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FOCUS

Indian arid zone miracle plants for food and livelihood security

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Abstract

Developing countries are being encouraged to diversify their food exports by developing new products and adding more value to existing products. Adding value to and diversifying food exports depends not only on changing production but also processing system. The traditional Indian arid fruits are very rich in nutritional parameters and a variety of by products can also be prepared from them. As consumers today are increasingly conscious of health and nutrition, there is a tendency to avoid chemicals and synthetic foods, thereby choosing natural foods. In this context, underutilized fruits have unlimited potential in fresh and processed form for their therapeutic, medicinal and nutritive values. A number of species are already being used and marketed as antioxidants, staple food, food supplements and sources of condiments, spices, thickening agents, flavours, edible oil, etc. Some of the underutilized fruits and nuts are rich sources of vitamin C, proteins and Vitamin A. They contain pectin and celluloses, which stimulate the intestinal activity and protect human body against diseases. Value of underutilized fruits in traditional medicines is well known as a major source of raw materials for drugs since antiquity. In India, the fruits of Emblica officinalis (aonla), Terminalia chebulla (harar) and Terminalia bellerica (bahera) are the most common, entering into 219 patented drugs.

Keywords : Underutilized fruits, vitamins, food supplement, livelihood, food security.

INTRODUCTION

Underutilized fruits provide food, nutrition, and substances to tile native communities and are an additional source of income. Though the wild and domesticated diversity is composed of nearly 3000 tropical fruit species, only a few have been cultivated on large scale (Vietmeyer, 1990). The global scenario indicated that worldwide about 600 tropical, and sub tropical species are better known in their areas of diversity (Negy and Shaw, 1980). Many fruit species have not yet been utilized to full potential inspite of their economic value. The role played by underutilized species is indeed central to reducing poverty and empowering the poor so as to allow poor rural communities to pursue resources-based rather than commodity-based development. But the people who benefit from underutilized species in a globalized world are not just for the poor. The benefits in terms of more balanced diets, diversified income to farmers as well as related sectors of the society, better maintenance of agro-ecosystems and greater use of marginal lands along with enhanced preservation of cultural identity (Padulosi, 1999) can be shared by all the humankind.

An attention to the minor fruits can play a significant role in increasing the income, providing employment opportunities, uplifting of the poor, small and marginal farmers and the development of value added products. Increased reliance on major food crops has been accompanied by a shrinking of the food basket which humankind has been relying upon for generations (Prescott and Prescott, 1990). Although 'hidden hunger' affects mainly developing countries, particularly children and older people (FAO, 1997), it is increasingly being recorded also among the more vulnerable social groups in developed nations. If the 20th Century witnessed the undertaking of systematic collecting to rescue the genetic resources of staple crops (Pistorius, 1997) the 21st Century has started with the awareness on the need to rescue and improve the use of those crops left aside by research, technology, marketing systems as well as conservation efforts.

These underutilized crops (referred to also by other terms such as minor, orphan, neglected, underutilized, underexploited, underdeveloped, lost, new, novel, promising, alternative, local, traditional, niche crops) have been included in world-wide plans of action after having successfully raised the interest of decision makers. Leading international research organisations such as the Consultative Group on International

Agricultural Research (CGIAR) are also among those taking a keen interest in strengthening the work on these species (Swaminathan, 1999). This global "opening" towards underutilized species is the result of a gradual change of attitude towards biodiversity and plant genetic resources by many countries. The Global Forum on Agricultural Research (GFAR) in 1999 also emphasized the role of underutilized species in raising income of the rural poor. Hence, diversifying production and consumption of underutilized fruits can therefore contribute significantly to improve health, income generations and ecological sustainability. In nutshell, use of underutilized fruits has a vital role in imparting nutritional security to people. The father of green revolution, Dr. M.S. Swaminathan has also rightly stated that "Fruits and vegetables are the food of the future" (Kurian and Peter, 2007). This paper addresses aspects related to composition, nutritional value, processing and utilization of some of the neglected and underutilized fruits of origin.

India (Hindustan), the centre of origin for many tropical fruit tree species, (Table 2) most of which are not commercially cultivated but provides significant source of livelihood support for many rural communities. Attention to underutilized species may also originate from considerations that are not directly related to food security or poverty alleviation, but to the need to safeguard artistic, landscape and cultural values of these species.

Fruits are important in the human diet, as they act as:

As a source of food: Arid and semi-arid zone vegetation comprises a wide range of edible fruit-bearing and food-producing species: *Tamarindus indica*, *Ficus spp.*, *Manilkara spp.*, *Aegle marmelos*, *Bcehannan lanzan*, *Grewia asiatica*, *Salvadora oleoides*, *Balanites aegyptiaca*, *Cordia spp.*, Ziziphus spp., *Prosopis cineraria*., *Capparis decidua*, *Salvadora persica* etc. There are around 30 plant species in arid zone known for their edible use and of these around 20 plant species are known for their edible fruits either raw or use as vegetable (Rathore, 2009).

The highest energy available is from tamarind pulp (142 calories) with low moisture and high carbohydrate (34g) content, while *A. squamosa* supplies half the energy, but has 70.5% moisture and 11.8g carbohydrates (Table 4). On the dry basis, the energy content will be 127, 178 and 179 cal. and carbohydrate content of 45, 40 and 43g for dates, seethaphal and tamarind pulp, respectively. In fact, on the dry basis there is not much difference between the various fruits. Fibre provides good motility to intestine, which helps the digestive process. Most of these fruits are good source of fibre with *Ficus* spp. having the highest amount (3.2 to 5.0 g).

As a Source of nutrients: The tribal people of arid zone are severely malnourished along with multiple nutrient-deficiency disorders due to ignorance about importance of fruits and vegetables in their diets. The tribal areas are full of biodiversity having natural vegetation which is not harnessed fully. Due to which a wide gap is formed between health and optimal use of natural sources of nutrients, i.e., underutilized crops. As underutilized fruits, nuts, and vegetables are rich of source of carbohydrate, fat, protein, energy, vitamins-A, B_1, B_2, B_3, B_6, B_9, B_{12}, C, folic acid, and minerals-Ca, P, Fe, and dietary fiber. Thus, they have the nutritional capacity to prevent and cure various diseases like kwashiorkor, marasmus, night blindness, anaemia, diabetes, cancer, hypertension, and hidden hunger. Underutilized fruits contribute significantly in maintaining tribal population nutrition, especially as very good source of vitamins {ascorbic acid (vitamin C), carotenoids (vitamin A), thiamine (vitamin B_1), riboflavin (vitamin B_2), niacin (vitamin B_3), pyridoxine (vitamin B_6), folacin}, minerals, fat, protein and dietary fibre. Some underutilized fruits like wood apple (7.10 mg100gm-1 pulp) are very good source of protein, tamarind (17.01 mg100gm-1 pulp) and karonda (39.14mg100gm-1 pulp) are richest source of iron, kumquat (2575 IU) and drumstick (190 IU) are excellent source of vitamin A, aonla (500-625 mg100gm-1pulp), ber (39-166 mg100gm-1 pulp) and Chinese jujube (188-544 mg100gm-1 pulp) are good source of vitamin C, wood apple (3.70-3.75 mg100gm-1 pulp) have good amount of fat, bael (31.80 mg100gm-1 pulp), tamarind (67.40 mg100gm-1 pulp) and date palm (70 mg100gm-1 pulp) are very good source of carbohydrate.

Underutilized fruits such as ber, bael, ker, khejri pod and jamun are more nutritious than other

Table 1: Major regions of diversity and domestication of less known/ underutilized fruits and nuts.

Region/ Category	Less known edible types		Species diversity/distribution
	Fruits	Seeds/ nuts	
Tropical/ Subtropical			
lndo-Chinese-Indonesian	61	14	Maximum diversity occurs in humid tropical/ subtropical species
Chinese-Japanese	50	18	Maximum diversity occurs in subtropical and temperate species
South American	69	12	Maximum diversity occurs in humid tropical species
Central American	36	8	Rich diversity
Hindustan (India)	17	11	Rich diversity in humid tropical species; also of species adapted to drier/ moist tropical/subtropical/ temperate climate
African	13	21	More diversity in types adapted to subtropical/tropical dry-moist climate; relatively very low proportion of cold adaptable types
Temperate/Subtropical			
North American	38	4	Diversity suited more to colder climate pome, stone and soft fruits
European-Siberian	14	6	More diversity in types adapted to very cold conditions; pome and stone fruit/several nuts
Mediterranean	5	7	Diversity in subtropical and temperate species including cold adaptable types
Central Asian	19	4	Diversity in subtropical/ temperate fruits; more in pomes and stone fruits
Near Eastern	13	10	Diversity in subtropical/ temperate fruits and nuts
Australian	4		Diversity limited, largely in humid tropical/ subtropical species

Source: Arora (1985)

commercial fruits. Ker (*Capparis deciduas* (Forssk.) Edgew) also a underutilized fruit of Rajasthan is very good source of protein (4.24 gm), fat (2.0 gm), fibre (4.24 gm), carbohydrate (18.2 gm), energy (107 Kcal) and vitamin C (50 mg) in 100 Gm^{-1} of fresh fruit. The unripe green pods of khejri (*Prosopis cineraria* (L.) Druce) commonly known as sangri are very good source of digestive protein (5.1 gm), fiber (6.7 gm), carbohydrate (14.15 gm) and energy (82 Kcal) in 100 Gm^{-1} of fresh pods. A good balanced diet should supply sufficient amount of the major nutrients protein, fat and carbohydrate and the minor constituents-vitamins and minerals. Minerals and vitamins are largely supplied by the fruits and vegetables. Although most of the common fruits are low in protein, some of the underutilized fruits and nuts are rich sources of vitamin C, protein and Vitamin A. Ker (*Capparis decidua* (Forsk.) Edgew) of the family capparidaceae, is one of the prominent wild flora of the arid zone of India. Its immature fruits contain 8.6 and 5 percent crude and true proteins respectively, besides the minerals immature acid fruits are used for making vegetable and pickle.

Arid zone vegetation comprises a wide range of edible fruit bearing and food producing species viz.

Table 2: Some Promising/ potential underutilized fruits and nuts from different regions of diversity:

Region	Fruits
Indochinese-Indonesian	*Artocarpus altills* (Breadfruit), *Averrlhoa carambola* (Carambola), *Citrus grandis* (Pummelo), *Diospyros discolor* (Velvet apple), *Garcinia mangostana* (Mangosteen), *Mangifera foetida* (Horse mango), *Mangifera odorata* (Kuwini mango), *Syzygium* spp.
Australian	*Inocarpus fragifer* (Tahiti chestnut), *Macadamia integrifolia* (Macadamia nut), *Santalum acuminatum* (Quandong), *Terminalia catappa* (Indian almond), *Terminalia kaernbachii* (Okari nut).
Hindustan	*Aegle marmelos* (Bael), *Artocarpus lakoocha* (Monkey jack), *Borassus flabellifer* (Palmyra palm), *Buchanania lanzan* (Chironji), *Capparis decidua* (Ker), *Carissa congesta* (Karonda), *Citrus medica* (Citron), *Dillenia indica* (Elephant apple, Chalta), *Emblica officinalis* (Aonla), *Feronia limonia* (Wood apple), *Garcinia indica* (Kokam), *Madhuca indica* (Mahua), *Manilkara hexandra* (Khirni), *Porkia roxburghii* (Tree bean), *Phoenix sylvestris* Roxb (Date sugar palm), *Prosopis cineraria* (Khejri), *Syzygium cumini* (Jamun), *Ziziphus mauritiana* (Indian jujube), *Zizyphus nummularia* (Jharberi).
Central Asian	*Morus nigra* (Black mulberry), *Pinus gerardiana* (Chilgoza nut), *Pistacia vera* (Pistachio nut).
Near Eastern	*Punica granatum* (Pomegranate).
Mediterranean	*Argania sideroxylon* (Argan tree).
African	*Adansonia digitata* (Monkey bread), *Annona senegalensis* (Wild custard apple), *Balanites aegyptiaca* (Desert date), *Carissa grandiflora* (Natal plum), *Garcinia livingstonei* (African mangosteen), *Phyllanthus acidus* (Otaheite gooseberry), *Tamarindus indica* (Tamarind).
European-Siberian	*Corylus colurna* (Turkish filbert), *Hippophae rhamnoides* (Seabuckthorn).
South American	*Anacardium giganteum* Hancock ex Engler (Wild cashew), *Annona cherimola* Mill. (Cherimoya), *Carica candamarcensis Hook. f.* (Mountain papaya), *Carica pentagona Heilb.* (Babaco), *Passiflora edulis* (Purple granadilla).
Central American and Mexican	*Annona divercifolia* Safford (Ilama), *Annona purpurea* (Soncoya), *Pithecellobium, dulce* (Manila tamarind), *Annona reticulata* (ramphal), *Annona muricata* (Soursop), *Malpighia glabra* (Barbados cherry), *Pereskia aculeata* (Barbados gooseberry).
North American	*Annona atemoya* (Atemoya), *Juglans cinerea* (Butternut).

Source: Pareek and Sharma 1993

Capparis decidua (Ker), *Cordia dichotoma* (lasoda), *Ziziphus mauritiana* (ber), *Ziziphus nummularia* (Bordi), *Salvadora oleoides* (Jal), *Balanites aegyptiaca* (Hingota), *Prosopis cineraria* (Khejri) etc. which play an important role in the nutrition of children in rural and urban areas alike and are relished by them. Most of these fruits are rich sources of protein and energy. Ker is a rich source of fibre, vitamin A and vitamin C. Ber is richer than apple in protein, phosphorous, calcium, carotene and vitamin C. However they are often undervalued and underutilized as more exotic fruits become accessible. Amongst fruits, Table 6 Aonla (300 mg) is the best source of vitamin C. Ber (38 mg), Cape gooseberry (25 mg) and Mahua (20 mg) comes next with values comparable to that of citrus fruits (Singh,1990). Fruits like Cape gooseberry (714 µg), Loquat (280 µg), Khirni (248 µg) and Phalsa (210 µg) are rich in carotene. Pilu (Bara jal) or Toothbrush tree (*Salvadora aleoides* Decne)

Table 3: Flowering and fruiting time of arid underutilized fruits

Arid Fruits	Botanical Name	Flowering Time	Fruiting Time
Ber	*Ziziphus mauritiana*	Sept-October	Nov- February
Phalsa	*Grewia subineaqualis*	Feb- March	April-May
Custard apple	*Annona squamosa*	July-August	Sept-October
Fig	*Ficus indica*	Feb-March	July- September
Pomegranate	*Punica granatum*	June- July	Dec-January
Khejri	*Prosopis cineraria*	Feb.- March	April- May
Aonla	*Emblica officinalis*	March- April	Nov- January
Sapota	*Achras zapota*	Oct- November	Jan-February
Karonda	*Carissa carandus*	Jan-February	May- June
Bael	*Aegle marmelos*	April- May	March-April
Mahua	*Madhuca latifolia*	March-April	May- July
Jamun	*Syzigium cuminii*	March-April	June- August
Chironji	*Buchanania lanzan*	Feb- March	May- June
Tamarind	*Tamarindus indica*	July-August	Feb.- March
Khirni	*Manilkara hexandra*	February - March	April- May
Kair	*Capparis decidua*	February - March	April- May
Lasura	*Cordia dichotoma*	February - March	April- May
Mulberry	*Morus spp.*	Dec- January	Feb- March
Pilu	*Salvadora aleoides*	March-April	May–June

Table 4: Comparison of Non conventional fruits with the traditional fruits

	Conventional fruits				Non conventional fruits				
	Apple	**Oranges**	**Guava**	**Mango**	**Banana**	**Phalsa**	**Jamun**	**Bael**	**Khirni**
Energy (Cal.)	59	48	51	74	116	72	62	137	134
Carbohydrate (g)	13.4	10.9	11.2	16.9	27.2	14.7	14.0	31.8	27.7
Fibre (g	1.0	0.3	5.2	0.7	0.4	1.2	0.9	2.9	-
Minerals(g)	0.3	0.3	0.7	0.4	0.8	1.1	0.4	1.7	0.8
Calcium (mg)	10	26	10	14	17	129	15	85	83
Phosphorus (mg)	14	20	28	16	36	39	15	50	17
Iron (mg)	1	0.3	1.4	1.3	0.9	3.1	1.2	0.6	0.9
Carotene (øg)	0	1104	0	2743	78	419	48	55	495
Vitamin C (mg)	1	30	212	16	7	22	18	8	16
Thiamine (mg)	0.04	0.08	0.03	0.08	0.05	-	0.03	0.13	0.07
Riboflavin (mg)	0.03	0.03	0.03	0.09	0.08	-	0.01	0.03	0.08
Niacin (mg)	0.2	0.2	0.4	0.9	0.5	0.3	0.2	1.1	0.7

Source: Rathore, 2009

Table 5: Nutrient content of some important fruits from arid zone (50 g of edible portion of fruit)

Species	Moisture (%)	Energy (Kcal/g)	Carboh-ydrate (g)	Fibre (g)	Fat (g)	Protein (g)
Tamarindus indica	20.9	142	34	2.8	0.05	1.6
Manilikara elangii	54.7	80	18	2.2	0.50	0.9
Phoenix dactylifera	59.2	72	16.9	1.9	0.20	0.6
Aegle marmalos	61.5	68	15.9	1.5	0.15	0.9
Manilikara hexandra	68.6	67	13.9	-	0.20	0.3
Feronia limonia	64.2	67	9.1	2.5	1.85	3.6
F. indica	67.8	57	11.4	2.4	0.90	0.9
Annona squamosa	70.5	52	11.8	1.6	0.20	0.8
Ficus bengalensis	74.1	36	5.9	4.3	1.00	0.9
Emblica officinalis	81.8	29	6.8	1.7	0.05	0.3

Source: Pareek and Sharma 1993

Table 6: Vitamin content of some fruits (50 g of edible portion)

Fruits	Vitamin C (mg)	Carotene (µg)	Thiamine (µg)	Riboflavin (µg)	Niacin (µg)
Aonla	300.0	4.5	15	5	100
Timru	0.5	180.0	5	20	1150
Gular	2.5	81.0	30	25	300
Ber	38.0	10.5	10	25	350
Khirni	8.0	248.0	35	40	350
Phalsa	11.0	210.0	-	-	150
Mahua	20.0	154.0	-	-	-
Tamarind	1.5	30.0	-	35	350

Source: Singh, 1990

Table 7: Mineral content of certain fruits (50 g of edible portion)

Fruits	Mineral (g)	Calcium (mg)	Phosphorus (mg)	Iron (mg)
Tamarindus indica	1.45	85	55	5.5
Ficus religiosa	1.15	145	45	-
Cordia dichotoma	1.10	20	30	-
Manilkara elangii	1.15	106	15	-
Feronia limonia	0.95	65	55	0.3
Aegle marmelos	0.85	43	25	0.3
Bcehannan lanzan	0.85	39	14	-
Ficus tunia	0.80	94	20	-
Grewia asiatica	0.55	65	20	1.6

Source: Pareek and Sharma 1993

Table 8: Medicinal values of some minor fruits

Arid fruits	*Medicinal value*
Bael	Cures dysentery, diarrhea, Appetizer, stomachic, cooling, restore vitality
Bullock's heart	Arthritis, bile disease, vomiting, weakness, anaemia, blood dysentery
Cordia	Anthiliniatic, diuretic, demulcent, and expectorant
Custard apple	Arthritis, bile disease, vomiting, weakness, anaemia, blood dysentery, Storehouse of Vitamin C acts as antioxidant, Vitamin A present is good for hair, eyes, healthy skin, rich source of dietary fibre so helps in digestion, expectorant, coolant, stimulant, haematinic
Emblica	Hemorrhage, diarrhea, dysentery, anemia, jaundice, dyspepsia and cough
Feronia	Antiscorbutic, used as liver and cardiac tonic and, when unripe, as a means to halt persisting diarrhea and dysentery and effective treatment for hiccup, sore throat, and diseases of the gums.
Phalsa	Blood purification, anemia, tonic and aphrodisiac, fruits allay thirst and burning sensation, remove and cure inflammations, good for heart and blood disorders, fevers and diarrhoea, for the troubles of throat. , cures urinary troubles , rheumatism.
Jamun	Cures Stomach ache, anaemia, improves haemoglobin in blood, Diabetes, Diarrhoea, Dysentery, Nocturnal emission, sores, ulcer, leucorrhoea and stone in kidney.
Kair	Cardiac trouble, useful in cough, asthma, inflammation, rheumatism, intermittent lever. Cures biliousness, asthma, inflammations, fever, cough, stomach pain, vomiting, arthritis, diabetes and hypertension, laxative
Karonda	Bleeding, kalajor, scabies, worm, Antiscorbutic, remedy of several diseases like biliousness, anemia and also used as aphrodisiac for women, antiparasitic, antifungal, antimicrobial, topical wound treatment (juice) and skin remedy
Khejri Pods	Help in blood purification, cures skin disease, respiratory problem andpiles, cures ringworm infection, dyspepsia and fevers.
Khirni	Cures anaemia, improves haemoglobin content in blood
Pomegranate	Leprosy, diarrhoea, dysentery, jaundice, bleeding, worm
Salvadora	Rheumatic pains, cough and purgative, root bark is vesicant, fruit is useful in cnlarge spleen and low lever. Helps in blood purification and digestion
Tamarind	Diarrhoea, paralysis, cold, dyspepsia, head ache, teeth ache, asthma, Useful in heart care and against stone, cure infections in urinary system
Wild date palm	Weakness, worm, heart disease, fever, stomach disease, weakness, diarrhoea, renal diseases, Supply instant energy, natural laxative, nicotinic content cures intestinal disturbances, checks growth of pathological organisms
Zizyphus	High potency, longevity, lofty thinking, blood purification andimproves digestion

Source: Pareek and Sharma 1993

Table 9: Processed products from underutilized fruits

Product	Fruits
Jam	Jamun, Karonda, Aonla, Jackfruit, Aonla, Ber, Mulberry, Soursop, Tamarind, Wood apple, West Indian Cherry, White sapota, Star apple, Tree tomato, Brazilian grape, Surinam Cherry, Carambola, Natal plum, marula nut, seabuckthorn, tamarind and wood-apple.
Jelly	Tamarind, Jamun, Karonda, Imbu (*Spondias tuberosa*), Barbados cherry, wood-apple
Preserve	Ber, Ker, Sangri, Bael, Karonda, Soursop, Aonla, Palmyra palm
Candy	Aonla, Karonda, Tamarind, Ber
Glazed fruits/ Confectionary	Tamarind, Annanas, Aonla, Ber, Fig
Juice/Syrup/Sharbet/ Beverage / Squash	Aonla, Ber, Bael, Jamun, Karonda, Phalsa, Jujube, Mulberry, Pomegranate, Soursop, Wood apple, Tamarind, Natl plum, Seabuckthorn, Aonla
Wine	Jujube, Barbados cherry, Ber, Indian fig, Karonda,
Chutney	Karonda, Woodapple, Anola, Carambola,
Sauce	Karonda, Tamarind, Woodapple, Pomegranate,
Pickle	Jujube, Jackfruit, Tamarind, Ker, Lasoda, Carambola, Gonda (Cordia),
Dehydration	Aonla, Karonda, Ker, Bael, Ber, Custard apple, Wild apricot, Indian jujube, Indian fig, Karonda, Mulberry, Phalsa, Siberian crab apple, Peach, Plum, Longan
Frozen Puree	Bael, Karonda, Phalsa,Tamarind, Custard apple
Canning	Aonla, Ber, Ker, Prickly Pear, Karonda

Source: Ghosh, 2000

Table 10: Underutilized fruit crops and Waste lands

Waste lands	Suitable underutilized crops
Degraded forest lands	Custard apple, Indian jujube, Kair, Bael, Anola, Tamarind, Fig, Jamun,
Sandy Waste land	Ber, Bael, Bullock Heart, Custard apple, Kair, Pilu
Gullied and runoff area	Jamun, Ber, Custard apple, Mulberry, Tamarind, Rayan
Salt affected lands	Ber, Date palm, Jamun, Mulberry, Rayan, Pilu
Industrial waste land	Jamun, Tamarind, Ber, Custard apple, Phalsa
Undulated upland	Custard apple, Jamun, Aonla, ,Phalsa, Pilu, Gonda, Kair
Degraded pasture, and grazing land	Aonla, Tamarind, Jamun, ,Kair, Fig

Source: Pareek and Sharma 1993, Singh and Singh 2011, Singh *et al.,* 2012

belongs to the family Salvadoraceae its fruit is sweet in taste, eaten fresh and sweet pulp contains 1.7-1.86% glucose, fructose and sucrose and are used by villagers to prepare squash. Fermented drinks are also made from fruits (Rathore, 2009).

Calcium, phosphorous and iron are the major mineral constituents required by the human body in addition to sodium and potassium. Most of the requirement can be fulfilled by vegetables, but inclusion of fruits makes further addition of calcium and phosphorus responsible for the growth of bones. The amount of minerals in 50 g of the edible portion of the fruit is presented in Table 7.

Highest mineral content is present in *T indica* (1.45g) followed by *C. dichotoma, M. elangii* and *F. religiosa*. All fruits except *C. dicholoma, M. oleifera, B. arundinocea* have higher iron content than the other fruits listed here. It is also higher than that present in apricot and peaches.

As a Source of medicine: These fruits have been a major source of raw materials for drugs since time immemorial and had provided a number of products used in traditional medicines. Today, for instance, an increased interest is recorded among national and international research organisations towards medicinal and aromatic species in view of their role in improving the health of poor and their contribution to combat poverty through income generation. In India, the fruits of *Emblica officinalis* (aonla), *Termilnalia chebulla* (harar) and *T belliricaria* (bahera) are the most common, entering into 219 patented drugs. *Aegle marmelos* (bael) is used in 60 drugs (Khurdiya , 2001). The demand for products threat enters into the manufacture of popular medicines for common ailments find home remedies in truly large. "Chyavanpras" based on *Emblica officinalis* (aonla) is other excellent example. Ker (*Capparis deciduas* (Forsk.) Edgew.) tender branches and leaves are used as a plaster for boils and swellings and to relieve toothache on chewing. Its stem bark is used as a laxative, diaphoretic and anthelmintic. Lasoda (*Cordia myxa* L.) fruit has anthelmintic, diuretic, demulcent and expectorant properties. Bael *(Aegle marmelos)* pulp contains marmelosin which acts as a laxative and diuretic and in strong doses as cardiac depressent. Jujube *(Zizyphus mauritiana)* fruits are used as an ingredient in the preparation of "*joshanda*" (an ayurvedic medicine used in chest trouble), jamun seeds in diabetes and black mulberry in docking of AIDS virus on human cells (Anon, 2006). Fruits of prickly pear and their products help in treating diabetes, high blood cholesterol and obesity (Hegwood, 1990). They contain pectin and celluloses, which stimulate the intestinal activity and protect human body against diseases. Jharber (*Ziziphus nummularia* (Burm. f.) bark is used as ointment for foul sores and scabies. Value of underutilized fruits in traditional medicines is well known (Ali and Rab, 2000). These have been a major source of raw materials for drugs since antiquity and have provided bulk of products used in the traditional system of medicine (Ogle and Grivetti, 1995).

As a source of raw material for processing industry: The galaxy of underutilized fruits available in the tropical and subtropical world desperately needs to be popularised. Many of these fruits are highly perishable and not possible to keep them for more than 24 hours under ambient conditions. Some of them are not easy to eat out-of hand because of the hard shell, mucilaginous texture and numerous seeds; as a result these are is not popular as a dessert fruit. A few of the fruits are not acceptable as a fresh fruit because of its high acidity content and strong astringent taste. However, these fruits have unlimited potential in the processed form and consumers all over the world can get the opportunity to enjoy the fruits in the form of their products. Several under-exploited fruits provide raw material for processing industry. Commercial production of food products from under-exploited fruit species has helped to reduce wastage and promote widespread marketing of these items (Pareek and Sharma 1993). A number of products that could be produced commercially from under-exploited plants are listed in Table 9.

As a source of fodder: Jharber (*Ziziphus nummularia* (Burm. f.) fruits are small in size and edible. Its leaves contain appreciable amounts of nutrients and minerals and form the most valuable fodder for camel, goats and cattle fodder during November-December months. Lasoda (*Cordia myxa* L.) fruits are rich in minerals and the leaves are used for making pattal (trays) and as fodder. Phalsa leaves are also very much used as fodder for small ruminants.

Underutilized fruit crops for Ecological/ Environmental Conservation: The increased demand for food, clothing and shelter arising out of the population growth had its adverse effects on the environment of tropical regions. A vast area has been denuded and has deranged the delicate environment balance at micro level. Due to unpresidential removal of the forest trees and setting of industries and buildings there is major degradation in the environment conditions necessary for well beings of flora and fauna. Many of the underutilized and unexploited fruit species can tolerate heavy rains, drought, shallowness of soil profile, hot as well as wet soil and summer hardiness, so can be grown in different types of Waste lands.

Industrial use of oils, fats and essential oils

Sources of plant products: Products from underutilized fruits can generate substantive income for the rural and tribal people. Small scale forest based industries can serve as a source of income especially for rural landless people in developing countries. Raw materials can be collected from the forest and supplied to these industries which have significant potential for improvement to develop commercially viable enterprises.

Sugars and sweetness: In arid zone of India palms are the oldest sources of crystal sugars and palm sugar is still considered important. Palm sugar and jaggery contains 12- 17 per cent sucrose (Rehm and Espig, 1991). Palmyra palm (*Borassus flabellifer*) yields 3-4 litres, toddy or kittul palm (*Caryoto urens*) produces 7-14 liters of sap per day per inflorescence (Rehm and Espig, 1991). Wild date palm i.e. *Phoenix sylvestris* yields 20 tonnes sugar per hectare by trapping of trunk. Besides, major proportion of juice is commercially used for production of palm wine (toddy) from which vinegar or arrack is produced (Macmillan, 1991).

Starch: The average daily human energy need of 6.7 to 8.4 MJ can be provided by 400- 500 g starch which is generally met from cereals, roots and tubers. Seeds of water chestnut, breadfruit and tamarind are rich sources of starch. Sometimes palms such as *Caryota, Phoenix* and fruits of plantain are also used for starch production (Rehm and Espig, 1991).

Gums and resins: A number of underutilized fruits produce gums of good quality. *Sterculia ures*, a deciduous tree found in central India produces *Karaya* gum. It is used in textiles, cosmetics, cigar, paste and ice cream industries. Bael produces two distinct types of gums. Chirongi (*Buchnania lanzan*) produces gums suitable for dressing textiles, tanning and for use in diorrhea and inter costal pains. The trunk and branches of wood apple produces gums similar to gum Arabic (Macmillan, 1991). Tamarind gum is the major component of tamarind kernel powder and forms major component of thickening and stabilizing of foods. Trees of' *Termanalia bellirica* also produce gums (Rehm and Espig, 1991). Indian gamboges tree (*Garcinia morella*) yield resin on tapping the bark. It is used as an additive to paint colour. It is a strong purgative in veterinary medicine. Resins are also used as fixative in perfume industry and for varnishes (Macmillan, 1991).

Essential oils and fats: Essential oils or volatile oils possess pleasant taste and strong aroma, The two principal groups of essential oils are the terpenes which are hydrocarbons and the oxygenated and sulphurated oils. They are used in toiletry, perfumery and food industry. About 100 peels of *Citrus auriantiam* var. Bergainia yields 850 g of perfume bergamot oil. Unexpended flower buds of *Capparis spinosa* yields flavour oil (Rhem and Espig, 1991). Oils and fats from some of the underutilized fruits have potential for use as edible oils. These are also used as raw materials for production of soaps, paints, varnishes, hair oils, plastics, candles, pharmaceutical bases and lubricants. Mahua (*Madhuca indica*) seeds yield 51.1% fatty oil which contains 23, 15, 46 and 14 percent respectively of palmitic, stearic, oleic and linoleic acids, and traces of linolenic acid (Rehm and Espig 1991). It is used for cooking in some rural areas of central India, but is primarily used in the manufacture of soaps. Refined oil is used in the manufacture of fatty alcohol and lubricating greases. Tamarind seed oil is used for making varnishes, paints and burning oil lamps (Singh *et al.,* 2007). Kokam (*Garcinia indica*) seeds yield 23-26% of a valuable edible fat known in commerce as kokam butter. The oil is used as a vaseline and also for soap making. Kokan butter is rich in stearic and oleic acids and is used as

confectionery butter. It is also suitable for candle and soap manufacture.

Tannins, Dyes and colours: Jharber (*Ziziphus nummularia* (Burm. f.) bark of twigs and roots contain 12% tannin and is used for leather tanning. Fruits of harad (*Terminalia chebula*) contain 25-30 per cent tannins. Dried nuts of *Terminalia bellirica* are used for dying and tannin. Leaves of aonla and marking nut are used for tanning (MacmilIan, 1991). Tamarind seed testa is used for tanning leather and imparting fast colour to the wools. Bark and leaves are used for tanning hides and dyeing (Singh *et al*., 2007). The plastid pigments (chlorophyll, carotenoids) being soluble in fats are used in fatty foods and cosmetic preparations. These can also be used in fat-free food stuffs with help of dispersing agents and emulsifiers (gums, starch derivatives). The pigments (Anthocyanins and betacyanins) are water soluble and use in drinks and confectionary industries.

Spices and condiments: Spices and condiments are used for flavouring foods, and as medicine, and in pharmaceutical, perfumery and cosmetic industry. Tamarind pulp is used for culinary preparations. These are used for flavouring foods and medicines and in perfumery, cosmetics and pharmaceutical industries. Pulp of Kokam is used to flavour other fruits. *Anaradana i.e.* dehydrated seed of *Punica granatum* is used for acidification of chutney and as a very prominent spice (Singh and Singh 2004).

CONCLUSION

Minor fruits play an important role in the security of food and nutrition. These fruits are known for their typical flavour and taste. Consumers today are increasingly conscious of health and nutrition, and there is a tendency to avoid chemicals and synthetic foods, thereby choosing natural foods. In this context, underutilised fruits have unlimited potential in their processed form. Appropriate process technology needs to be developed to popularise these fruits. Neglected and underutilized crops are essential to the livelihoods of millions of poor farmers throughout the world. As noted above, they are part of the (threatened) biological assets of the rural poor. In identifying research and development issues, which should be addressed, it is essential to approach the problem from this perspective. The filiere concept can be considered an evolution of networking concept for plant genetic resources based on more efficient partnership and participatory approaches. The filiere would thus bring about greater participation of local actors to ensure the addressing of local needs properly. It would also ensure the wider representation and participation of stakeholders of food processing and marketing sector as well policy makers who have traditionally been left aside from PGR activities (Padulosi, 1999).

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Evaluation of chemical composition and assessment of antimicrobial activities of essential oil of lemongrass (*Cymbopogon citratus* (dc.) stapf)

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ABSTRACT

Use of synthetic antimicrobial agents raises harmful effects for environment and human health. Therefore, this study focused on analysis of the chemical composition and assessment of the antibacterial and antifungal activities of essential oil of lemongrass (Cymbopogon citratus (DC.) Stapf). The essential oil was extracted from fresh leaves of lemongrass by hydro-distillation technique. Chemical composition of essential oil was analyzed by Gas chromatography and Mass spectroscopy (GC-MS) and Citral (35.97%), â- Citral (26.5%), cis – Verbenol (26.3%) and Citral diethyl acetal (19.58%) were identified as main chemical compounds. Antifungal activity of essential oil was tested using Poisoned Food Technique. Essential oil of lemongrass possessed promising growth inhibitory effect on tested fungal strains. Total growth inhibition was observed in Fusarium spp., Penicillium spp. and Crysosporium spp. respectively for all four different concentrations (1,000, 5,000, 10,000 and 15,000 ppm) of essential oil and Colletotricum truncatum at 10,000 ppm and 15,000 ppm concentrations. Disk diffusion method was applied to assess the antibacterial activity of essential oil (25, 50, 75, and 100%) against 3 different pathogenic bacteria strains (Escherichia coli, Bacillus cerveius and Staphylococcus aureus). Essential oil had significant (pd"0.05) growth inhibitory effect against tested pathogenic bacterial strains compared to the control. Therefore, it can be concluded that essential oil of Cymbopogon citrates (DC.) Stapf exhibited strong antimicrobial activity against tested pathogenic fungi and bacterial strains and there is a high potential to use as a natural antimicrobial agent.

Key words: Lemon grass, chemical composition, anti-microbial activity, essential oil

INTRODUCTION

The essential oils are natural products obtained from plants. These are formed by heterogeneous and complex volatile mixtures of chemical compounds, with predominance of terpene associated to aldehyde, alcohols and ketone which are deposited in several structures of the plant (Linares *et al*., 2005). Lemongrass (*Cymbopogan citratus* (DC.) Stapf) belongs to family *Poaceae* and great interest is due to its commercially valuable essential oils, it is ranked among the top ten oil bearing crops in the world (Ravinder *et al.*, 2010). Essential oils of lemongrass widely used in pharmaceutical, cosmetics, food, flavor, and agriculture industries.

The interest on bioactive potential of *Cymbopogan* essential oils and their constituents have been rapidly increased in last few years. There were a number of studies carried out to prove the antioxidant, antibacterial, antifungal and antiviral activities of lemongrass (Oloyede, 2009; Pereira *et al*., 2004; Matasyoh *et al*., 2011; Bankoel and Joda 2004; Minami, 2003). Plant pathogens including fungi, nematodes, bacteria and viruses can cause diseases or damage in plants. They cause yield losses in numerous economically important crops (Fletcher and Bender, 2006).

Different chemicals and synthetic compounds have been used as antimicrobial agents for many years. Benzimidazoles, aromatic hydrocarbons and sterol biosynthesis inhibitors are often used in control of plant diseases in agriculture (Zhang *et al*., 2009). However, there is a risk of developing resistance towards the antimicrobial agent and high level toxic residues in the agricultural products, which harmfully affect human health. *Cymbopogon citratus* (DC.) Stapf. contains 1 to 2% essential oil on a dry basis and non-phytotoxic in nature (Paranagama, 2003). Many researches explained that citral is the chemical constituent responsible

antimicrobial properties of the lemongrass oil (Paranagama *et al*., 2003; Kakarla and Ganjiwala, 2009). Therefore, this research was carried out to analyze the chemical composition and assess the antibacterial and antifungal activities of essential oil of *Cymbopogon citratus* (DC.) Stapf.

MATERIALS AND METHODS

Extraction of essential oil

Lemongrass grown in Uva Wellassa University, Sri Lanka research field during March, 2015 to June, 2016 was used for this study. Essential oil of *Cymbopogon citratus* (DC.) Stapf was extracted by hydrodistillation method (Guenther, 1950). Fresh leaves were harvested and dried in shade in room temperature for 24 hours. Leaves were cut into small pieces (1 cm x 1 cm) and 200 g of each sample was put into 2 L round bottom flask and covered with distilled water. Distillation process was carried out for 2.5 hrs. The distillate was collected into a separating funnel to separate oil from water and oil was dried over anhydrous sodium sulfate to remove existing moisture from the oil.

Analysis of the chemical composition of essential oil

Chemical composition of essential oil was analyzed by Gas chromatography and Mass spectroscopy (GC-MS). A Thermoscientific TRACE 1300 GC-MS was used and RTX WAX was used as capillary column. The operating conditions were: Injection Mode: Split (1:50). GC-MS analysis was done at 1700 eV. Helium was used as the carrier gas. Oven temperature program: 60˚C (0.00 min.), 60˚C to 240˚C (@ 5˚C/min.), 240˚C (10.00 min.) Quad temperature was 250˚C. MS Source temperature was 250˚C. Scan parameters: 50-450 (amu). Library Search: NIST.

Antifungal activity of essential oil of *Cymbopogon citratus* (DC.) Stapf

Propagation and maintenance of test organisms

Colletotricum truncatum, *Fusarium spp*, *Penicillium spp* and *Crysosporium spp* were used as test organisms. The tested fungal strains were inoculated into Potato Dextrose Agar (PDA) medium. Plugs of mycelium were removed with a cork borer, inverted and placed in PDA plates and plates were kept in room temperature. The pure cultures were kept under refrigerated conditions (4˚C) and they were sub cultured after every fourteen days.

Antifungal Assay

The different concentrations (v/v) of essential oil (1,000, 5,000, 10,000 and 15,000 ppm) of *Cymbopogon citratus* (DC.) Stapf were prepared aseptically diluting in tween 20 (10%). Tween 20 (10%) alone used as the control. Poisoned Food Technique (Trivedi and Singh, 2014) was used to assess antifungal activity.

The different concentrations (v/v) of essential oil were mixed with 15mL of cooled molten PDA medium and allowed to solidify at room temperature for thirty minutes. Mycelia discs (6 mm diameter), cut out from periphery of five day old fungal cultures using a 6 mm diameter cork borer, inverted and placed in the center of each agar plate containing the essential oil. Tween 20 (10%) along used as the control. Inoculated plates were kept in room temperature after sealed and labeled properly. Diameters of mycelia were recorded after 3 days. The rate of mycelia growth inhibition (GI %) was calculated by the following formula.

$GI\% = dc\text{-}dt/dc \times 100$

Where dc, is mean colony diameter of control sets and dt, is mean colony diameter of treatment sets (Amini *et al*., 2012). The experiment was conducted in a Completely Randomized Design (CRD) with three replicates.

Antibacterial activity of essential oil of *Cymbopogon citratus* (DC.) Stapf

Propagation and maintenance of test organisms

Four different pathogenic bacteria strains (*Escherichia coli, Bacillus cerveius and Staphylococcus aureus)* were used for the experiment. The test organisms were streaked on the Nutrient Agar plates and were incubated overnight at 37°C. The pure cultures were kept under refrigerated conditions (4˚C) and they were sub cultured after every fourteen days.

Antibacterial assay

The different concentrations (v/v) of essential oil (25, 50, 75 and 100%) of *Cymbopogon citratus*

(DC.) Stapf were prepared aseptically by diluting in EthylacetateEthylacetate alone used as the control. Disc diffusion method (Bauer and Kirby, 1966) was used to assess the antibacterial activity.

Nutrient Agar plates were prepared and allowed to solidify under aseptic conditions. Inoculums were prepared by suspending the organism in 2 mL of sterile saline solution and mixed well to create smooth suspension. Turbidity of this suspension was adjusted to a 0.5 McFarland standard. The suspension was evenly distributed on the Nutrient Agar medium. Sterilized filer paper disks were impregnated with 10 µL of essential oil in different concentrations (25, 50, 75 and 100%) and Ethylacetate as the control. Each disk was placed on the medium with a forcep and slightly pressed down to ensure complete contact with the agar surface and incubated at 37°C inside an incubator for 24-48 hours.

The zone of inhibition (mm) was measured after the period of incubation. The experiment was conducted in a Completely Randomized Design (CRD) with three replicates.

Statistical Analysis

Data were statistically analyzed using Analysis of variance (ANOVA) and means were compared using Tukey test. Statistical analysis was performed with Minitab 17 software.

RESULTS AND DISCUSSION

It has been reported that lemongrass possesses strong lemony odour due to its high content of aldehyde citral, which has two geometric isomers, geranial (citral A) and neral (citral B) (Shahi et al., 2005). It has also been reported that the essential oil content of lemongrass is 1-2% on dry basis (Carlson et al., 2001). However it is obvious that the chemical composition of essential oil is varying widely upon genetic diversity, habitat and agronomic practices. Chemical composition of essential oil of *Cymbopogon citrates* (DC.) Stapf analyzed by Gas chromatography and Mass spectrometry (GC-MS) in this study is summarized in table 1.

Table 1: Essential oil composition of *Cymbopogon citrates (*DC) Stapf

Chemical compound	Retention Time (RT)	Percentage (%)
Citral	20.54	35.97
β- Citral	19.17	26.50
Citral diethyl acetal	18.82	19.58
α Pinene	5.60	2.00
cis - Verbenol	19.16	26.30
Epoxy-linalooloxide	25.68	0.56
Geraniol	23.55	1.16
(R) – lavanduly acetate	21.33	1.13

Citral (35.97%), β- citral (26.5%), cis-verbenol (26.3%) and citral diethyl acetal (19.58%) were identified as main chemical constituents in essential oil of *Cymbopogon citrates* (DC.) Stapf.

Aromatic plants are the source of secondary metabolites with biological activities. The interest on bioactive potential of lemongrass essential oils and their constituents have been rapidly increased in last few years. There were number of studied carried out to prove the antioxidant, antibacterial, antifungal and antiviral activities of lemongrass. The antifungal assay of this study clearly showed that essential oil of *Cymbopogon citrates* (DC.) Stapf possessed promising growth inhibitory effect on tested fungal strains. 100 % growth inhibition was observed in *Fusarium spp., Penicillium spp.* and *Crysosporium spp.* respectively for all four different concentrations (1,000, 5,000, 10,000 15,000 ppm) of essential oil and *Colletotricum truncatum* at 10,000 ppm and 15,000 ppm concentrations (figure 1).

Recent studies indicated that *Cymbopogon citrates* (DC.) Stapf essential oil has the potential for fungi control. Kumar *et al*. (2009) found that essential oil of *Cymbopogon citrates* (DC.) Stapf exhibited broad fungitoxic activity against *Aspergillus flavus.* Soares *et al*. (2013) have found that *Cymbopogon citrates* (DC.) Stapf essential oil is effective against *Candida albicans* as well as the emerging *Candida parapsilosis* and *Candida tropicalis* pointing to its usefulness as an antifungal agent. Tzortzakis and Economakis (2007) proved the antifungal activity against *Colletotrichum coccodes, Botrytis cinerea, Cladosporium herbarum, Rhizopus stolonifer* and *Aspergillus niger.* Helal *et al*. (2006) demonstrated

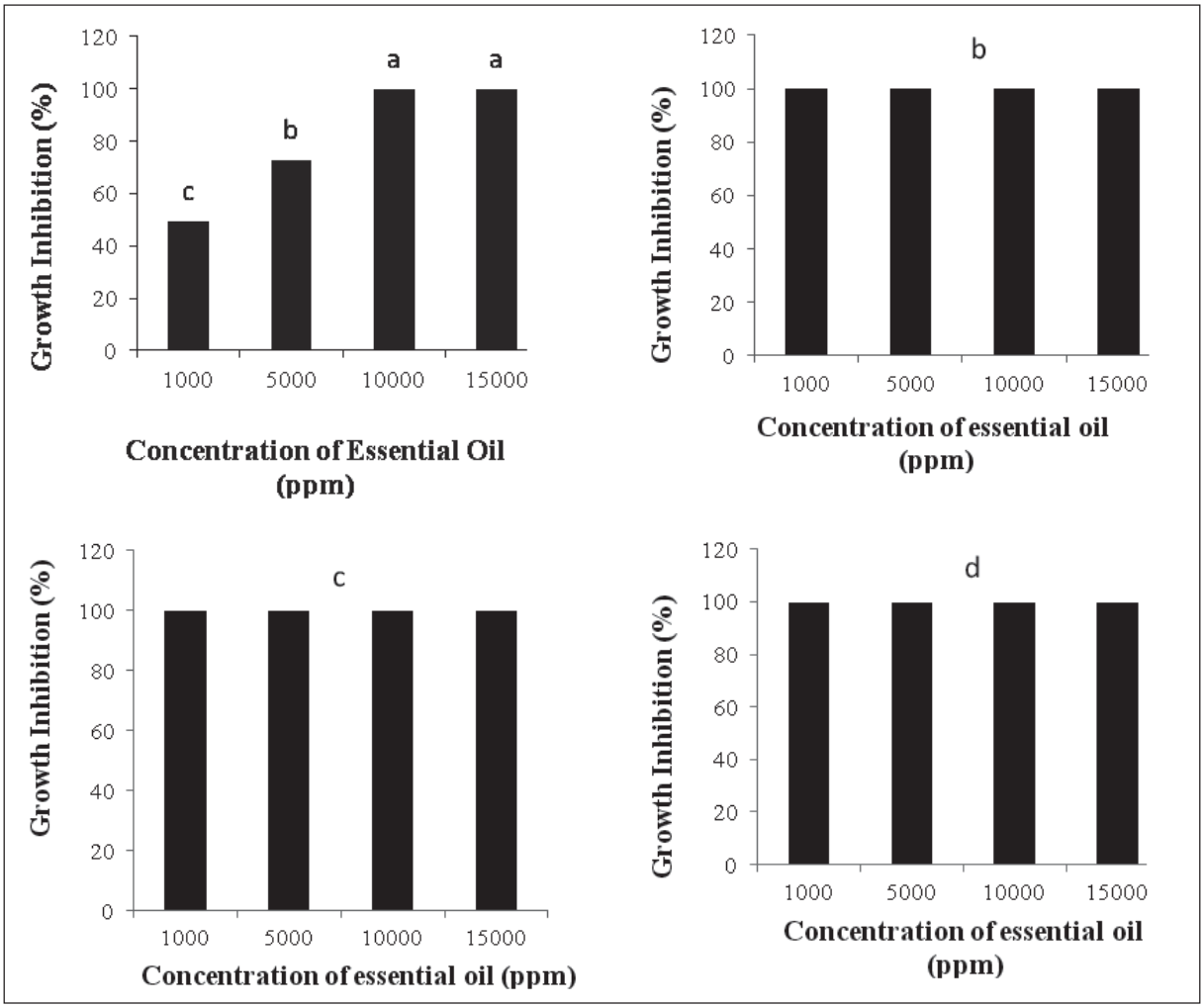

Figure 1: Effect of essential oil on growth inhibitions of (a) *Colletotricum truncatum* (b) *Fusarium spp.* (c) *Penicillium spp.* (d) *Crysosporium spp.*

the antifungal activity of essential oil of *Cymbopogon citrates* (DC.) Stapf against *Aspergillus niger* ML2-strain. Farhang *et al*. (2013) indicated that essential oil of *Cymbopogon citrates* (DC.) Stapf effectively controls the mycelium growth of three species of *Phytophthora* including *P. capsici, P. drechsleri and P. melonis*. Yousef (2013) studied the antifungal activity of volatiles of *Cymbopogon citrates* (DC.) Stapf against *Aspergillus niger*, *A. flavus* and A. *fumigates* and results proved that lemongrass oil produces a fungi toxic effect.

Paranagama *et al*. (2003) and Gupta *et al*. (2011) explained that citral is the chemical constituent responsible antifungal properties of the lemongrass oil. In addition to that, Palhano *et al*. (2003) mentioned that citral has proved effective in controlling mycelia growth and conidia germination of *Colletotricum gloeosporioides.*

The antibacterial assay of this study revealed that essential oil of *Cymbopogon citrates* (DC.) Stapf had significant (pd”0.05) growth inhibitory effect against tested pathogenic bacterial strains when compared to the control (figure 2).

The antibacterial activity was found progressively increasing with the increase in concentration of essential oil. Gram positive bacterial strains were more sensitive to essential oil of *Cymbopogon citrates* (DC.) Stapf with respect to all concentrations of oil than gram negative strain (*Escherichia coli*). Antibacterial activity of the essential oil of lemongrass has been studied by

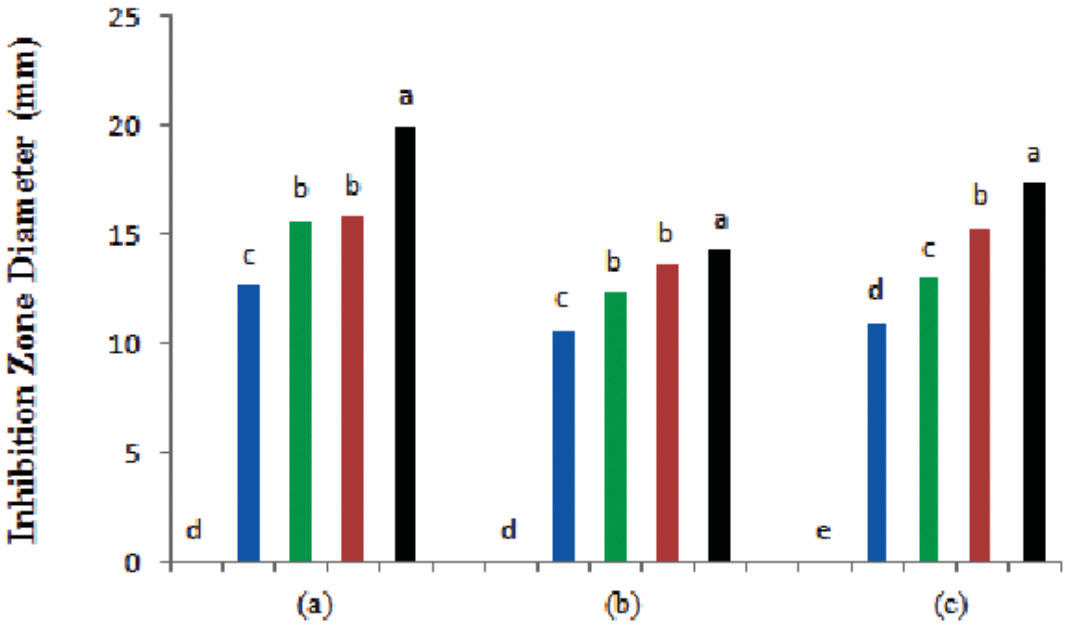

Figure 2: Growth inhibitions of essential oil of *Cymbopogon citrates* (DC.) Stapf on (a) *Staphylococcus aureus*, (b) *Escherichia coli*, (c) *Bacillus cerveius*

many researches. As an examples Naik *et al*. (2010) investigated antibacterial activity of lemongrass oil against *Staphylococcus aureus*, *Bacillus cereus*, *Bacillus subtilis*, *Escherichia coli*, Klebsiella *pneumoniae and Pseudomonas aeruginosa*. Lemongrass oil was found effective against all the test organisms except *P. aeruginosa.* In this study, gram positive organisms were found more sensitive to lemon grass oil as compared to gram negative organisms. Similar results were reported by Soares *et al*. (2013), Pereira *et al*. (2004), Marta War *et al*. (2004) and Alam *et al.* (1994). Nikaido (2003) suggested that higher resistance pattern of gram negative bacteria could be due to the constitution of the outer membrane that acts as a relatively effective permeability barrier. Gram-negative bacteria are inherently resistant to hydrophobic antibiotics, as their outer membrane limits the entry of these antibiotics into the cell (Pool, 2002). Saha *et al*. (2008) hypothesized that the essential oil of *Cymbopogon citrates* (DC.) Stapf is less effective against gram-negative bacteria because of the out membrane barrier that these bacteria present to hydrophobic molecules.

Numerous studies have been conducted to assess antibacterial activity of *Cymbopogon citrates* (DC.) Stapf against diverse range of gram-positive and gram-negative bacteria. Naik *et al*. (2010) reported that essential oil of *Cymbopogon citrates* was found effective against *Staphylococcus aureus*, *Bacillus cereus*, *Bacillus subtilis*, *Escherichia coli*, *Klebsiella pneumonia.* Ethanol extract exhibited high inhibitory activity against all the tested bacteria in order of sensitivity as *Staphylococcus aureus>Salmonella typhi>Bacillus aureus>Escherichia coli*, while aqueous extract was more active against *Salmonella typhi*, at the tested concentrations (Oloyede, 2009).Chemical costituents present in oil must be resposible for these antimicrobial properties. Results of Kakarla and Ganjiwala (2009) reported that citral is the main chemical constituent present in lemongrass oil reposible for antibacterial activity.Onawunmi *et al*. (1984) and Bibiana (2012) concluded that, antimicrobial activity of the oil is exhibited by Geraniol.

CONCLUSION

Essential oil of *Cymbopogon citrates* (DC.) Stapf exhibited strong antifungal activity against *Colletotricum truncatum*, *Fusarium* spp., *Penicillium* spp. and *Crysosporium* spp. and high antibacterial activity against *Staphylococcus aureus, Escherichia coli*, *Bacillus cerveius.* Further

studies should be conducted to find out the minimum inhibitory concentrations of essential oil against tested organisms. It can be concluded that *Cymbopogon citrates* (DC.) Stapf oil is a good alternative to the synthetic chemical antimicrobial agents and can be effectively used as natural antimicrobial agent.

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Studies on performance of different custard apple (*Annona squamosa* Linn) grown in red laterite zone of West Bengal

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ABSTRACT

A study was conducted in red laterite zone of West Bengal with the view to find out suitable custard apple cultivars for the zone. Five year old nine cultivars viz., Atemoya x Balanagar, Pink Mammoth, Washington, Atmoya, Iceland Gem, Chance Seedling, Arka Sahan, Balanagar and Red Sitaphal were undertaken for the study which were planted at spacing of 3 m x 3 m following randomized block design having 3 replications with 4 plants in each replication. Results of 3-consecutive years of study clearly indicated that Island Gem gave significantly highest yield (10.7 kg/ plant) followed by Balanagar (6.1 kg/plant). Maximum fruit weight (162.0g) was recorded from Arka Sahan followed by Balanagar (128.0 g). Fruit quality in terms of TSS and acidity was good in most of the cultivars except Atemoya. Arka Sahan produced maximum sizeable fruits having highest pulp content (52.0%) maximum TSS (24.8^{0}Brix), less acidity (0.17%) highest total sugar (22.4%) with less plant mortality (0.17%). Considering over all performance, the cultivars Balanagar and Iceland Gem are recommended for commercial cultivation in red laterite zone of West Bengal or in similar agro-climatic condition. The cultivar Arka Sahan may also be recommended but special care should be taken for fruit setting and retention.

INTRODUCTION

Custard apple (*Annona squamosa* Linn), popularly called ata or sitaphal in West Bengal and Bangladesh, is commercially cultivated in dry treats of Maharashtra, Andhra Pradesh, Karnataka, Tamil Nadu, Bihar, Madhya Pradesh etc. The fruit prized a high demand due to its delicious taste and nutritive values (Gopalen *et al.*, 1987 and Singh, 1995). Fruits have also high demand in the industry for preparation of ice-cream and others due to richness in carbohydrates (Maurya and Singh, 2006; Nath *et al.*, 2008). The custard apple is considered as a crop of wasteland and can successfully be grown in sandy, rocky, gravel, heavy and even in saline soil (Singh, 1992). The custard apple can successfully be grown in tropical, sub-tropical, arid and semi-arid region and best performed where there is less rainfall. It is established fact that successful cultivation of any crop mainly depends on suitable cultivar/s in an area or zone and selection or recommendation of such cultivar/s require through scientific investigation. In different parts of India suitable or selected cultivars are grown (Girwani *et al.*, 2011; Bhatnagar, 2012; Rymbai *et al*., 2014 ; Ghosh, 2017). In West Bengal practically the red laterite zone, where rainfall is less as compared to other parts of the state, no such varietal recommendation is available. Thus a study was undertaken towards this direction.

MATERIALS AND METHODS

The investigation was carried out during the year 2011-2013 on five year old grafted custard apple plants *viz.*, Atemoya x Balanagar hybrid (Hybrid-1), Pink Mammoth, Washington, Atmoya, Icland Gem, Chance Seedling, Arka Sahan, Balanagar and Red Sitaphal. Original source of the cultivars was from Fruit Research Station, Sangareddy, Andhra Pradesh. The cultivars were planted at 3 m x 3 m spacing in a private Farm at Jhargram, Paschim Medinipur, West Bengal in a randomized black design having 3 replications and 3 plants in each replication. The soil of the orchard was laterite with pH 5.5. The area receives annual precipitation of about 1100-1600 mm mainly during June to September. Fruits yield was recorded at harvest The physico-chemical characteristics of fruits were noted from 5 matured fruits, collected from each

Table 1: Evaluation of different cultivars of custard apple grown in West Bengal

Cultivar	*Fruit yield / plant (kg)	**Fruit weight (g)	**Fruit length (cm)	**Fruit diameter (cm)	**Pulp content (%)	**Seed content (%)	**Skin content (%)	**TSS (ºB) (%)	**Acidity (%)	**Total sugar (%)	**Plant Mortality (%)
Atemoya x Balanagar	5.9	87	5.9	6.9	33.8	4.8	61.4	20.2	0.13	18.3	86
Pink Mamonth	1.9	110	6.6	7.2	42.7	7.3	50.0	17.2	0.15	15.3	76
Washington	3.4	122	7.1	7.2	46.7	8.5	44.8	19.8	0.16	18.7	86
Atmoya	1.1	120	7.6	7.6	36.5	4.4	59.1	11.4	0.18	8.3	57
Island Gem	10.7	114	6.8	7.1	49.2	4.5	46.3	22.5	0.14	19.3	62
Chance Seedling	0.7	124	7.6	7.0	49.1	5.0	45.9	21.8	0.16	19.0	90
Arka Sahan	1.6	162	8.7	7.6	52.0	3.5	44.5	24.8	0.17	22.4	20
Balanagar	6.1	128	7.7	7.4	51.8	3.6	44.6	17.2	0.11	13.8	15
Red Sitaphal	1.6	122	7.2	7.5	47.6	5.5	46.9	16.8	0.12	15.8	81
C.D. at 5%	0.7	3.2	0.2	0.3	1.2	0.6	0.8	4.8	0.02	2.2	5.2

* Average of 3 years ** Average of 2 years

plant separately following standard procedure (A.O.A.C., 1990). Plant mortality was observed 5 years after planning.

RESULT AND DISCUSSION

Fruit yield

The data presented in Table 1 reveal that fruit yield among the cultivars was significantly varied. Highest fruit yield (10.7 kg/plant) was recorded from the cultivar Island Gem followed by Balanagar (6.1 kg/plant) and Atemoya x Balanagar hybrid (5.9 kg/plant). Rest cultivars particularly chance seedling, Red Sitaphal, Arka Sahan, Atemoya and Pink Mammonth gave poor yield (0.7 kg to 1.9 kg/plant). Arka Sahan, a promising hybrid from Indian Institute of Horticultural Research (Jalikop and Sampath Kumar, 2000), showed poor performance in respect of fruit production. The cultivars which were not performing well in the present area, however, they were reported to be good in other areas for which they have been 'named' (Rymbai *et al.*, 2014). The unsatisfactory performance of few cultivars in the studied area was mainly due to varied agro-climatic condition. Besides, fruit set and its retention are greatly affected by climatic variation and tree physiological factors (Rymbai, *et al.*, 2014).

Fruit weight and size

Fruit weight and size in custard apple are very important for consumer's acceptability. Consumer's preference is always towards larger size fruit. In the present study, the cultivar Arka Sahan significantly produced largest size fruit (162 g weight and 8.7 x 7.6 cm size) followed by Balanagar (128 g in weight). Lowest fruit weight (87 g) and size (5.9 x 6.9 cm) was recorded from the cultivar Atemoya x Balanagar hybrid (Table 1).

Pulp Content

Pulp content in custard apple is considered as one of the important selection criteria for varietal development or recommendation. In most of the local types pulp content is very poor irrespective of the fruit size/weight. From the cultivars under study, maximum pulp content was recorded from Arka Sahan (52.0%) closely followed by Balanagar (51.8%) and Iceland Gem (49.2%).

Seed Content

Seed content was highest in Washington (8.5%) followed by Pink Mammonth (7.3%) and lowest in Arka Sahan (3.5%) and Balanagar (3.6%) (Table 1).

Skin Content

Highest skin content (61.4%) was recorded from Atemoya x Balanagar hybrid followed by Atemoya (59.1%) and lowest from Arka Sahan (44.5%) closely followed by Balanagar (44.6%) (Table 1).

Fruit quality

Different quality parameters have been presented in Table 1. Significantly highest TSS was recorded from the cultivar Arka Sahan (24.8 ^{0}B) and minimum in Atemoya (11.4 ^{0}B). Acidity content in different cultivars was estimated from 0.11% (Balanagar) to 0.18% (Atemoya). Total sugar content was highest in Arka Sahan (22.4%) followed by Iceland Gem (19.3%). Variation in quality parameters among the cultivars may be due to their genetic make up which determine the ability to absorb nutrients from 'source' and their metabolism for synthesis of sugars and other products for the sink. It was interesting to note that fruit quality in respect of TSS and acidity was better in most of the cultivars as compared to the different land races of custard apple, reported by Bahatnagar *et al.* (2012).

Plant Mortality

Incidence of bacterial wilt is a common problem in many areas which lead to plant death. First symptoms were noticed as sudden yellowing of leaves followed by gradual wilting of plants which lead to ultimate death of plant. The cultivars in the present investigation showed different degree of resistance against bacterial wilt that causes plant death. Highest mortality of plant was noticed in the cultivar Chance Seedling (90%) followed by Atemoya x Balanagar and Washington (86%) and Red Sitaphal (81%). Lowest plant mortality was noticed in Balanagar (15%) followed by Arka Sahan (20%) (Table-1).

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Variability of fruit characters of Jackfruit in Rongram Block of West Garo Hills, Meghalaya

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ABSTRACT

Jackfruit (Artocarpus heterophyllus Lam.) is a popular fruit among the Garo tribe, and is grown as a homestead crop. Most of the cultivated trees are of seedling progeny. Wide variations are found among the trees concerning fruit-bearing, fruit morphology, and fruit quality. A survey was conducted in Rongram block of West Garo Hills district of Meghalaya to study the fruit and seed characters of different jackfruit trees. Out of the 20 trees observed, Type 4, Type 6, Type15, Type19 and Type 20 produced very juicy pulp which are suitable for juice processing. Type 1, Type 11 and Type 17 produced fruits with firm textured, thick flakes which are suitable for chips making. Type 4, Type 9, and Type12 produced fruits with soft and sweet flakes which can be used for processing into products like jam, jelly, halwa, etc. Fruits of Type 11 and Type 18 exhibited a total soluble solids (TSS) content of 25^{0}Brix which may be used for table purpose.

Key words: Jackfruit, West Garo Hills, Fruit Characters, Seed characters

INTRODUCTION

The jackfruit tree (*Artocarpus heterophyllus* Lamk.) is a tropical evergreen tree belonging to family Moraceae bearing a dicotyledonous compound fruit. Jackfruit is a very popular fruit among the Garo tribe, commonly known as 'Tebrong' and is grown as a homestead crop. The fruits are good source of vitamin A, B, C, potassium, calcium, iron, proteins, minerals and carbohydrate (Chadha, 2009). Jackfruits are highly nutritive and a rich source of pectin, carotene, ascorbic acid and contain the substantial amount of fiber (Sharma *et al.,* 2009). The seeds are very rich in protein and contain a high amount of starch. Most of the jackfruit trees grown in Garo Hills are of seedling origin and do not bear true-to-type.Considerable variations in morphological characters of jackfruit trees were observed for various traits like tree growth habit, canopy structure, leaf size, leaf shape, leaf petiole, fruit maturity, fruiting season, fruit shape, fruit size, number of fruits per tree, fruit weight, fruit rind thickness, pulp texture, seed shape, and seed weight (Haq (2006). This has drawn the attention of researchers to find out desirable characters in jackfruit for eventual release as novel variety in future. Although jackfruit is grown extensively in West Garo Hills, it is still a neglected fruit crop and very less research work has been done in this region. Therefore, an investigation was conducted to study the fruit characters, flake characters and seed characters of jackfruit trees grown in different locations of Rongram block of West Garo Hills district of Meghalaya.

MATERIALS AND METHODS

The present study was carried out in the Rongram Development block of West Garo Hills district of Meghalaya during 2014-2015. The West Garo Hills district lies approximately between 90° 30' and 89° 40' E longitudes and 26° and 25° 20'N latitudes. Twenty trees were selected randomly from different locations within the district, and 10 fruits from each tree were selected to record the fruiting behavior, fruit characters (quantitative and qualitative), flake characters (quantitative and qualitative) and seed characters (quantitative and qualitative). The data were collected as per the jackfruit descriptors prescribed by IPGRI (International Plant Genetic Resources Institute, 2000), Rome, Italy. Statistical tools such as standard deviation, the coefficient of variation, etc. were used to assess variations among the different types of jackfruit trees.

RESULTS AND DISCUSSION

Among the 20 jackfruit trees studied under Rongram block, wide variations were observed

among the fruit and seed characters. The fruiting season of the selected trees started from March to May and ended during June-September. All trees showed a regular bearing habit. It was observed that fruits of Type 4, Type 6, Type 7, Type 8, Type 9, Type 15, Type 17 and Type 20 were borne on primary branches. Type 5 and Type 16 produced fruits on secondary branches, while Type 13 and Type 14 bore fruits on the main trunk. The remaining types produced fruits on primary, secondary and tertiary branches. Type 1, Type 2, Type 3, Type 4, Type 6, Type 7, Type 10, Type 12, Type 13, Type 14 and Type 18 bore fruits in clusters while Type 5, Type 9, Type 15, Type 16, Type 17, Type 19, and Type 20 showed solitary bearing. Type 11 and Type 8 showed cluster as well as a solitary bearing habit (Table 1).

Varied fruit shapes were observed among the 20 trees like the ellipsoid, oblong, spheroid, clavate, obloid and irregular (Table 2). Similarly, varied flake shapes were also observed like spheroid, obovate, rectangular, cordate, twisted and irregular (Table 3). Type 1, Type 6, Type 11, Type 14 and Type 17 had thick flake. The flake texture was observed to be firm, soft, coarse and fibrous among the 20 trees. Type 1, Type 3, Type 8, Type 11, Type 13, Type 17 and Type 20 exhibited firm flake texture. Pulp taste was sweet in Type 1, Type 2, Type 3, Type 4, Type 7, Type 8, Type 9, Type 11, Type 12, Type 16 and Type 18; insipid in Type 5, Type 6, Type 10, Type 14, Type 15, Type 17and Type 20; acidic in Type 13 and Type 19. Pulp consistency was found to be soft, firm, medium and slimy.Some types exhibited a very strong pulp flavour, while some had weak and intermediate flavour. Fruits of Type 4, Type 6, Type 15, Type 19 and Type 20 were very juicy. Pulp colour varied from light to deep yellow and white to creamy white (Table 3).

Type 16 exhibited the highest average fruit weight of 12.1 kg followed by 11.9 kg in Type 1 and 10.1 kg in Type 17. The highest number of flakes per kg fruit (35.21) was recorded in Type 7. Highest flake weight per kg fruit (225 g) was recorded in Type 19. The weight of fresh flake with seed was recorded highest (46.7 g) in Type 1, which also recorded the highest weight of fresh flake without seed (39.42 g). Highest flake**:** fruit ratio of 0.61 was noted in Type 12 followed by 0.59 in Type 16. Flake length was highest (6.5 cm) in Type 4 and 14. Flake width was highest (4.3cm) in Type 4. The longest rachis of 38.7 cm was noticed in Type 4 while the diameter of the rachis was highest in Type 14 (11.3 cm). Type 11 and Type 18 recorded the highest TSS of 25 ^{0}Brix (Table 4).

Highest seed length (3.6 cm) was recorded in Type 15 while highest seed width was recorded in Type 13. The highest number of seeds per kg fruit (35.21) was noted in Type 7. Highest 100-seed weight (1084.33 g) was recorded in Type 6. Flake: seed ratio was highest in Type 1 (6.44) while lowest ratio (1.07) was observed in Type 5 (Table 5). Varied seed shapes were observed among the 20 types like reniform, spheroid, elongate and irregular. Seed coat colour varied from brown to dull brown and creamish to off-white (Table 6).

Reddy *et al.* (2004) conducted characterization studies on jackfruit in South Karnataka and observed enormous variability in the qualitative and quantitative traits of fruits. Mannan *et al.* (2005 and 2006) studied 28 off-season jackfruit germplasm of South Western regions of Bangladesh and observed significant variations among the germplasm in relation to fruit characteristics. Mitra and Mani (2000) observed nearly 1800 trees in Eastern India over a period of 7 years and identified 2 types with very juicy content as suitable for processing. Jagadeesh *et al.* (2007) observed 34 jackfruit types in a hilly region of Karnataka and identified 4 types suitable for chips making based on study of 9 flake characters. Mitra and Mani (2000) identified some types which were exhibiting TSS more than 25 ^{0}Brix and considered suitable for table purpose.

The sensory attributes of jackfruit flakes like appearance, colour, flavour, texture, and sweetness showed wide variation among the 20 types studied in Rongram block. Type 1, Type 11, and Type 17 produced fruits with firm textured, thick flakes suitable for chips making. Type 4, Type 9 and Type 12 produced fruits with soft and sweet flakes suitable for processed products like jam, jelly, halwa, candy, etc. Fruits of Type 4, Type 6, Type15, Type19 and Type 20 produced very juicy pulp which may be suitable for juice processing. Type 11 and Type 18 produced fruits with total soluble solids (TSS) content of 25^{0} Brix suitable for table purpose.

Table 1: Fruiting behaviour of different types of jackfruit of Rongram block of West Garo Hills

Tree type	Start of fruiting season	End of fruiting season	Fruit bearing habit	Fruit bearing position	Fruit clustering habit	Fruit bearing intensity
Type 1	March	June-July	Regular	Other	Clusters	Heavy
Type 2	March	June-July	Regular	Other	Clusters	Heavy
Type 3	March	June	Regular	Other	Clusters	Medium
Type 4	March	June	Regular	Primary branch	Clusters	Poor
Type 5	April	August-September	Regular	Secondary branch	Solitary	Medium
Type 6	April	August-September	Regular	Primary branch	Clusters	Medium
Type 7	April	August-September	Regular	Primary branch	Clusters	Medium
Type 8	April	July-September	Regular	Primary branch	Other	Medium
Type 9	April	July-September	Regular	Primary branch	Solitary	Poor
Type 10	May	September	Regular	Other	Clusters	Medium
Type 11	March	June-July	Regular	Other	Other	Medium
Type 12	March	June	Regular	Other	Cluster	Poor
Type 13	March	June	Regular	Main trunk	Cluster	Poor
Type 14	March	June	Regular	Main trunk	Cluster	Poor
Type 15	March	July	Regular	Primary branch	Solitary	Poor
Type 16	March	July	Regular	Secondary branch	Solitary	Poor
Type 17	April	September	Regular	Primary branch	Solitary	Poor
Type 18	April	September	Regular	Other	Cluster	Medium
Type 19	April	September	Regular	Other	Solitary	Poor
Type 20	April	September	Regular	Primary branch	Solitary	Poor

Table 2: Fruit morphological characters of different types of jackfruit

Tree type	Fruit shape	Fruit surface	Shape of spine	Spine density	Latex exudation
Type 1	Ellipsoid	Spiny	Sharp pointed	Sparse	Low
Type 2	Irregular	Spiny	Sharp pointed	Sparse	Low
Type 3	Ellipsoid	Spiny	Sharp pointed	Dense	Low
Type 4	Oblong	Spiny	Sharp pointed	Dense	Medium
Type 5	Spheroid	Spiny	Intermediate	Sparse	High
Type 6	Ellipsoid	Spiny	Intermediate	Dense	High
Type 7	Spheroid	Spiny	Intermediate	Sparse	High
Type 8	Spheroid	Spiny	Intermediate	Sparse	Medium
Type 9	Oblong	Spiny	Sharp pointed	Dense	High
Type 10	Oblong	Spiny	Sharp pointed	Sparse	High
Type 11	Spheroid	Spiny	Intermediate	Sparse	Low
Type 12	Oblong	Spiny	intermediate	Sparse	Medium
Type 13	Spheroid	Spiny	Intermediate	Sparse	Low
Type 14	Ellipsoid	Spiny	Intermediate	Sparse	Medium
Type 15	Obloid	Spiny	Intermediate	Sparse	Low
Type 16	Clavate	Spiny	Sharp pointed	Sparse	High
Type 17	Oblong	Spiny	Intermediate	Sparse	Low
Type 18	Clavate	Spiny	Intermediate	Sparse	High
Type 19	Clavate	Spiny	Intermediate	Dense	Low
Type 20	Spheroid	Spiny	Sharp pointed	Dense	Medium

Table 3: Flake qualitative characters of different types of jackfruit

Tree type	Flake shape	Flake thickness	Flake Texture	Pulp Taste	Pulp Consistency	Pulp Flavour	Pulp Juiciness	Pulp Colour
Type 1	Irregular	Thick	Firm	Sweet	Medium	Intermediate	Not juicy	Yellow
Type 2	Irregular	Medium	Coarse	Sweet	Medium	Weak	Not juicy	Creamy white
Type 3	Twisted	Medium	Firm	Sweet	Slimy	Intermediate	Juicy	Deep yellow
Type 4	Irregular	Thin	Soft	Sweet	Soft	Strong	Very juicy	Yellow
Type 5	Cordate	Medium	Soft	Insipid	Slimy	Intermediate	Not juicy	Creamy white
Type 6	Rectangular	Thick	Soft	Insipid	Slimy	Intermediate	Very juicy	Light yellow
Type 7	Twisted	Medium	Soft	Sweet	Medium	Strong	Not juicy	Light yellow
Type 8	Irregular	Medium	Firm	Sweet	Firm	Weak	Not juicy	Deep yellow
Type 9	Cordate	Medium	Soft	Sweet	Slimy	Strong	Not juicy	Yellow
Type 10	Spheroid	Medium	Soft	Insipid	Soft	Intermediate	Juicy	Light yellow
Type 11	Spheroid	Thick	Firm	Sweet	Firm	Intermediate	Juicy	Yellow
Type 12	Cordate	Medium	Soft	Sweet	Slimy	Intermediate	Juicy	Yellow
Type 13	Twisted	Medium	Firm	Acid	Firm	Weak	Juicy	White
Type 14	Twisted	Thick	Soft	Insipid	Soft	Intermediate	Juicy	Light yellow
Type 15	Rectangular	Thin	Fibrous	Insipid	Slimy	Weak	Very juicy	Creamy white
Type 16	Obovate	Medium	Fibrous	sweet	Slimy	Strong	Juicy	Yellow
Type 17	Rectangular	Thick	Firm	insipid	Firm	Weak	Juicy	Light yellow
Type 18	Rectangular	Thin	Fibrous	Sweet	Slimy	Intermediate	Juicy	Yellow
Type 19	Rectangular	Thin	Soft	Acid	Slimy	Strong	Very juicy	Creamy white
Type 20	Rectangular	Medium	Firm	Insipid	Firm	Weak	Very juicy	Creamy white

Table 4: Fruit characters (quantitative) of different types of jackfruit

Tree Type	Stalk length (mm)	Stalk diameter (mm)	Average fruit weight (kg)	Number of flakes per kg fruit	Weight of flakes per kg fruit (g)	Avg. weight of fresh flake with seed (g)	Avg. weight of fresh flake without seed (g)	Flake/ fruit ratio	Flake length (cm)	Flake width (cm)	Rachis length (cm)	Rachis diameter (cm)	TSS (^{0}Brix)
Type 1	43.21	37.12	11.9	7.31	341.42	46.7	39.42	0.34	6	4.1	33	5.6	20
Type 2	68	18.5	3.25	32.61	369.23	11.3	6.6	0.36	3.6	2.5	18.2	4.4	20
Type 3	49.23	17.36	3	29.33	483.33	16.48	11.9	0.48	5.3	3.4	16.9	5.3	22
Type 4	55	36.35	6.55	14.19	389.31	27.42	21.18	0.38	6.5	4.3	38.7	4.4	19
Type 5	51.35	14.86	3.5	18.85	428.57	22.73	16.67	0.42	4	3.6	12.08	4.6	15
Type 6	75.85	30.08	8.55	10.29	380.11	36.93	26.7	0.38	6.4	3.9	32.5	8.3	19
Type 7	75.85	30.08	2.3	35.21	478.26	13.58	9.88	0.47	3.4	2.3	12.9	4.3	24
Type 8	79.44	17.74	2.5	9.6	340	35.42	27.08	0.34	4.9	3.8	13.9	3.4	21
Type 9	39.34	21.98	3.9	14.87	358.97	24.14	18.1	0.35	4.2	3.5	18	5.5	20
Type 10	66.17	16.87	3.8	11.31	315.78	27.91	20.93	0.31	4.8	3.8	17.6	3.9	19
Type 11	80.28	20.08	5.7	11.4	429.82	37.69	30	0.43	4.6	3.9	21	5.8	25
Type 12	78.25	21.23	4.2	19.52	607.14	31.09	23.78	0.61	4.9	3.6	17.8	4.6	22
Type 13	67.26	19.17	2.95	21.02	372.88	17.74	11.29	0.37	4.6	3.2	11.6	3.7	15
Type 14	33.8	23.11	9.85	10.65	639.59	43.52	36.57	0.46	6.5	3.9	23.6	11.3	17
Type 15	28.32	20.39	6.1	34.43	450.81	13.09	7.86	0.45	4.8	2.4	22.5	7.9	14
Type 16	50.23	16.19	12.1	16.3	586.95	36	27.33	0.59	5.6	3.6	34.5	4.9	20
Type 17	118.18	21.92	10.1	15.15	495.04	32.68	22.87	0.49	5.9	3.2	5.8	3.9	17
Type 18	47.51	18.1	3.4	22.5	376.81	16.88	12.99	0.38	5.2	2.6	15.5	3.5	25
Type 19	32.03	23.47	2	32.5	225	6.92	3.08	0.22	2.1	2.8	15	4.7	10
Type 20	49.23	24.18	4.5	28.89	377.77	13.08	9.23	0.38	5.7	2.4	4.9	2.4	18
Mean	59.43	22.44	5.51	19.80	422.34	25.57	19.17	0.41	4.95	3.34	19.30	5.12	19.1
SD	21.67	6.33	3.25	9.25	102.94	11.65	10.13	0.09	1.13	0.63	9.23	2.02	3.77
SEM±	**4.85**	**1.42**	**0.73**	**2.07**	**23.02**	**2.60**	**2.26**	**0.02**	**0.25**	**0.14**	**2.06**	**0.45**	**0.84**
CV (%)	**36.47**	**28.23**	**59.03**	**46.74**	**24.37**	**45.55**	**52.82**	**22.29**	**22.79**	**18.85**	**47.83**	**39.41**	**19.73**

Table 5: Seed quantitative characters of different types of Jackfruit

Tree type	Seed length (cm)	Seed width (cm)	Number of seeds per kg fruit	100-seed weight (g)	Flake/seed ratio
Type 1	3.5	2	6.89	771.95	6.44
Type 2	2.6	1.8	32.61	471.69	2.5
Type 3	2.3	1.6	28.66	465.11	3.62
Type 4	2.9	2	13.28	666.66	4.3
Type 5	2.8	1.7	18.85	606.06	1.07
Type 6	3.2	2.2	9.71	1084.33	3.61
Type 7	2.4	1.5	35.21	370.37	3.66
Type 8	2.9	2.4	9.2	869.56	4.25
Type 9	2.7	1.9	14.87	603.44	4
Type 10	3.2	2.4	11.31	697.67	4
Type 11	2.7	2.5	11.23	781.25	4.9
Type 12	3.1	2.3	19.05	750	4.25
Type 13	2.8	2.7	21.02	645.16	2.75
Type 14	3.2	2.1	10.65	697.14	6.24
Type 15	3.6	1.6	33.61	600	2.39
Type 16	3.3	1.9	16.19	800	4.15
Type 17	3.5	2	13.96	1063.82	3.33
Type 18	2.8	1.7	20.87	416.66	4.33
Type 19	2.1	1.6	32.5	384.61	1.8
Type 20	3.2	1.6	28.89	384.61	3.4
Mean	2.94	1.98	19.43	656.50	3.75
SD	0.41	0.35	9.29	208.09	1.30
SEM±	**0.09**	**0.08**	**2.08**	**46.53**	**0.29**
CV (%)	**13.93**	**17.68**	**47.82**	**31.70**	**34.57**

Table 6: Seed qualitative characters of different types of jackfruit

Tree type	Seed shape	Seed surface sliminess	Seed surface pattern	Seed coat colour	Adherence of seed coat to kernel	Vivipary
Type 1	Irregular	Highly slim	Uniform	Creamish	Easily separable	Present
Type 2	Irregular	Intermediate	Uniform	Creamish	Intermediate	Absent
Type 3	Irregular	Intermediate	Uniform	Creamish	Difficult to separate	Present
Type 4	Irregular	Highly slim	Patches	Dull brown	Difficult to separate	Absent
Type 5	Irregular	Highly slim	Regular striations	Dull brown	Easily separable	Present
Type 6	Reniform	Intermediate	Uniform	Dull brown	Easily separable	Present
Type 7	Reniform	Slightly slimy	1uniform	Creamish	Difficult to separate	Absent
Type 8	Irregular	Intermediate	Uniform	Off-white	Difficult to separate	Present
Type 9	Spheroid	Highly slim	Uniform	Dull brown	Difficult to separate	Absent
Type 10	Reniform	Intermediate	Uniform	Creamish	Easily separable	Present
Type 11	Spheroid	Intermediate	Uniform	Brown	Difficult to separate	Absent
Type 12	Irregular	Intermediate	Uniform	Dull brown	Difficult to separate	Absent
Type 13	Irregular	Intermediate	Other (crack)	Brown	Easily separable	Present
Type 14	Irregular	Slightly slim	Uniform	Brown	Easily separable	Present
Type 15	Elongate	Intermediate	Uniform	Dull brown	Intermediate	Absent
Type 16	Irregular	Intermediate	Uniform	Brown	Intermediate	Present
Type 17	Irregular	Slightly slim	Uniform	Dull brown	Difficult to separate	Present
Type 18	Irregular	Highly slim	Uniform	Brown	Difficult to separate	Absent
Type 19	Spheroid	Highly slim	Uniform	Dull brown	Difficult to separate	Absent
Type 20	Elongate	Intermediate	Uniform	Creamish	Difficult to separate	Absent

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Response of number of air layers per shoot in pomegranate (*Punica granatum* L.)

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ABSTRACT

The experiment was carried out at Akola with the objectives to study the effect of number of air layers per shoot and to find out the retention of appropriate number of air layers per shoot for higher success in pomegranate. The pomegranate propagation significantly influenced by number of air layers per shoot treatment. Results revealed that two layer per shoot significantly showed better response for root initiation, rooting percentage, length of root, fresh weight of root, dry weight of roots and number of leaves, However, number of roots, root volume, height of rooted air layered, survival percentage was maximum in four layer per shoot.

Keywords : Air layering, IBA, DAP, DAT, Pomegranate.

INTRODUCTION

The pomegranate (*Punica granatum* L.) is one of the ancient and highly praised favorite fruit. It is commercially grown, apart from India, in a number of countries for its sweet acidic fruits, which provide cool refreshing juice, and is valued from its medicinal properties its popularity is also due to the ornamental nature of the plant which bears bright red, very attractive flowers. The area under pomegranate is increasing day by day due to its export potential as well as demand in domestic market. The pomegranate is propagated through cutting and layering on commercial scale but the rooting and survival success is very less. In the recent years the area under pomegranate is increasing day by day in state of Maharashtra state especially in western Maharashtra and Vidarbha region. Present area 90,000 ha, production 9,45,000 MT and productivity 10.5 MT/Ha. There is a heavy demand for planting materials so there is need to produce large planting material in shortest possible time so there is need to do multiple air layers per shoot so one can get maximum number of air layers per shoot per tree. At present there is no standard available with pomegranate growers to perform air layers per shoot and it's retention per shoot. Therefore present investigation will be undertaken to study and to find out the response number of air layers per shoot in pomegranate for correct and precise advice to pomegranate growers.

MATERIAL AND METHOD

The present investigation was carried out during the year 2015-16 at Commercial Fruit Nursery unit, College of Horticulture, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola (MS). The materials used and methodologies adopted in the investigation given below:

The experiment was laid out in Randomized Block Design (RBD) with four treatment i.e. number of air layers per shoot *viz*., L_1 two layer per shoot, L_2 four layer per shoot, L_3 six layer per shoot and L_4 eight layer per shoot and four replication. The layering operation in all the four treatments was made in July.

Selection of plants and branches

The uniformed sized, healthy and vigorous growth of 8 year old trees of *Punica granatum* cv. Bhagwa grown at Commercial Fruit Nursery Unit, were selected. On these plants, well-matured and healthy branches of pencil thickness were selected for air layering. The average length of branches was 60 cm for each replication and each treatment, total 20 plants were selected and 20 air layers were taken on each plant's branch for each treatment.

Preparation of plant growth regulators (IBA) in lanolin paste

For preparation of 5000 ppm lanolin paste of IBA 500 mg of IBA was weighed on a chemical balance and was transferred in a beaker. Thereafter, 5 ml of ethyl alcohol (95 %) was added to it and shaked thoroughly to dissolve properly. Then 100 g lanolin was taken in petri dish and heated. The dissolved growth regulator was transferred into the melted lanolin paste and stirred firmly with clean glass rod until evaporation alcohol. In this way, harmonious mixture of growth regulator and lanolin paste was prepared.

RESULTS AND DISCUSSION

The result obtained from the present investigation as well as relevant discussion have been summarized under following sub heads and given in Table. 1.

Days required for root initiation

The result obtained in respect of short period required for root initiation significantly influenced by number of air layers per shoot on minimum days for rooting (22.54 days) was observed in L_1 treatment *i.e.* two layer per shoot. However, treatment L_4 *i.e.* eight layer per shoot took maximum days (26.48) for rooting as compare to other treatment. It clearly indicated that, treatment L_1 *i.e.* two layers per shoots found to be significantly minimum days required for root initiation.

Rooted air layers (%)

The result obtained in respect of maximum percentage of rooted air layers (70.44%) was recorded in L_1 treatment *i.e.* two layer per shoot. However, minimum percentage of rooted air layers (59.88%) was recorded in treatment l_4 i.e eight layers per shoot.

Number of primary and secondary roots

Observation in respect of maximum number primary roots (14.56) and secondary roots (32.75) per layers was observed in treatment L_2 *i.e.* four layer per shoot. However, minimum number of primary roots (11.21) and secondary roots (29.38) per layers were observed in treatment L_4 *i.e.* eight layers per shoot.

Table : 1. Response of number of air layers per shoot in Pomegranate.

Treatment	Days required for root initiation	Rooted air layer (%)	Number of primary roots after 90 DAL	Number of secondary roots after 90 DAL	Length of primary roots (cm) after 90 DAL	Length of econdary roots (cm) after 90 DAL	Fresh weight of roots (g) after 90 DAL	Dry weight of roots (g) after 90 DAL	Root volume (cm^3) after 90 DAL	Height of rooted air layered (cm) after 60 DAT	Number of leaves per layer after 60 DAT	Fresh weight of shoot (g)after 60 DAT	Dry weight of shoot (g)after 60 DAT	Survival percentage (%)
L_1 - Two layer/shoot	22.54	70.44 (57.06)	20.94	36.25	12.00	2.36	2.04	0.59	3.69	25.84	42.00	10.14	3.93	75.31 (60.21)
L_2 - Four layer /shoot	23.83	67.83 (55.17)	22.32	37.79	11.00	2.13	1.74	0.42	4.04	27.41	40.69	10.57	4.66	77.13 (61.43)
L_3 - Six layer/shoot	25.14	63.59 (52.89)	19.53	35.31	9.46	2.06	1.52	0.29	2.95	25.13	38.33	9.53	3.92	70.13 (56.87)
L_4 - Eight layer /shoot	26.48	59.88 (50.70)	18.34	34.87	10.31	1.88	1.43	0.24	2.83	23.84	37.44	9.24	3.66	67.88 (55.48)
F Test	Sig	Sig	Sig	Sig	Sig	Sig	Sig	Sig	Sig	Sig	Sig	NS	NS	Sig
SE (m)±	**0.54**	**1.31**	**0.95**	**0.88**	**0.48**	**0.14**	**0.10**	**0.6**	**0.34**	**0.84**	**1.34**	**0.63**	**0.42**	**1.20**
CD at 5%	**1.33**	**3.23**	**2.34**	**2.17**	**1.19**	**0.34**	**0.23**	**0.15**	**0.84**	**2.06**	**3.30**	-	-	**2.94**

Note – Figures in parenthesis denote the arc sign transformation value DAL- Days after layering DAT- days after transplanting

Length of primary and secondary roots

Observation in respect of maximum length of primary roots (12cm) and secondary roots (2.36 cm) per layers were observed in L_1 *i.e.* two layer per shoot. However, minimum length of primary roots (9.46 cm) and secondary roots (1.88 cm) per layer was observed in L_3 *i.e.* six layers per shoot (9.46cm).

Fresh and Dry weight of roots

Observation in respect of maximum weights of fresh root (2.04 g) and dry weights (0.59 g) was found to be maximum in treatment L_1 *i.e.* two layer per shoot. However, minimum fresh weight of root (1.43g) and dry weight of roots (0.24g) was recorded in treatment L_4 *i.e.,* eight layer per shoot.

Root volume

Observation in respect of maximum root volume was found in treatment L_2 *i.e.* four layer per shoot (4.04 cm^3). However, minimum root volume was recorded in treatment L_4 *i.e.* eight layer per shoot (2.83 cm^3).

Heights of rooted air layer

Observation in respect of heights of rooted air layer at the stage of 60 DAT, significantly maximum height of rooted layer was observed in L_2 (27.41cm).Whereas, minimum height of rooted layer was observed in L_4 (23.84 cm).

Number of leaves per layer at final survival

Observation in respect of Number of leaves per layers at final survival L_1 *i.e.* two layer per shoot (42.00) had recorded significantly higher number of leaves at final survival. and minimum number of leaves at final survival was registered in treatment L_4 *i.e.* eight layer per shoot (37.44).

Fresh and Dry weight of shoot

Observation in respect different treatments of number of air layer per shoot of fresh and dry weights of shoot showed non significant results.

Survival percentage

Observation in respect of final survival percentage treatment L_2 *i.e* four layers per shoot had recorded significantly higher survival percentage (61.43%) and minimum survival percentage was recorded in treatment L_4 *i.e.* eight layers per shoot (55.48%).

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Effect of some plant bioregulators on fruit yield and quality characteristics of Apple cv. Red Delicious.

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ABSTRACT

An investigation was carried out at a commercial orchard in Pulwama district of J&K, India during the year 2016 to study the suitability of chemical sprays in improving the apple (Malus x domestica Borkh 'Red Delicious') fruit set visa vise yield, in consequence of the climatic factors particularly during the bloom, and lack of proper pollination and pollinizers. The treatments applied were: GA_3 (Progibb); Cytokinin + Enzymes (Poushak); GA_{4+7} + 6-benzyladenine (Promalin); Hand Pollination; and á-naphthalene acetic acid (Agronaa), and control (water spray). Hand pollination (proper pollination) and GA_{4+7} + 6-BA (Promalin), proved to be best for setting 14.33% and 11.67%, and retaining 20.66% and 24% of apple fruit respectively over control. Further, GA_{4+7} + 6-BA (Promalin) enhanced the fruit size (length: 6.66 cmm; diameter: 7.03 cm) and weight (263 g) significantly over all other treatments. Implying Promalin can be used to boost the yields in unfavorable fruit setting conditions.

***Keywords**:* Red Delicious, Fruit Set, Fruit Retention, Weight, Kashmir, Bioregulators

INTRODUCTION

Apple is the predominant temperate fruit crop of India which accounts for about 10 % of the total fruit production of the country (Gautam *et al.*, 2004). At present these Delicious group cultivars mainly Red Delicious, Royal Delicious and Starking Delicious constitute nearly 80 % of apple trees. The cropping of apple (*Malus x domestica* Borkh 'Red Delicious'), the main desert cultivar grown in the Kashmir, is not only irregular, but the yield is also low as compared to the cultivars grown in other regions. Several factors like inadequate pollinizer proportion, reduction in natural population of pollinating agents, inadequate winter chilling, occurrence of spring frost *etc*. have been attributed as the main factors leading to poor fruit set.

In conventional orchards apple fruit set is promoted by cross-pollination achieved by inter-planting the main varieties with other compatible cultivars. Golden delicious and Red gold are the predominant pollinizing cultivars being used, and have attained biennial bearing tendency, thus providing the pollinizing services only during the 'on' years. Transfer of pollen is often facilitated by hived bees placed in orchards, the positioning of pollinizer trees being arranged to take advantage of the preferred flying patterns of bees. The population of natural pollinators has gone down due to indiscriminate use of pesticides and the deterioration of the ecosystem. Managed bee pollination is very limited and available bee hives during bloom hardly meet 2-3 % of the demand (Gautam *et al.*, 2004). However cold or overcast weather or high winds during the flowering period can greatly reduce bee activity, while low temperatures can slow pollen tube growth so much that embryo sac degeneration can occur before fertilization has been affected. Thus, efforts made to achieve a satisfactory initial set fail due to unfavorable weather. The situation thus encourages diverting to the chemical methods for improving the fruit set in apple.

Gorter and Visser (1958), showed that mature fruit could be developed from unpollinated flowers (parthinocarpy), with the application of synthetic auxins in apple and pear. There was an increase in initial fruit set with some cultivars, but obtained little improvement in the number of harvested fruit. Later the treatments with gibberellic acid (GA_3)

by Luckwill (1960), could stimulate parthenocarpy in some pear and apple cultivars, but could attain the fruits of half the size as that of seeded fruits. The use of plant growth regulators such as NAA, GA_3 and indole-3-butyric acid (IBA) by many researchers have shown reduced flower drop, high flower retention, increased yield and fruit quality in various fruit species such as citrus, apple, mango and guava (El-Shewy, 1999; Iqbal *et al*., 2009). Watanabe et al., (2008), in their study on apple observed 60% fruit set in GA_3 treated 'Ohrin' cultivar and about 7% in 'Fuji'. Moreover, GA_3 + 2,4-DP + CPPU treated 'Ohrin' apple showed the highest fruit set percent of 89.3. These researches have put the corner stones for the fruit production through chemical means even under the unfavorable conditions.

As apple trees bloom during a cool period and also suffer from self-incompatibility, any factor that can improve pollination, pollen germination and pollen tube growth or extend the effective pollination period, such as the application of plant bioregulators , should be beneficial for fruit production. Thus an investigation was conducted to explore the effectiveness of various chemical sprays in improving the apple fruit yield.

MATERIALS AND METHODS

The experiments was initiated on mature 'Red Delicious'/ seedling apple growing at a commercial orchard in Pulwama district of J&K, India (latitude 33°48'38"N – longitude 74°51'12" E) during the year 2016. Normal control and cultural management practices were used during the course of the experiment. Eighteen 20-year-old 'Red Delicious' apple trees were selected for the study in such a way that each six trees representing the six treatments of a replication were equidistant from pollinizer tree at the center. Two limbs on each tree were selected and tagged prior to flowering and the total number of flower clusters and the flowers counted. The treatments as described in Table 1 were applied during the full bloom. The observations, Percent fruit set and fruit retention were recorded 20 days after petal fall and at harvest respectively. Fruit length and diameter were measured using digital vernier calliper, and the weight using digital balance.

The experiment was conducted according to Randomized Complete Block Design (RCBD) by using six treatments, each comprising of three replications. Statistical analysis of the data was performed by using Analysis of Variance (ANOVA) technique and difference among treatment means were compared by the Duncan's Multiple Range (DMR) test at 1% level of probability (Steel *et al*., 1997).

RESULTS

Fruit set

The results of the treatments applied at full bloom on fruit set in Red Delicious apples at 50 days after flowering can be seen in Table 2. The treatments sprayed achieved significantly higher levels of fruit set than control except NAA, which recorded the lowest fruit set of all (51.67%). The highest percentage of fruit set was achieved in hand pollinated apple flowers followed by Promalin and GA_3 (Progibb) sprayed apple flowers with the fruit set of 84.33%, 81.67% and 77% respectively. Poushak sprayed flowers with the fruit set of 76% did not differ significantly with control (70%).

Fruit retention

Significantly highest fruit retention percentage was recorded in Promalin sprayed flowers with 75.67% followed by hand pollinated trees with 72.33%. And the lowest fruit retention percentage of 48% and 51.67% were recorded in NAA sprayed and control respectively. Poushak and GA_3 applied fruits recorded 60.33% and 63% of fruit retention respectively.

Fruit length

All the treatments applied recorded significantly higher fruit length than control. Promalin applied fruits had highest fruit length of 6.66 cm followed by GA_3 with 6.23 cm. No significant difference in fruit length was observed between the Hand pollinated and Poushak applied fruits and recorded 6.08 cm and 5.99 cm of length respectively. Agronaa (NAA) applied fruits recorded the mean fruit length of 5.8 cm.

Fruit diameter

The treatments applied significantly affected the fruit diameter of the fruit. The highest fruit diameter

of 7.03 cm was recorded in Promalin applied fruits, followed by GA_3 and Hand pollinated fruits with 6.84 cm and 6.70 cm respectively. Poushak and NAA applied fruits were at par with each other with the diameters of 6.53 cm and 6.50 cm respectively.

Fruit weight

Fruit weight was significantly affected by the treatments applied. The highest fruit weight of 263 g was observed in Promalin treated fruits and the lowest 176 g in control fruits. However, treatments which did not differ significantly among themselves were GA_3, Hand pollinated, Poushak and NAA applied with the mean fruit weight of 225 g, 220.67 g, 219.33 g and 213 g respectively.

DISCUSSION

Improving fruit set is a useful way to increase yield. As evident from the results, partial pollination (Control) set 70% fruit, while as, hand pollination proved the best for setting fruit followed by Prolamin application. Since up to 30% of ovules in Delicious become nonfunctional and degenerate within 72 hours following bloom. Also, the apple pollen being relatively large in size and not getting carried away by wind can be the reason for low fruit set in control. Therefore, for good fruit set adequate pollination is required immediately after bloom. Thus, hand pollinated flowers showed the highest fruit set by ensuring sufficient pollination. The results are in accordance with the earlier researches and holds true for most of the crops cultivated (Can-Medrano and Darnell, 1998; Chauta-Mellizo, 2012). Moreover, pollen germination and pollen tube growth are key events in the sexual reproduction of plants (Wu *et al*., 2008). Seeds are usually formed, and the ovary and receptacle enlarge if pollination and fertilization occur normally in apples. Simultaneously, seeds produce indole-3-acetic acid, gibberellins and cytokinins during growth. These plant growth regulators apparently control fruit growth. Currently, it is accepted that both fruit set and fruit development are regulated by the coordination action of hormones produced in the ovary after pollination or fertilization (Mariotti *et al*., 2011). Pollination and subsequent fertilization lead to a strong shift in the balance of phytohormones and development of the ovule (Obroucheva, 2014). Exogenous application of gibberellins have been reported to promote pollen germination and increase pollen tube length in vitro in apricot (Bolat and Pirlak, 1999). The active components of Promalin (GA_{4+7} + 6-BA) operate as growth promoters at cellular level and improve the development of fruitlets immediately after flowering (Vilardell *et al*., 2008). This validates the significantly higher fruit sets in the treatments, Promalin and GA_3, next to the hand pollinated treatment.

Cytokinins are plant hormones promoting cell division and differentiation (Mok and Mok, 2001). They have also been reported to influence the development of flowers and seeds, nutrient uptake and demand, and organ assimilation (Zalabak *et al*., 2013). Also, exogenous treatment with cytokinins delay flower senescence in several plant species (Trivellini *et al*., 2015). Bolat and Pirlak (1999) found that the exogenous application of kinetin at low concentrations in vitro improved pollen germination in apricot and significantly improved pollen tube lengths. In some species, the application of cytokinins to flowers before fertilization, originates the beginning of fruit growth (Pandolfini, 2009). However, in this experiment, Poushak treated flowers showed enhanced fruit set than control but didn't differ significantly.

The lowest fruit set was found in 'Red Delicious' apple flowers treated with auxin, NAA. The application of synthetic auxin, naphthlene acetic acid at flowering did not increase fruit set or yield significantly, as was also found in earlier studies (Vilardell *et al*., 2008, Theron *et al*., 2011).

Highest fruit retention percentage was observed in promalin treated fruits followed by hand pollinated ones. Whereas, the lowest retention percentage was found in NAA treated and control fruits. Gibberellins either from fruit seed or exogenously applied, have been found to intensify organ ability to function as nutrient sink and also can increase the biosynthesis of IAA in plant tissue which delays the formation of the separation layer and thus enhances fruit retention. Reports claim a correlative relationship of depleted endogenous levels of gibberellins with mango fruit abscission (Bains *et al*., 1997; Singh *et al*., 2010). Further findings have also indicated that foliar sprays of gibberellic acid

Table 1: Description of the treatment combinations.

Treatment		Active Ingredient	Dosage	Manufacturer
T1	Control	Water spray	-	-
T2	Progibb	Gibberellic acid 90% w/w	0.01g/l	Valent Agricultural Products
T3	Poushak	Cytokinin + Enzymes	2.5 ml/l	Krishi Rasayan Exports Pvt. Ltd.
T4	Promalin	GA_{4+7} 1.8% + 6-Benzyladenine 1.8%	1.5ml/l	Valent Agricultural Products
T5	Hand pollination	-	-	-
T6	Agronaa	á-Naphthelene acetic acid 4.5% w/w	0.1ml/l	Aries Agro Ltd.

Table 2: Treatment effects on yield parameters of apple cv. Red Delicious

Treatments		Fruit set (%)	Fruit retention (%)	Fruit length (cm)	Fruit diameter (cm)	Fruit weight (g)
T1	Control	70.00c	51.67c	5.40e	6.14e	176.00c
T2	GA_3	77.00b	63.00b	6.23b	6.84b	225.00b
T3	Poushak	76.00cb	60.33b	5.99c	6.53d	219.33b
T4	Promalin	81.67ab	75.67a	6.66a	7.03a	263.00a
T5	Hand pollination	84.33a	72.33a	6.08c	6.70c	220.67b
T6	NAA	51.67d	48.00c	5.80d	6.50d	213.00b

Mean separation within columns by Duncan's Multiple Range Test; (Pd"0.01)

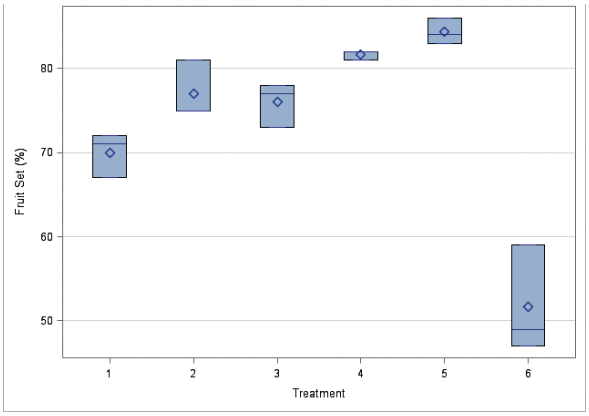

Fig.1: Distribution pattern of fruit set in apple cv. Red Delicious owing to various treatment effects.

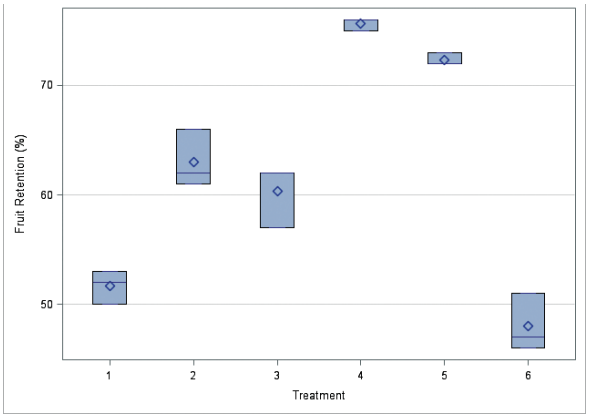

Fig.2: Distribution pattern of fruit retention in apple cv. Red Delicious owing to various treatment effects.

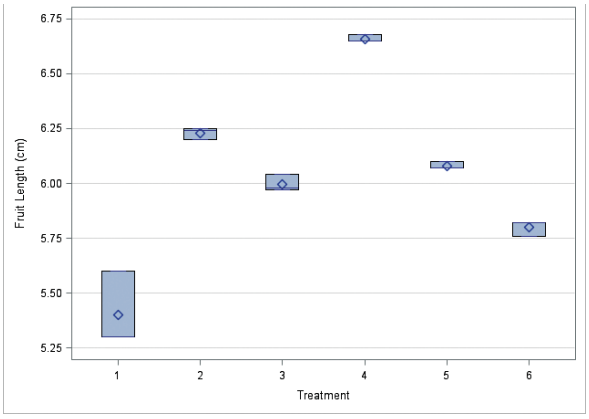

Fig.3: Distribution pattern of fruit length in apple cv. Red Delicious due to various treatment effects.

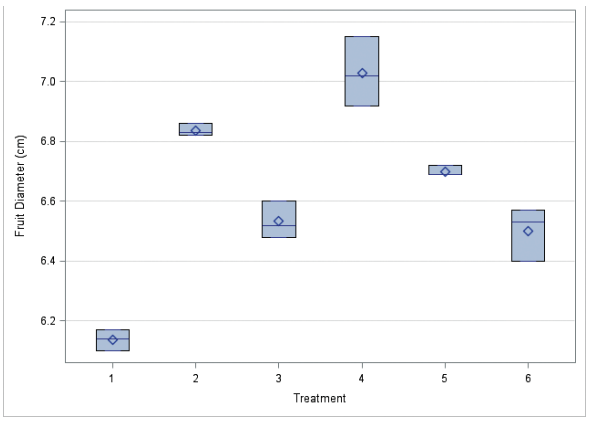

Fig.4: Distribution pattern of fruit diameter in apple cv. Red Delicious due to various treatment effects.

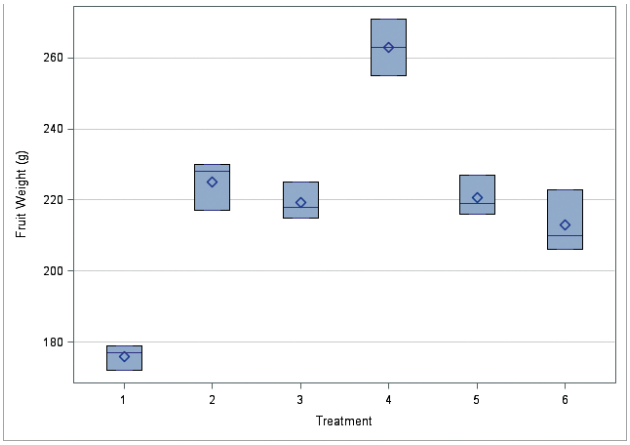

Fig.5: Distribution pattern of fruit weight of apple cv. Red Delicious owing to various treatment effects.

resulted in higher fruit retention (Wally *et al.*, 1999).

Size of the fruit is one of the main quality factors which determine the price and marketability, especially for those which are intended for fresh consumption. In this experiment, the size and subsequently the weight of the Red Delicious apple fruits were significantly enhanced with all the treatments as compared to control. The maximum size and weight among the treatments was found in Promalin treated fruits followed by GA_3 treated. Bengerth and Schroder (1994) reported an increase in length to diameter ratio in parthinocarpic apple fruits induced by CPPU + GA. Early application of GA_3 reduced seed number and increased fruit length in 'Conference' pear (Vercammen and Gomand, 2008). GAs are synthesized in seeds, young leaves and roots and function at cellular level by elongating and expanding cells at the whole plant level (Brock and Kaufman, 1991).

NAA treated fruits also showed significantly enhanced size and weight, which can be attributed to thinning effect. As reported by Shargal *et al.* (2006), the two commercial practices commonly applied to enlarge the fruit are: reducing the competition between fruits for assimilates by thinning flowers or fruitlets; and by directly enhancing fruit size by stimulating and extending cell division, e.g. application of synthetic cytokinins.

CONCLUSION

It is apparent from the results that pollination and pollinizers if properly maintained may result in better fruit set and fruit retention. However, during unfavorable weather conditions or when proper pollination is hindered, GA_{4+7} + 6-benzyladenine (Promalin) application may turn helpful in improving the fruit set and yield.

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Evaluation of some small seeded aromatic indigenous genotypes for commercial utilization as high value rice

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ABSTRACT

Eighteen aromatic genotypes were collected and evaluated along with one high yielding variety IR 36 to assess its quality/speciality at Gontra village, Chakdah, Nadia, West Bengal during kharif season of 2016 and 2017 in Randomized Block Design with three replications following standard agronomic practices. Seed yield of those small grain indigenous genotypes ranged from 240.5g/ m^2 (Radhunipagol) to 525.6 g/m^2 (Kedargouri) against the check variety IR-36 having yield of 527.5 g/m^2, which is marginally higher than that of Kedargouri. However, most of these small grain aromatic rice types require longer days to 50% flowering ranging from 102.2 days in Kalijoha to 130.8 days in Chinikamini against 88.5 days for IR-36. All these genotypes were very tall and plant height ranged from 120.2cm in Kalijira to 180.5cm Tulsimanjari, but average plant height of IR-36 was only 103.5 cm. Thousand grain weight of aromatic types ranged from 10.2g in Danaguri to 28.1 g Agulha. Though, these genotypes did not have significant edges in yield advantage and duration, a good number of genotypes are preferred by the farmers for various purposes for multiplication. Most of the small grain aromatic rice returns more money than most of the popular high yielding varieties from unit area of land.

Keywords: aromatic rice, high quality, commercial utilization

INTRODUCTION

Rice is the staple food of more than half of the world's population and has been cultivated in Asia since ancient time generation after generation. It is one of the most widely used cereals in Asia, Africa, Latin America (Richaria, 1960; Chang, 1964; Adair, 1966). Wild species of *Oryza* are the genetic foundation for the breeding efforts needed for enhancement and sustenance of productivity. Besides the landraces and wild species, the genetic resources of rice also include natural hybrids and a range of different genetic stocks comprising commercial and obsolete varieties (Bordolui *et al.*, 2006). Aromatic or scented rice have long been highly regarded in Indian society not only because of its excellent quality, but also because those had been considered auspicious. The aromatic rice varieties being grown in the states of West Bengal, Orissa, Chattisgarh, Bihar and North East region are very short, fine grained and highly scented. Each one is highly priced in the locality where they are grown. These varieties are characterized by weak stem, very long growth duration, low grain weight and poor yield. Farmers mainly grow aromatic rice for their own consumption as well as for use in ceremonial programmes, leading to non-existence of well developed market. Adaptation of high yielding varieties has resulted in rapid erosion of the traditional small seeded aromatic types. In course of development of modern agriculture, many cultivars, including land races and folk varieties, have been replaced by a much smaller number of varieties. It is increasingly felt that these traditional varieties having important unique characters, can be utilized in a better way for development of high quality types.

Uniqueness of aromatic genotypes based on intensity and type of aroma is dependent on its genetic architecture and the agro-climatic factors of its growing location. Active participation of farmers having experience on quality aspects is vital to protect the existence of such high value aromatic types of rice. It cannot be denied that any success in the persistence of these genotypes depends to a large extent on the personal motivation of the farmers who intimately know these genotypes.

Therefore, for making an attempt towards documentation of the available indigenous aromatic rice genotypes, it is important to exploit such intelligent and experienced farmers having high skill not only in growing rice crop but also in the

process of its evaluation. Keeping these aspects in consideration, present investigation was undertaken to evaluate a collection of 18 aromatic genotypes along with 01 high yielding variety for seed quality parameters at farmers' field, Gontra village, Chakdah, Nadia, West Bengal, India.

MATERIALS AND METHODS

The field experiment was carried out at farmers' field during kharif season of 2016 and 2017 at Gontra village, Chakdah, Nadia, West Bengal in new alluvial soil having pH 7.07, organic carbon 0.8%, clay loam soil type, EC 0.7m mhs/cm^2, available Nitrogen, Phosphorus and Potassium as 222.6, 24.3 kg and 189.7 kg/ha respectively. 18 aromatic genotypes having diverse origin, popularly grown in varying agro-climatic conditions, along with one high yielding variety were grown in the farmers' field. Seedlings were raised in individual plots. Standard agronomic practices and intercultural operations were followed in the main field. 30 days old seedlings (one per hill) were transplanted in field with three replications following Randomised Block Design. Spacing was maintained as 25 cm between the rows, 20 cm between the plants and 50 cm between the two plots. Each plot was 2m length and 1m breadth. Fertilizers were applied in both the years as per standard recommendation (120:60:60:: N:P:K). Observations were recorded on plant height and number of effective tillers per hill at pre-harvest stage, days to 50% flowering, panicle length, test weight (thousand seed weight) and seed yield. Nature of aroma of individual genotypes was assessed through individual evaluation made by five persons (both scientists and farmers) and then average was made.

RESULTS AND DISCUSSIONS

Information on relevant characters of the genotypes is presented through Tables 1 and 2 based on observations during 1st year and 2nd year along with the pooled analysis. The magnitudes of average plant height of individual genotypes recorded in 1st year and 2nd year as well as for pooled condition were very close with each other indicating the non-existence of significant variation for this parameter over the years of study having negligible or no environmental influence during expression of the trait. However, the tallest and most dwarf plants were noted for Tulsimanjari and IR-36 respectively irrespective of the years of experimentation.

The maximum number of effective tillers was recorded for Danaguri, while it was minimum for Kedargouri and the magnitudes of this trait were almost similar for all the genotypes studied in all the situations. Chinikamini required the longest period (131.0 to 130.7 days for 1st and 2nd year respectively) to 50% flowering followed by Kalijira, Kalonunia, Parbatjira and Badshabhog. But the shortest duration for 50% flowering was noted for the high yielding variety IR-36. It is very important to note that all the aromatic types required significantly higher number of days to 50% flowering. Almost similar/same number of days required to 50% flowering for all the genotypes indicate the non existence of significant variation and it may be the more or less actual genetic expression of this trait (Sharma and Koutu, 2011).

Majority of the aromatic genotypes including the high yielding one exhibited almost similar panicle length over the years of study, while slight variation in this trait for only a few types over the years may be due to the effective environmental influence during its expression (Bordolui et al., 2015). However, average longest panicles were produced by Gobindo bhog followed by Tulsimanjari and Badsha bhog irrespective of the years of study, but the shortest panicles were consistently produced by Radhunipagol.

Agulha produced seeds with maximum density as indicated by 1000 seed weight followed by Kedargouri and Kalojira consistently over the years, while seeds of Badshabhog were of least weight in all situations and that of IR-36 were having medium weight. Consistency in performance of all the genotypes over the years may be due to no/negligible environmental influence for expression of this trait, rather expression of this trait was more specific to its genetic potentiality.

Maximum seed yield (g/m^2) was recorded after the high yielding variety IR-36, also noted by Hijam et al. (2011) and it was Kedargouri among the aromatic ones, though performance of these two genotypes were statistically at par over the years. However, the genotypes displayed significant variation in performance. On the other hand, more or less equal performance of each genotype over the years indicated that environmental variation exerted no/less influence on seed yield.

Table 1: Mean value of Plant height (cm), Effective tiller number and Days to 50% flowering in 1st year, 2nd year and pooled performance.

Sl .	Designation	Plant height (cm)			Effective tiller number			Days to 50% flowering		
No		1st year	2nd year	pooled	1st year	2nd year	pooled	1st year	2nd year	pooled
1.	Gopalbhog	161.7	161.0	161.3	7.0	7.7	7.3	117.5	117.5	117.5
2.	Khaskani	154.3	155.3	154.8	8.0	9.2	8.6	110.0	110.3	110.1
3.	Kalojira	171.5	173.1	172.3	9.0	8.0	8.5	120.3	117.5	118.9
4.	Radhunipagol	160.3	157.7	159.0	7.5	7.5	7.5	121.3	120.7	121.0
5.	Mohan bhog	157.0	157.0	157.0	10.0	8.0	9.0	119.0	108.3	113.7
6.	Agulha	127.3	129.3	128.3	9.5	8.0	8.7	108.6	108.7	108.7
7.	Danaguri	127.3	127.7	127.5	13.0	12.8	12.9	118.3	117.7	118
8.	Kalonunia	151.0	151.0	151.0	7.8	8.5	8.1	127.3	126.7	127
9.	Badshabhog	148.3	148.7	148.5	7.5	7.5	7.5	125.3	124.7	125
10.	Gobindo bhog	161.8	161.3	161.6	11.0	11.2	11.1	126.3	125.7	126
11.	Tulsimanjari	180.0	181.0	180.5	10.0	10.7	10.3	108.6	108.7	108.7
12.	Parbatjira	154.3	154.3	154.3	9.0	9.0	9.0	125.3	125.3	125.3
13.	Chinigura	168.0	167.7	167.8	9.2	9.1	9.1	112.3	111.7	112.0
14.	Kalijira	119.0	121.3	120.2	8.0	8.0	8.0	128.0	128.3	128.2
15.	Tulaipanji	156.2	156.1	156.2	9.3	9.3	9.3	115.0	115.0	115.0
16	Kalijoha	137.3	138.3	137.8	9.0	9.1	9.0	102.3	102.0	102.2
17	Chinikamini	139.8	139.0	139.4	10.0	10.2	10.1	131.0	130.7	130.3
18	Kedargouri	142.8	143.7	143.3	7.1	7.0	7.0	119.0	117.7	118.3
19	IR-36	104.3	102.7	103.5	10.0	10.1	10.1	88.7	88.3	88.5
SEm (±)		**2.694**	**2.941**	**2.817**	**1.107**	**0.676**	**0.891**	**0.565**	**0.8771**	**0.721**
LSD (0.05)		**5.34**	**5.82**	**5.58**	**2.19**	**1.34**	**1.76**	**1.12**	**1.74**	**1.43**

Table 2: Mean value of Panicle length (cm), thousand grain weight (g) and Yield (g/m^2) in 1st year, 2nd year and pooled performance.

Sl.	Designation	Panicle length (cm)			Thousand seed weight (g)			Yield (g/m^2)		
No.		1st year	2nd year	pooled	1st year	2nd year	pooled	1st year	2nd year	pooled
1.	Gopal bhog	29.5	29.5	29.5	10.8	10.9	10.8	257.3	257.7	257.5
2.	Khaskani	32.2	32.0	32.1	10.8	10.8	10.7	318.0	387.3	352.6
3.	Kalojira	30.3	30.3	30.3	23.2	23.0	23.1	374.7	382.0	378.3
4.	Radhunipagol	23.2	23.5	23.3	14.5	14.5	14.5	240.3	240.7	240.5
5.	Mohanbhog	29.0	29.0	29.0	12.4	12.4	12.4	240.7	241.3	241.0
6.	Agulha	26.0	25.9	25.9	28.2	28.0	28.1	403.7	402.3	403.0
7.	Danaguri	29.0	29.0	29.0	10.3	10.1	10.2	340.3	340.0	340.2
8.	Kalonunia	30.0	30.0	30.0	15.4	15.3	15.3	346.0	345.3	345.6
9.	Badsha bhog	30.0	29.8	29.9	10.5	10.3	10.4	324.7	324.7	324.7
10.	Gobindo bhog	32.3	32.5	32.4	11.5	11.3	11.4	300.3	310.3	305.3
11.	Tulsimanjari	30.0	32.0	31.0	12.7	12.8	12.8	273.3	277.3	275.3
12.	Parbatjira	20.5	20.5	20.3	13.3	13.3	13.3	403.7	270.4	337.1
13.	Chinigura	25.2	26.5	25.8	15.5	15.5	15.5	459.3	459.3	459.3
14.	Kalijira	24.5	24.6	24.5	20.5	20.5	20.5	376.7	376.7	376.7
15.	Tulaipanji	24.8	24.8	24.8	17.5	17.1	17.3	471.7	471.7	471.6
16	Kalijoha	29.1	29.1	29.0	15.2	15.5	15.3	354.0	353.7	353.8
17	Chinikamini	21.0	23.5	22.2	19.5	19.2	19.4	462.0	463.0	462.5
18	Kedargouri	25.5	27.0	26.2	23.5	23.9	23.7	525.3	526.0	525.6
19	IR-36	25.7	25.5	25.6	21.8	22.2	22.0	528.7	626.3	527.5
SEm (±)		**1.326**	**0.835**	**1.082**	**1.423**	**0.427**	**0.925**	**7.646**	**27.858**	**17.8**
LSD (0.05)		**2.626**	**1.660**	**2.143**	**2.817**	**2.665**	**2.742**	**15.139**	**8.002**	**11.6**

Table 3: Yield of such selected genotypes and cost effectively of production

Sl. No.	Genotypes	Desirable trait (s)	Yield of clean rice (husk less) (kg/ha)	Rate (Rs./kg)	Value (Rs./ha)
1.	Gopal bhog	Small grain, high aroma	1493.5	55	82142.5
2.	Khaskani	Small grain, high aroma	2045.08	55	112479.4
3.	Kalojira	Small grain, high aroma	2194.14	58	127260.1
4.	Radhunipagol	Small grain, high aroma	1394.9	60	83694
5.	Mohanbhog	Small grain, high aroma	1397.8	53	74083.4
6.	Agulha	Small grain, high aroma	2337.4	50	116870
7.	Danaguri	Small grain, high aroma	1973.16	50	98658
8.	Kalonunia	Small grain, high aroma	2004.48	55	110246.4
9.	Badsha bhog	Small grain, high aroma	1883.26	55	103579.3
10.	Gobindo bhog	Small grain, high aroma	1770.74	62	109785.9
11.	Tulsimanjari	Small grain, high aroma	883.34	60	53000.4
12.	Parbatjira	Small grain, high aroma	1955.18	52	101669.4
13.	Chinigura	Small grain, high aroma	2663.94	54	143852.8
14.	Kalijira	Small grain, high aroma	2184.86	55	120167.3
15.	Tulaipanji	Small grain, high aroma	2735.28	52	142234.6
16	Kalijoha	Small grain, high aroma	2052.04	45	92341.8
17	Chinikamini	Small grain, high aroma	2682.5	51	136807.5
18	Kedargouri	Small grain, high aroma	3048.48	48	146327
19	IR-36	Popular HYV	3291.5	28	92162

Milling quality is often expressed as a ratio of head rice yield to milled rice yield. For example, a 58/70 value would indicate a head rice yield of 58 percent, milled rice yield of 70 percent, and 12 percent broken kernels, the difference between the two values i.e., milling percentage is 58.

Table 3 clearly depicted the comparative yield performance and money return from one hectare of land. Most of the small grain aromatic rice types showed higher money return than that of the popular high yielding varieties from one hectare of land. Most of the quality parboiled rice also showed higher money return than IR-36 (high yielding variety) from one hectare of land. Examples of those varieties are Kedargouri, Tulaipanji and Chinigura etc. As the small grain aromatic rice varieties do not require high input, the cost of cultivation is less than high yielding variety.

CONCLUSION

The genotypes were collected from different places through direct involvement of farmers. Most of the small grain aromatic rice returns more money than most of the popular high yielding variety. These small grain aromatic high value rice genotypes give higher money return and also require low inputs which are cost effective for the farmers.

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Short communication

Blood fruit [*Haematocarpus validus* (Miers) Bakh. f. ex Forman] – A potential nutraceutical and therapeutic fruit plant

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INTRODUCTION

The increasing population coupled with poverty, natural and man-made crisis poses a challenge to the socio-economic and accessibility to food. However, it is well known that wild edible plants are vital, inexpensive, rich source of vitamins, anti-oxidants, fibre, minerals and other nutrients. A rich diversity of one or the other wild edible plants is found throughout the country that is being consumed by the locals. Since time immemorial, traditional knowledge and indigenous evidences suggest that a variety of wild edible plant species have played a prominent role in providing health and nutritional security to man and animals (Hunde *et al*. 2011). Inspite of their potential, there are large numbers of wild edible plants that have still not been properly addressed for their nutritional issues and are still greatly neglected in daily diets.

Amongst the various species of wild plants, one of the promising and potential sources as fruit, medicine, nutrition and natural colourant is *Haematocarpus validus*, popularly known as '**Blood Fruit**'. Etymologically, the word *Haematocarpus* is derived from two words, *viz*., *haem* meaning iron containing compound and *carpus* meaning fruit. It was first described by John Miers (Singh and Bedi, 2016). Fruits are dark red in colour with full of copious blood red juice when ripe and densely fibrous and hence the name '*blood fruit*'. *H. validus* is a dicotyledonous plant species included in the genus *Haematocarpus* and belongs to the family Menispermaceae. The family Menispermaceae is mainly restricted to tropics and subtropics; however, few species are also found growing in the temperate regions. The plants in the Menispermaceae family are known to be rich in different alkaloids and are famous for their traditional medicinal usages.

Two species of the genus *Haematocarpus, viz., H. subpeltatus* Merr., and *H. validus* (Miers) Bakh.f.ex Forman has been reported from South Asia extending to Philippines, Borneo and Sulawesi (Mabberley, 2008) and one species, *H. Validus* from India (Kanjilal *et al*., 1934).

The importance and ethno-medicinal values of this fruit is well recognized and are utilized by few old members of the village people for its iron-rich fruit. But a little research has been done on identification, proper utilization and the information available is scanty.

Synonym:

Baterium validum, *Fibraurea haematocarpus, H. comptus* Miers., *H. thomsonii* Miers. (Singh and Bedi, 2016)

Vernacular name:

Blood fruit (English), Khoon phal (Hindi), Roktogula/Lalgula (Bengali), Rosco (Chakma), Thoyphal (Tripura), Te.pattang (Garo), Theichhung-sen (Mizo), Ranguichi (Marma) Raktaphal (Tamil/Telugu/Malayalam), Sohsnam (Khasi & Pnar).

Distribution and habitat

Blood fruit is native to South East Asia and is mainly distributed in India, Bangladesh, Indonesia, Singapore, Thailand and Sri Lanka. In India, the fruit is found growing wild in Andaman & Nicobar Islands, Arunachal Pradesh, Mizoram, Tripura, Assam and Meghalaya. The plant is generally found growing wild but not cultivated.

H. validus is an evergreen perennial creeping woody climber capable of growing under extreme conditions, from very dry environments to highly acidic soils. It grows up to 1000 m and more in height (Rahim *et al*., 2015) with dark green glabrous profusely branched stems. It creeps and grows on other big trees like banyan tree, jackfruit, *Baccaurea species* or other long supporting tree. A recent study by Singh and Bedi (2016) in Meghalaya stated that the forest type of species occurrence was characterized by the presence of subtropical moist evergreen trees, and a huge number of herbaceous undergrowth on a hilly landscape. The vegetation composition at this site was found to be dominated by native tree species such as *Castanopsis indica* (Roxb.) A.DC. (Fagaceae), *Engelhartia roxburghiana* Wall. (Juglandaceae), *Litsea salicifolia* Roxb. ex Nees (Lauraceae), *Mallotus philippensis* (Lam.) Muell–Arg. (Euphorbiaceae), *Ostodes paniculata* Blume (Euphorbiaceae), *Schima wallichii* Korth.(Theaceae), and *Terminalia chebula* Retz. (Combretaceae).

Botanical Description

Haematocarpus species are large woody climbers which spread on tall trees. Leaves are simple, alternate, non-peltate, elliptic, 3 veined, petiolate. Bark is light grayish brown, rough, branches stout, wood consisting of consecutive layers of thin radiating plates. Inflorescence is cauliflorous, axillary, extra-axillary, terminal panicle or raceme. *Haematocarpus* species are dioecious where the male and the female flowers are borne separately. . Male flowers, sepals 12-15, in 3 series, usually inner series larger, imbricate, petals 6, 3 of the inner series auriculate at the base, stamens 6, free, enlarged connective projecting inwards. Female flowers sepals and petals similar as in male flowers, staminodes 6, minute, carpels 6, style reflexed. Fruits are drupes, narrow near the base, stalked, style scar near the base, smooth endocarp. Seeds are curved, non- endospermic, radicle short, cotyledons thick and long. Seeds may be dispersed by barochory *i.e*., gravitational dispersal, zoochory i.e., dispersal by birds or animals, anthropochory i.e., dispersal by humans.

Table 1: Morphological characteristics of Blood fruit collected from Garo Hills, Meghalaya

Characters	Value
Leaf length	9.34-13.00 cm
Leaf width	3.89-5.78 cm
Fruit weight	12.85-30.85 g
Fruit girth	25.34-35.93 mm
Rind weight	6.21-16.34 g
Rind thickness	3.98-5.31 mm
Seed weight	1.47 -6.41 g
Seed length	3.20-5.20 cm
Seed girth	14.0-19.69 mm
Pulp weight	3.21-8.79 g
Pulp peel ratio	0.32-0.95%
Pulp seed weight	4.96-15.08 g

(Source: Sangma, 2016)

Table 2: The nutritional composition of fruit (per 100 gm)

Parameters	Unit	Contents
Moisture	gm	90.12
Protein	gm	0.6
Carbohydrate	gm	6.99
Fat	gm	1.44
Crude fibre	gm	1.22
Ash	gm	1.23
Energy	Kcal	50
Vitamin C	mg	13.15
Carotenoids	µg	1170
β- carotene	µg	9.0
Iron	mg	0.57
Copper	µg	129.57
Zinc	µg	0.14
Manganese	µg	152.04
Calcium	mg	9.16
Magnesium	mg	6.86
Sodium mg	0.42	
Potassium	mg	255.70
Phosphorus	mg	39.50

(Source: Khatun *et al*., 2014)

The flowering time varies depending on the place. Under Andaman conditions, the species has been observed to flower more than once in a year. Peak season of harvesting is from April to August (Bohra *et al*., 2016). In Bangladesh, the vines produce

Table 3: Anti-nutritional factors (mg/100g) in *H. validus* fruits

Fruit fraction	Anti-nutritional factors (mg/100g)			
	Nitrate	Phytate	Oxalate	Saponin
Pulp	16.25	422.68	34.95	85.56
Pericarp	25.00	506.83	39.82	85.28
Seed	19.58	415.83	33.82	100.06

(Source: Singh *et al*., 2014)

flower in mid November-January and the fruiting season is May to August (Khatun *et al*., 2014). Under Garo hills condition of Meghalaya, the vine comes into flowering from October to December and fruits are available in the local markets from last week of March till June (Sangma, 2016).

The study on the morphological characteristics of this plant was conducted by Sangma (2016) in Garo Hills region of Meghalaya. Studies revealed that the plants have climbing growth habit, tall and fruit shapes were recorded to be ovoid . Fruit colour varied and according to RHS colour chart, N34A, N30A, 53D, 33A, 45A, N34B, 53A, 45B, 46-A, 42A, 46B colour. Inflorescence was small to intermediate and inflorescence position was found to be pseudo-raceme axillaries.

Phyto-chemical composition

Analysis and identification of phyto-chemicals is important for recognizing the potential of indigenous wild edible fruits as reliable supplementary food nutrition. The fruit taste is acidic but of a pleasant flavor when fully ripe. The fruit contains 90.12% moisture, highly acidic pH (2.77), TSS (12.40%), titratable acidity (5.08%), total sugars (27.232%), reducing sugar (6.90%), non-reducing sugar (26.67%) and phenol of 0.51% (Sangma, 2016; Rahim *et al*., 2015). Fruits are also rich in total polyphenol (400 GAE mg/100g), flavonoid (542 RE mg/100g), tannin (275.56 TAE mg/100g) and anthocyanin (203.77 C3GE mg/100g) as reported by Singh *et al*. (2014).

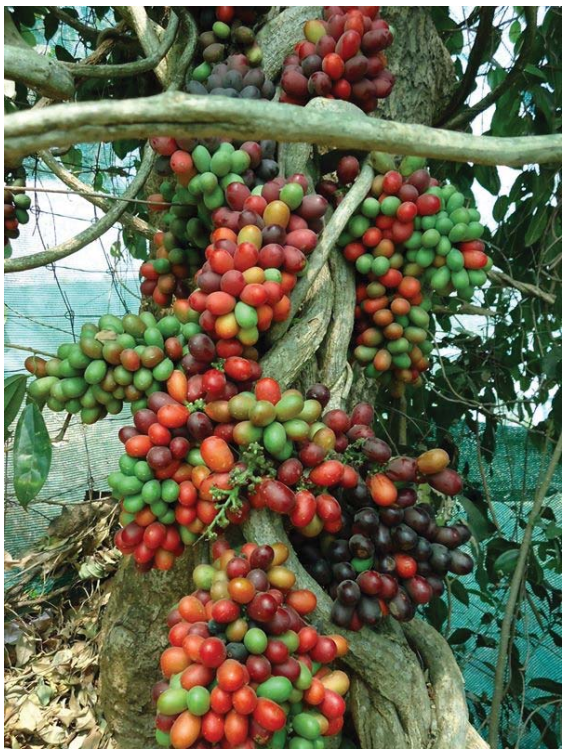
Nutritional composition

Wild edible fruits which have been identified to have rich nutritional value as the cultivated ones play an important role in food and nutrient supplement of the rural poor and tribal communities.. Many of these edible fruits are abundantly available in the forest and wild areas, and huge quantities of wild fruits are usually not collected and wasted because their therapeutic properties and potential as subsidiary food sources are practically unknown to the village and rural communities (Nazarudeen, 2010). The nutritional and therapeutic value of this fruit is extremely important to consume in greater quantity for a balance diet. Regular consumption of such nutraceutical fruit could provide several health benefits and may reduces the risk of several diseases like diabetes, cancer, coronary heart disease, neurodegenerative ailment and aging as well. With alarming increase in human population and depletion of natural resources, it has been felt necessary to explore the potential of this crop for food and other industrial uses to meet challenges of hidden hunger.

Fruits of *H. validus* are found to be rich in iron (0.57 mg/100 g) and seeds contain 0.11 mg/100g which is comparatively higher than the commercial fruit crops such as mango (0.2 mg/100g), apple (0.1 mg/100g), guava and cherries (0.3 mg/100g) (Singh, 2013). Consumption of blood fruit can help in overcoming iron deficiency problems and also anaemia related disorders. Vitamin C content (13.15 mg) is also higher than the commercially available fruits, *viz*., jackfruit (11.08 mg), litchi (7 mg), papaya (7.48 mg) and mango (10.88 mg) (Islam *et al*., 2012). Besides fruits are also a rich source of micro-nutrients like Ca, , Mg, K and P and natural antioxidants due to the high content of carotenoids, β- carotene and minerals.

Presence of anti-nutritional factors

Advances have been made in the nutritional values and health benefits of wild edible fruits, however, there is a dearth of knowledge about its anti-nutritional contents. Available of information on the anti-nutritional contents of these fruits will aid their maximum utilization as food products. These fruits are also known to contain anti-nutritional factors that can interfere with the metabolic activities of the body which in most cases predispose negatively on growth and bioavailability of nutrients. Anti-nutritional factors are the determining factors for the exploitation of plants



a. Bearing plants of *Haematocarpus validus*

b. Ripe fruits

c. Flowers

d. Cross section view of blood fruit

as food materials. They are also known as secondary metabolites and are generated naturally in feed stuffs through normal metabolism of the plant species. Some of the common examples are saponins, tannins, flavonoids, alkaloids, trypsin (protease) inhibitors, oxalates, phytates, haemagluttinins (lectins), cyanogenic glycosides, cardiac glycosides, coumarins, gossypol, etc. (Rout and Basak, 2015). The presence of anti-nutritional compounds have also been reported in fruits like *Ficus racemosa L., Elaeagnus conferta Roxb. Flacourtia indica (Burm. f.) Merr,etc.* which is within the safe permissible limit (Rathod and Valvi, 2011).

Blood fruit was also found to contain nitrate, phytate, oxalate and saponin (Table 3; Singh *et al*., 2014),. The analysis of three different parts of blood fruit showed that the pulp, an edible portion had low nitrate and oxalate content and in a safe health limit for consumption. The seeds comparatively had high amount of saponin which indicates its potential for use in industries.

Uses

Even though *H. validus* is a lesser known fruit, yet it has a lot of potential uses. Fruits are slightly acidic, sweet in taste when fully ripe and are eaten raw. The fruits have high anthocyanin content which gives true blood red colour which can be used as a natural colouring agent and natural additive dye for food products (Singh *et al*., 2014). Fruit extracts can also be used in colouring soft drinks and desserts. This will be helpful in avoiding health risk associated with artificial colouring. The Chakma and Marma tribes of Chittagong in Bangladesh use the tender shoots extract as curative measure for jaundice. Fruits and seeds are also used as curative measure for anaemia and root mash is used to get relief from itching (Rahim *et al*., 2015). The iron rich blood fruit is highly valued by the Garo tribe in Meghalaya to treat anaemic or blood related disorders. Ripe fruits are sliced and soaked in a glass of water overnight and taken as medicine the next morning. They also use this fruit for preparing wines (Sangma, 2016). In Tripura, the fruits are being used as a dye in colouring the handicrafts and also in preparation of squash. Processed products like pickles and chutneys are also prepared from green fruits. Ripe fruits can also dried and stored and used for future consumption (Bohra *et al*., 2016).

Future prospects

With the growing concern and commitment to hill area development and poverty alleviation by the government, there has been an increasing interest in low untapped and underutilized wild bio-resources that contributes to the household food and livelihood security. The value and importance of the wild edible plants and *H. validus* in particular, is less attention being given at various level. Many neglected and underutilized species play a role in balancing a cultural diversity associated with food habits, health practices, religious rituals and social exchanges. Focusing attention on neglected and underutilized species is an effective way to help a diverse and healthy diet and to combat micronutrient and deficiencies, the so-called 'hidden hunger' and other dietary deficiency particularly among the rural poor and the more vulnerable social groups in developing countries. An emphasis needs to be given to identify more areas to explore the potential pockets for cultivation which can bring in more economic benefits to the local communities if harnessed properly.

Research on the utilization aspect will help to identify new uses and improve production and also promote welfare of the local community. Information and research concerning the crop improvement, propagation, utilization, agro-techniques, nutritional and conservation aspects, especially on this particular fruit species is extremely scarce and needs to be worked upon. Efforts need to be directed towards better maintenance of their resource base, both through *ex situ* and *in situ* conservation methods, to ensure their development and sustainable use by present and future generations. For making the blood fruit more popular, it is important to morphologically screen populations from different geographical regions of the country. This endeavour can assist in identifying plants with edible and larger fruits, exhibiting wider adaptability, having tolerance to disease and insect pests which can later be used for the breeding purpose. It is also important to improve the acceptability and marketability of this fruit by making people aware of their nutritional qualities.

New technologies like molecular genetics and GIS, will certainly play their part in the process of developing conservation and use strategies. Improving the availability of information on underutilized crop species is one of the most important areas that demand our immediate attention. Besides these, there is a scope for studying the response of pruning, training and other cultural practices. Standardization the post-harvest techniques including packaging and value addition could also be taken up. Suitable procedures for isolation of anthocyanins and its utilization as a natural colourant for preparing products also need to be standardized (Bohra *et al.,* 2016). Since traditional knowledge in this wild edible fruit is being eroded through acculturation and the loss of plant biodiversity along with indigenous people and their cultural background, hence promoting research on this wild fruit is crucial in order to safeguard this information for the future generations and their conservation.

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Proceedings: Blake, M.A. 1932. The J.H. Hale as a parent in peach crosses. *Proc. Am. Soc. Hort. Sci.,* **29**:131-136.

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Annual report: Anonymous, 2010. *Annual Report for 2010-11*, Faculty of Horticulture, Bidhan Chandra Krishi Viswavidyalaya, Monhanpur, Nadia, West Bengal, India. Pp.80-85.

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