasted and ground to a fine paste**.**

DISTRIBUTION AND GENETIC RESOURCES

This leguminous tuber crop is grown in the wild along the mountain slopes of Himalayas. It is found in some part of China, Nepal, Khasi Hills and Jaintia Hills districts of Meghalaya. It is also sparsely found in Laos, Philippines and Vietnam. However, it is commercially cultivated only in Meghalaya (Van and Bunyapraphatsara, 2001; National Research Council, 2002).

Specific varieties are not known in *sohphlang* however, there is a wide variation in tubers with respect to shape, size and weight. Authors conducted survey during 2016-17 in different parts of Meghalaya and found that a vast variability exists among *sohphlang* genotypes. Tubers are found to be cylindrical, fusiform, napiform, round and oval in shape with varying size; 2.5-8.6 cm in length, 1.5-3.0 cm in width and 5-40 g in weight.

CULTURAL PRACTICES

Sohphlang is generally propagated vegetatively through small tubers. After harvesting, the healthy tubers are selected as seed and stored underground for the next planting season. It is interesting to note that *sohphlang* is planted in a virgin soil for one year, after that the place is left fallow or cultivation of another crops for five or more years before replanting of sohphlang. In Meghalaya, *sohphlang* is planted on bund at 30-45 cm plant to plant and 30-45 cm between the lines and covered with soil using a ridger during March-April. Earthing-up and weeding are done as soon as weeds emerge, but preferably when plants attain a height of about 8–10cm during June-July.

The crop takes 7 months to come to maturity. Usually sohphlang comes to the markets in Shillong by October and is available till May. The tubers are manually harvested by digging up with a spade and stored in a pit covered with earth and tubers are taken out as and when demanded in the market. An average yield of 3000 kg/ha has been reportedin Meghalaya (Singh and Arora, 1973). The polished tuber is sold at Rs. 250-400 per Kg in the local markets of Meghalaya.

CONCLUSION

Sohphlang has a huge potential and can be incorporated in our present farming system. This leguminous tuber crops can serve as a key to future food and nutritional security for small and marginal farmers. In addition, sohphlang also bring additional income to farmers. Therefore, it is imperative to undertake the scientific and systematic study on this locally available untapped underutilized tuber crop for standardizing their agro techniques and their productiveness.

REFERENCES :

Chaudhri, A.B. 2005. Forests Plants of Eastern India. Ashish. pp. 205–206. ISBN 8170245370.

Gangwar, A.K. and Ramakrishnan, P.S. 1989. Cultivation and use of lesser-known plants of food value by tribals in north-east India. Agriculture, *Ecosystems and Environment,* **25** (2-3): 253–267

Hrckova, G. and Velebny, S. 2013. Pharmacological Potential of Selected Natural Compounds in the Control of Parasitic Diseases. Springer. p. 64. ISBN 978-3-7091-1324-0.

Naguleswaran, A., Spicher, M., Vonlaufen, N., Ortega-Mora, L.M., Torgerson, P., Gottstein, B. and Hemphill, A. 2006. In vitro metacestodicidal activities of genistein and other isoflavones against *Echinococcus multilocularis* and *Echinococcus granulosus*. *Antimicrobial Agents Chemotherapy,* **50** (11): 3770–3778.

National Research Council 2002. Tropical Legumes: Resources for the Future. Books for Business/ The Minerva Group, Inc. pp. 37–38. ISBN 0894991922.

Rao, H.S. and Reddy, K.S. 1991. Isofavones from Flemingiavestita. *Fitoterapiam,* **62**(5): 458.

Ren, S. and Gilbert, M.G. 2010. "FLEMINGIA Roxburgh ex W. T. Aiton, Hort. Kew., ed. 2, 4: 349. 1812, nom. cons., not Roxburgh ex Rottler (1803)". *Flora of China,* **10** (3): 232–237. ISSN 1043-4534.

Roy, B. and Tandon, V. 1996. Effect of root-tuber extract of *Flemingiavestita*, a leguminous plant, on *Artyfechinostomumsufrartyfex* and *Fasciolopsisbuski*: a scanning electron microscopy study. *Parasitology Research,* **82** (3): 248–252.

Singh, H.B. and Arora, R.K. 1973. Sohphlang, *Moghaniavestita*, a leguminous root crop of India. *Economic botany,* **27**: 332-338.

Tandon, V., Pal, P., Roy, B., Rao, H.S. and Reddy, K.S. 1997. In vitro anthelmintic activity of root-tuber extract of *Flemingiavestita*, an indigenous plant in Shillong, India. *Parasitology Research,* **83** (5): 492–498.

Toner, E., Brennan, G.P., Wells, K., McGeon, J.G. and Fairweather, I. 2008. Physiological and morphological effects of genistein against the liver fluke, *Fasciola hepatica*. *Parasitology,* **135** (10): 1189–1203.

Van Valkenburg J.L. and Bunyapraphatsara N, eds. 2001. Plant Resources of South-East Asia No. **12**(2): Medicinal and Poisonous Plants 2. Backhuys Publisher, Leiden, The Netherlands. pp. 267–270. ISBN 90-5782-099-4.

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Annual meetings: Schenck, N.C. 1965. Compatibility of fungicides with insecticides and foliar nutrients. *57th annual Meeting of American Phytopathological Society,* 3-7 October, 1965.

Reports: Anonymous, 1971. Investigations of insects pests of sorghum and millets. *Final Technical report*, 1965-70, IARI, New Delhi, pp.157.

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