Genetically evolved papaya (carica) and its future in Sindh, Pakistan

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Abstract.

The province of Sindh lies between 23° 40' to 28° 30' N and 66° 40' to 71°, 30'E. The region has subtropical climate, receiving 100-550 chill unit and 3700-4500 heat units. Soil is Silts-loam having pH 7.8. The climate of Sindh is very suitable for papaya growing, but up-till now we have only local varieties, which are tall, needing spacing of 3m x 2m or 2m x 2m with density of 1667 and 2500 plants/hectare. In Sindh papaya tree is grown as an inter crop with mango and citrus. Its harvest season is January to April, and August to November, i.e. cool period. The fruit is mostly attacked by virus. Since the fruit is highly perishable its post-harvest life is very short. Papain industry is not developed in Pakistan.

Future work is going on genetically engineered papaya having plant of medium size, precocious cropping, uniform fruit size, moderate to long fruit stalk, multiple fruit stalks, tree and fruit resistance to mildew, fruit rot, other fungal and viral diseases, free from blemishes appearance, small cavity, thick flesh, sweet, good flavour and better post-harvest life. Hawaiian Solo cultivar, UH Sunup, and UH Rainbow Blue stem, Granam, Fairchid Betty, Kissimme, Co-1, Co-2, Ranchi, Barmani, Halflong have great future in Pakistan. These varieties also can help in boosting the papain industry in Pakistan.

Introduction.

Its scientific name is Carica and belongs to family Caricaceae. Its vernacular names are: Papaya, pawpaw, melon tree, papayier, arbre de melon (Fr), Papaya, (Indonesia) Gedang (Sudanese); kates (Javanese), papaya, (Malaysia) betek, ketalah, (Philippines) papaya, kapaya, lapaya, (Burma) Thimbaw, (Cambodia) Thong, Doeum, Lahong, (Laos) houng, (Thailand) Malakar (Central), Loko (peninsular), Makuai thet (Norther), Mamao (Brazil), Melon Zapote (Mexico), Kapaya, Kepaya, Lapaya or Tapaya in (South Asia)and (East Indies.)

- Papaya plant can not stand water-logging (Ref. 3)

Life of Tree.

- Tree may live for 25 years, yield decline with age, for papain production, the productive life is usually 3 years, there after the tree get too tall and latex yield declines. (Ref. 5).

Varieties.

Presently planted varieties on large scale in developed countries are:

Washington, Guajrat, Singapore, Hawaii and SriLanka Blue-stem Honey dew, Richter gold Corg honey dew, Graham, Hortus gold, Honey gold, Maroochy, Sunybank., Barbados, Kapoho Solo, Higgins, Wilders, Hortus Gold, Bettina, Peterson, Hybrid No.5, Yarwun Yellow, Gold Cross, Goldy, Hong Kong, Guinea Gold, Golden Surprise, Sunnybank, Campo Grande, Tocaimera, Bettina, 43-A-3, CO-1, CO-2, Santa Cruz Grant, Cedro, Singapore Pink, Purplestem, Bluestem, Big Bluestem, Bluestem Solo, Blue Solo, Cariflora, Surprise, Solo, P.R.6-65 (early), P.R. 7-65 (late) and P.R.8-65 (early)- (Ref.1)

- Papaya varieties of India are : Coorg Honey Dew, Co-1, CO-2, CO-3, Pusa Delicious (PUSA 1-15), PUSA Majesty (PUSA 22-3), PUSA Giant (PUSA-1-45V), PUSA Dwarf (PUSA 1-45D0, Eksotika, Cartiflora. (Ref.2)

- Papaya varieties- Line-5, Line-8, Kapoho , Masumoto Solo, Sunrise, Waimanalo, have been developed in Hawaii and Florida . (Ref.9)

Papaya plant.

The genus carcia has about 48 species (Ref.16). But only three of them of horticultural important are Carica papaya, carica candamarcensis, and carica monoica. Only carica papaya is grown on a commercial scale in Pakistan. Papaya is evergreen plant, it produce fruit within one and half years and plant economic life is 4-5 years. In some cases the plant survives 15-20 years but its yield become low and fruit size small after 5 years. The plant is dioecious, rarely monocious. Flowers are unisexual but some time hermaphrodite.

Papaya needs, rainfall 1500-2000 mm , high humidity which effects on sweetness of fruit. It can grow on various types of soils, roots are sensitive to water logging. Tree can reach up to 20 feet (6 meters) as straight trunk tree.

A minimum precipitation of approximately 100 mm, and minimum relative humidity 66% and optimum temperature for growth , 21-33C° is needed . Normally fruit growth and development takes 120-150 days, fruit set does not normally occur in winter, fruit set before winter takes up to 90 days, longer to reach maturity. 1.25 times the potential pan-evaporation is required for maximum yield from mature tree. In Sindh the pan-evaporation is 80-90 inches and therefore water requirement will be 100-115 inches annually, with maximum requirement of 15 inches per month from 15th April to 15th July, which would mean application of 2 inches water every 4th day. (Ref.20).

Spacing.

Spacing depend upon the variety, climate and soil condition.

- Normal spacing is 8 x 8 ft (2.4 x 2.4 m) per plant.
- CO-1, and CO-2, Solo- spacing are planted at 6 ft (1.8 m) Centres.
- In Australia the spacing is used 3 ft (1 m) -apart on ground level and then thinned out by removal of un-wanted plants.
- Hawaii- plants are used to be double rows with an alley between each pair providing room for cultural and harvesting operations. (Ref. 1)

Planting Distance.

Planting distance depend on contour of the land, its location and climate.

Spacing within rows and between rows.

Within rows.	Between rows	No. of tree/acre.
6 feet	9 feet	806
7 feet	9 feet	691
7 feet	11 feet	565
8 feet	10 feet	544
9 feet	10 feet	484

(Ref.9)

Soil.

It need warm climate rich, loamy and well drained soil. (Ref.19) . Light , porous soil, rich in organic matter, optimum pH 5.5-6.7 is good for the plant. (Ref.1)

Fertiliser.

The various doses of fertilisers are recommended by various soil scientist in various countries These are as under:

- Fertilisation dose is 400g nitrogen, 250g phosphorus and 400g of potassium per plant per year. High yield is obtained, if use 12 bags urea, 5 bags triple super-phosphate and 20 bags K2O are used per year per hectare.
- A good results comes by the use of 0.1 kg of 4-8-5 fertiliser or similar mixture given each plant at 2 weeks intervals for the first 6 months and 0.2 kgs there after. (Ref.3)
- Fertiliser- 250 g of nitrogen, 250 g of phosphorus, 500 potash in each plant each year. Divided in to 6 applications. (Ref. 10
- Mixed fertiliser N:P:K as 4:6:3 at the rate of 450 Kgs/acre.
- For papaya in South Africa, Malan (Alar) recommends applying 2oz (about 60g) of 20% nitrogenous fertiliser such as Calcium ammonium nitrate as soon as the plants are well established and show new growth. The same amount should be applied at intervals of six weeks until the plants are about one year old. Thereafter ½lb (225 g) may be applied to each plant every three months. This means that each plant receives about 100 g N the first year and 200g during subsequent years, or assuming a density of 1,000 plants per ha, 100kg N per ha in the first year and 200kg N per ha during subsequent years. Malan recommends applying about one lb(450g) of super phosphate per plant per year in the spring. If compound fertilisers are used regular NPK dressings with ratio such as 2:1:2 or 2:1:3 or more potash-deficient soils are recommended. A heavy mulch and heavy applications of fertiliser will reduce injury from nematodes.
- For papaya in Australia Cann (1966) recommends a fertiliser programme of 1½lb,(680 grams) for the first year and 2-3 lbs or 900-1350 grams., for older trees of an NPK 8-12-6, given in four split applications in September, November, February and April. The fertiliser should be broadcast over the root are a and watered in.

(Ref. 8)

Flowers.

Female flowers have five large twisted petals and pentamerous syncarpus ovary with five sessile stigma at the top. Male flowers borne in clusters on long branched racemose peduncles. Male flowers has 5-partite-tubular corolla with ten stamens and rudimentary ovary. Hermaphrodite flowers are like pistillate flowers ,but bear well developed stamens. The sex of the flowers on the some plant can under go changes with age, injury and other treatments. One male plant is sufficient to pollinate up to ten females i.e., 10% plants should be males. In case of bisexual none. (Ref. 3)

Pistillate plants, lacking anthers which are less affected by carpellody and tolerant to seasonal fluctuations in Sindh. Pistillate plants either dioecious or gynodiocecious produce good fruit. Both dioecious and gynodioecious, inter-crossing with desired penotypes mostly evaluate at seedling stage.

Haploid production and Anther culture.

Heterozygous hermaphrodite inbreeding result into homozygous The heterozygous condition, staminate and heterozygous condition produce diploid papayas but double haploid produce viable sex type other than homozygous , pistillate form is unclear. Papaya haploids can be produce by other cultures. Fruit quality, uniformity, various environmental adaptation can be solved by another culture.

Plant which developed from the seed as a pure pistillates will retain their sex without modification but plant which commence life as pure staminae may undergo a change of sex. (Ref.19)

Some papaya cultivars reported in the literature, many are variable and not true cultivars are shown in table below:

Country.	Country	Cultivar	Sex type	flesh colour
Australia		Improved Petersen	Dioecious	Yellow
		Guinea gold	Hermaphrodite	Yellow
		Sunny bank	Dioecious	Yellow
		Arline/57	Dioecious	Yellow
America	Mexico	Verde	-	-
		Gialla	-	-
		Cera	-	-
		Chincona	-	-
	USA-Florida	Cariflora	Dioecious	Yellow
		Betty	Dioecious	Yellow
		Homestead	Dioecious	Yellow
	USA- Hawaii	Kapoho Solo	Hermaphrodite	Yellow
		Sunrise	Hermaphrodite	Red
		Sunset	Hermaphrodite	Red
		Waimanalo	Hermaphrodite	Yellow

Country.	Country	Cultivar	Sex type	flesh colour
	Venezuela	Paraguanera	-	-
		Roja	-	Red
Caribbean	Barbados	Wakefield	-	-
		Graeme 5, and 7	-	-
	Cuba	Maradol	Hermaphrodite	Red
	Trinidad	Santa Cruz Giant	-	-
		Cedro	-	-
	Dominican Republic	Cartagena	Hermaphrodite	Yellow
Asia	India	Coorg Honey Dew	Hermaphrodite	Yellow
		Coimbitor 2	Dioecious	Yellow
	Indonesia	Semangka	Hermaphrodite	Red
		Bangkok	Hermaphrodite	-
		Dampit	Hermaphrodite	-
	The Philippines	Cavite Special	Mixture	-
	Thailand	Sai-nampueng	-	-
		Kek-dum	-	Red
South-Africa		Hortus Gold	Diocious	Yellow
		Kaapmuiden	-	Yellow
		Honey Gold	Dioecious	Yellow

(Ref. 20)

Seeds.

Seeds viability is 45 days. About 250-300g seeds are enough for two acres. Seeds are treated with 1% Agrosan G.N as prevention against damping off disease. Papaya seeds are stored at 10°C, and 50% Relative humidity , in cloth bag or at 5°C in sealed bag. This retains the viability of seeds for 6 years.

The use of seed treatment with 2500-500 ulL^{-1} Sodium Hydro- chloride, and a sterilised germination medium with good aeration and control of moisture give good results. (Ref. 20)

Rubbing the seeds with ashes before drying increased the germination to 55% and soaking them in cow's urine brought this up to 67% . (Ref. 4)

Fresh seeds can germinate within 10-14 days, if there is adequate moisture and heat. There are about 27,000 seeds per pound, which should be sufficient for 10 acres of land (ref. 9).

Fruit.

Fleshy berry, 7-30 cm long, weighing up-to 9 kg, ovoid-oblong, to nearly spherical from hermaphrodite flowers; skin thin, smooth, green, turning yellowish or orange when ripe; flesh yellow to reddish orange, mild and pleasant flavour central cavity 5 angled .A healthy plant give an average 75lbs (34 kg) of fruit per plant per year. (Ref. 5)

Yield and harvesting.

It hold about 25 fruits per plant, weighing up to 30 kgs. The average yield per acre is about 8840 fruits. in 5 years Fruit is harvested when fruit colour changes from green to pale green and latex ceases to be milky. Seeded fruits have thicker pulp than the seedless fruit. Ethylene gas at one part in 5,000 parts is sufficient to ripen the fruit overnight, but fruit should be exposed to open air before ripening. Benomyl at 0.5g per litre for post-harvest fungal control and thiobenolazole at 1,000 ppm as post-harvest dip, controls the post-harvest rotting. It should be stored at 10-13°C for maximum storage life of ripen fruit.

Papaya fruits are thinned at the time of harvesting. Thinning is needed because fruit tend to pack tightly on the stem or where threes have a tendency to produce carpellodic fruit.

Fruit ripens successfully by 6-7 days treatment with ethylene gas in airtight chamber at 77F° (25C°) and 85-95 % humidity, following the hot water bath. Fruit can be kept for longer time. (Ref.1)

Nutritional value of papaya.

100g edible portion supply energy 200 KJ/100g. Major sugars are sucrose (48.3%) , glucose (29.8) and fructose (21.9%). The yellow pigment in the papaya is Caricaxanthin Miller and Bazore (1945) report, 2,500, International units of this Vitamin. (Ref. 4)

Food value per 100g of edible portion of papaya.

Ingredients	Quality
Calories	23.1-25.8 Kcal.
Moisture	85.9-92.6 g
Protein	0.081-0.34 g
Fat	0.05-0.96 g
Carbohydrates	6.17-6.75 g
Crude Fibre	0.5-1.3 g
Ash	0.31-0.66 g
Calcium	12.9 - 40.8 mg
Phosphorus	5.3- 22.0 mg
Iron	0.25-0.78 mg

Ingredients	Quality
Carotene (in form of Cryptoxanthin)	0.0045-0.675 mg
Thiamine	0.021-0.036 mg
Riboflavin	0.024-0.058 mg
Niacin	0.227-0.555 mg
Ascorbic acid	35.5- 71.3 mg
Tryptophan	4-5 mg
Methionine	1 mg
Lysine	15-16 mg
Analysis made in Malaya.	-

(Ref. 1)

Post-harvest of Papaya fruit.

- In fumigation method, fruit packed in open field -lugs are fumigated with ethylene di-bromide at dosage of 450 grams per 1,000 cubic feet, (30 cubic meters) in fumigate chamber for 2 hours, with minimum temperature not less than 21 C°. Treated fruit is packed and transported with refrigerated vehicles. Before fumigation papayas are immersed in hot water at 49 C° for 20 minutes, then cooled in running tap water for 20 minutes. This post-harvest operation reduces storage decay 5 % but rate of anthracnose may be higher 25 % to 0%. Aroma and taste are not affected by this treatment. (Ref. 9)
- The Phytopathora and Pythium root rot controlled by soil fumigation methods.
- The quarantine requirement for vapour heat treatment acceptable in Japan and USA , is that the temperature in the centre of papaya fruit must be brought up to 117 F° or 47.1 C° under saturated conditions (100 % relative humidity) .To obtain post-harvest disease control, a minimum of four hours treatments is recommended. The pre-condition treatment is not a quarantine requirement. It consist of subjecting the fruits to dry heat (about 40% relative humidity 0 at about 110 F° or 43.5 C° for 6-8 hours. (Ref. 9)
- Irradiation at the range of 75-100 krad increase the fruit shelf-life for 3 days. (Ref. 9) and if stored in 2-4 % oxygen. (Ref.11)

Packing.

It is packed in bamboo baskets, or wooden box, use straw and soft grass as bedding agent.

Propagation.

Mostly produce by seeds. The vegetative propagation done by cutting but it is a slow process, other methods are grafting plants which give more rapid in growth and plant come in to fruit early (Ref. 19). For grafting cleft and Whip grafting are used., and patch budding is highly successful technique .Papaya is successfully grafted by Forkert and chip methods.

Cutting are treated with 3-5 % Indolebutyric Acid. (Ref. 7).

Tissue culture.

Tissue culture is used for mass production of male and female papaya clones. Papaya tree stem segment, leaf segments and roots are used in tissue culture for its propagation. Propagation by cuttings needs branches having basal swelling, due to non-ornanching growth habit of papaya, tree produce few cutting. On commercial scale propagation by cuttings is un-economical. Molecular polymorphism in Isozymes and DNA techniques are used for breeding and genetic diversity study within the species.

Papaya Rootstock

Root stock with their special characteristic are listed here:

- Betty.
- California - Resistant ring spot virus, adapted to warm low land conditions.
- Eksotika - Flesh reddish pink.
- Higgins - susceptible to phytophthora root rot.
- Kapono (Puna Solo) - Susceptible to Phytophthora root rot.
- Sunrise - Flesh reddish - orange, high sugar content, good shipping quality.
- Sunset - Resistant to anthracnose.
- Waimanalo - Flesh bright yellow colour, tolerant to phytophthora root rot.
- Wilder - Flesh orange - yellow.

Breeding.

There is great variation in shape, size, pulp of fruit. In line-breeding of fruit increases the number of chromosomes by colchicine treatment of 0.6 to 0.1% improved is found.

- Breeding of papaya based on following characteristics.
- Height to first flower (cm), bigger fruit mass (g), more soluble solids (%), good flesh colour, carpellodic fruit (%), other culls (%), better marketable (kg per tree), Phytopathora resistance and virus resistance. (Ref.20)
- Desirable tree characteristic are tree should be vigrous, low and precocious fruiting, minimum expression of stamen carpellody and female sterility. If hermaphrodites are preferred, resistance to diseases and insect pests and yielding ability. Universally desired fruit characteristic are smooth skin, free from blemishes , firm fruit with thick flesh, round seed cavity, absence of internal lumps and long shelf-life. (Ref. 20)
- More un-form of fruit size and shape seems to be possible in dioecious types. The most promising method is pure line breeding. (Ref.4)

Ideals in papaya breeding have not changed much since the following were proposed, additional criteria have related to diseases resistance (Higgins and Holt, 1914)

Tree	Character.
	Vigour
	Early and low fruiting-wide variation exists
	Freedom from branching habits.
Fruit	Productive but not compact fruiting
	Small size for table use
	large size for animal feed and papain production
	Uniformity in shape, symmetry and smoothness
	Uniformity in ripening
	Colouring before softening
	Colour of flesh-yellow, pink or red
	Easily separable without scraping flesh
	Flavour-not easily described but easily recognisable
	Keeping quality
Other	Papain yield
Ref. (Higgins and Holt, 1914)	

Reported mutant papaya genes.

Symbol	Description
A	Albino plants recessive to green plants.
D	Dwarf -ness recessive to tall, excessive branching in juvenile stage.
Dp	Diminutive plant recessive to large plant, short, slender trunk and petioles, small less, flowers and fruit.
Cp	Crippled leaves recessive to normal leaf, appearance resemble symptoms of PRSV.
Rg	Rugose leaf recessive to smooth leaf, puckering of blade, petioles short, obliquely upright.
W	Wavy leaf recessive to normal leaf
r	Red flesh recessive to yellow
y	Yellow flower colour dominant to while
P	Purple stem and petiole dominant to green, colour intensity may be affected by modifying genes.
B	Grey seed-coat dominant to black seed-coat.
PRSV, Papaya ring sport virus.	

(Ref. 20)

Average Tree and fruit characteristics of 9 inbred advanced lines and the Kauai selection of Kapoho Solo planted by growers are given in table below:

Lines	Fruit Weight	Soluble Solids	Fresh Colour	Number fruits	Yield per tree	Total yield
	(grams)	(%)		Per tree(a)	fruit (Kg)	of fruit/acre,Kgs.
Higgins	408.6	13.7	Orange	56.3	25.28	17474.00
Wilder	544.8	12.6	Orange	24.9	13.57	9,380.09
Kapoho	431.3	13.4	Orange	36.5	15.75	10,886.01
26F6	454.0	11.4	Light Orange	31.6	14.35	9,913.54
34F6	508.48	10.5	Orange	21.5	10.94	7,560.46
37F6	531.18	12.1	Light Orange	33.7	17.89	12,360.15
40F5	789.96	11.2	Orange	26.3	20.79	14,4368.19
93F4	744.56	11.7	Orange	29.6	22.01	15,215.36
96 S4	454.0	11.5	Light Orange	30.82	13.98	9,662.48
116S5	404.06	12.0	Pink	36.75	14.85	10,258.58

Average of 4 replication: fruit count include all fruits.
Estimates based on 691 trees per acre , at 7 feet between plants and 11 feet between rows .

Effect of Growth regulators.

Lange (1957) reported that treatment of young seedlings of papaya with 10 and 100ppm of gibberellic acid resulted in increased growth and fresh weight, and sprays of 2,3-dichlorooisobutyrate on hermaphrodite forms of dwarf papaya and solo increased the number of female flowers (Lange, 1961).

Spraying of Benzothiazole 2-oxyacetae produced flowers earlier at a lower node and higher yield than the control (Dedolph, 1962)

Chacko and Singh (1967) reported that soaking papaya seeds in GA^3 solution accelerated germination and increased the height and flesh weight of the stem.

GA^3 spray at 50 ppm increased the femaleness in C0-1 papaya (Padmanabhan, 1970),According to him the onset of flowering was hastened significantly by the application of MH and SADH, and the fruits appeared at a lower node and height than in the control. Further, as we reported by him that SADH treatment proved very effective in CO-1 papaya for the control of height.

According to Alagiamanavalan (1971), SADH at 500 ppm produced the maximum number of flowers and fruit set. further reported that sprays with GA^3 at 50 ppm, SADH at 250 ppm and Phosfon-D at 250 ppm increased the femaleness over control in Co-1 papaya.

Similar increase in femaleness was reported by Singh and Jindal (1972) when papaya seedlings were treated with TIBA at 100 ppm. More over, TIBA at 25 ppm induced flowering at lower nodes, but such an effect was not noticed wit higher concentrations. Selvaraj (1972) , recorded a fruit set of 44.28 and 43.75 percent with TIBA at 25 and 50 ppm, respectively, compared with 32.40 per cent under control. The quality, yield and size , papain yield, and the proteolytic activity of papain were increased by treatment with GA^3

Treatment with CCC increased the thickness of pulp and pectin content to an extent of 82% compared with the untreated plants, where it reduced the plant growth, delayed flowering and lowering the fruit and papain yields ,Application of GA^3 on Coorg Honey Dew increased the production of hermaphrodite and staminate flowers, caused a two-fold increase in ascorbic acid content, but reduced the seed number, fruit size and pectin content (Shanmugavelu et al. 1973)

Bhattacharya and Madhava Rao (1982) reported that CCC and TIBA advanced flowering by 9 and 4 days, respectively, in C0-2 papaya. In general, the role of growth regulators appears to be worth investigating further. (Ref.2)

All above findings are old but still being tried in South Asia.

Effect of Growth regulators in fruit quality , quantity and yield enhancements.

- Planofix (1ml. In 1 litre of water) or NAA spray during flowering and on tender fruits, prevents fruit drop and increases fruit size.

- Spraying of papaya seedling with GA3 at 50 ppm, Alar at 250 ppm and Phosfon-D at 250 ppm increase the number of female flowers. Hermaphrodite plant seeds are used for propagation, which is self-pollinated or crossed with another hermaphrodite, so 67% seeds become hermaphrodite offspring and 33% female off spring. Application of GA3 at nursery stage increases the number of female plants. In Corg-honey dew and Solo, male plants are not required for pollination. If we prune the leaves and leave 25

leaves per plant fruit yield increases 20%. A good way is transplant large number of seedlings and uproot the male and hermaphrodite plants after flowering for better yield.

Hofmeyr (1941) applied 0.06-0.1% Colchicine solution to the terminal buds of seedling papaya causing swelling and temporary retarding of growth. Out of 64 seedlings treated 14 showed sign of having the number of chromosome doubled. The resulted tree being shorter but wide spread and flesh was half and inch thicker than ususal (Ref.4)

Pests and Diseases Control

Rugosellus-caterpillar, borer-cut, ant and Mediterranean fruit fly, Damping off, die-back, powdery mildew, anthracnose are major diseases. Other diseases are stem rot; foot root, collar rot due to pythium Aphanidermatum are control by, treating the plant with 1% Lysol or carbolic acid paint, with Coaltar.

A fungous disease leaf-sport (Pucci-niopsis Caicae Earle) ,bring small black mass under-surface of the leaves. It is cured by Bordeaux mixture spray (Ref.19)

Some important diseases and disorders of papaya are as under:

Common name	Organism	Parts affected.
Phytphthora blight	Phytopthora palmivora	Root,stem,fruit
Pythium root rot	Pythium aphnidermatum	Root
Damping off	Phytophthora aphanidermatum, Pythium ultimum,	Seedling stem at soil line.
	Phytophthora palmivora,Rhizoctonia sp,	
Collar rot	Calonectria Crotolariae	Base of trunk, crown roots
Powdery mildew	Oidium caricae	Underside of leaves, petioles
Alternaria fruit rot	Alternaria alternata	Fruit body
Black spot	Cercospora papayae	Fruit body
Anthracnose chocolate spot	Colletrichum gloeosporiodides	Ripe fruit body
Spot rot	Rhizopus stolonifer	Injured mature fruit at stem end
Stem-end rot	Fusarium Solani	Wounded mature fruit at stem end
Phoma rot	Phoma caricae-papayae	Stem end, wounded area
Phomopsis rot	Phomopsis sp.	Stem end, wounded area
Stemphylium rot	Stemphyllium lycopersici	Stem end, wounded area
Fruit rots	Botrydiplodia sp.	Stem end, wounded area
	Cladosporium sp	Fruit body
Stem-end rot	Mycosphaerella sp.	Stem end
Yellow crinkle	Tomato bug bud organism	Leaves, flowers
Papaya ring spot virus	Aphid vectors	Leaves ,stems and petioles, fruit
		rings pots and distorted.
Bunchy top	Bacteria	Death of growing point
Dieback	Unknown	Yellowing and death of crown leaes
Yellow crinkle	Leaf hopper	Yellowing and death of crown leaves
		Yellowing of lod leaves, crown leaves, show translucent area.

(Ref.20)

Some important insects and pests of papaya.

Common name	Scientific name	Parts affected	Distribution.
Melon fly	Bactocera cucurbitae	fruit	Widespread
Oriental fruit fly	Bactocera dorsalis	Fruit	South-east
			Asia, the
			Philippines,
			Western Pacific
			Hawaii
	Bactocera melanotus	Fruit	Cook Islands
			South Pacific
Mediterranean	Ceratitis capitata	Fruit	Hawaii, Mexico,
fruit fly			Central, South
			America,
			Middle East,
			Africa
Fruit fly	Toxotrypana curvicaula	fruit	American
			Tropics,Florida
American fruit fly	Anastrepha fraterculus	Fruit	Subtropical and
			Tropical
			America
Caribbean fruit fly	Anastrepha suspensa	Fruit	Florida
			Caribbean
Green peach aphid	Myzus persicae	Virus vector	Widespread
Red and black flat	Brevipalus phoenicis	Fruit	Widespread
mite			
Broad mite	Hemitarsonemus latus	Emerging leaes,	Widespread
		leaves of young	
		seedling	
Camine spider mite	Tetranychus cinnabarinus	lower surface of	Widespread
		Mature leaves	
Texas citurs mite	Eutetranychus banksi	Mature leaves	Widespread
	Eutetanychus orientalis		Thailand
Citurs red mite	Panonychus citri	Mature leaves	Widespread

Common name	Scientific name	Parts affected	Distribution.
Leaf hoppers	Emporasca spp	Emerging and first	caribbean and
		few leaves	Hawaii
Monkeys			Kenya
			Barbados
Birds			Caribbean ,Hawii
Bats			Vanuatu, South
			Pacific

(Ref. 20)

- Catterpillar of dasyses bores in the stem, it should be treated with tar. The red spider mite causing the leaves turn yellow and fruit become roughened and brownish. The cure is spray with Sulphur or Lime with Sulphur (Ref.4).
- The lesion caused by Pythium Aphanidermalum a solid-dwelling fungus. It is treated with 6-6-50 Bordeaux mixture, other fungi, bacterial and insect may cause secondary infections, the infected area surface painted with antiseptic solution, such as 4-5 % solution of Lysol or 50 % solution of crude carbolic acid, then protected it with tar. Pythium and Rhizoctonia, in order to control soil is treated with 2.5 % Formaldehyde solution. (Ref.4).
- South Asian fruit flies can not in feet papaya as their ovipositir is too short to pentrates skin of paypa.

Other Insect and mites of Papaya.

Scientific name	Common name
Insect- Aphids	
Aphis gossypii Glover	Cotton or melon aphid
Aphis craccivora koch	Cowpea aphid
Aphis middletonii Tomas	Erigeron-root aphid
Hyperomyzus lactucae (L)	
(= amphorophora sonchi (Oestlund))	Sonchus aphid
Macrosiphum euphorbiae (Thomas)	Potato aphid
Neomyzus circumflexus (Buckton)	Crescent-marked lily aphid
Myzus persicae (sulzer)	Green peach aphid
Rhopalosiphum maidis (Fitch)	Corn leaf aphid
Beetles	
Exillis lepidus jordan	Fungus weevil
Rhabdoscelus obscurus (Boisduval)	New Guinea sugarrvane weevil

Scientific name	Common name
Flies	
Ceratitis capitata (Wiedemann)	Mediterranean fruit fly.
Leafhopper	
Empoasca solane Delong	Southen garden leafhopperr
Mites	
Hellothis zea(Boddie)	Corn earworm.
Mealy Bug	
Pseudococcus obscurus Essig	Obscure mealybug.
Thrips	
Thrips (Thrips) tabaci Lindeman	Onion thrips
Mites	
False spider mites	
Brevipalpus phoenicis (Geijskes)	Red and black flat mites.

(Ref.9)

Genetic engineering work on papaya fruit crop.

Following possibilities of work on genetic development project.

a) Quality improvement.

Following possibilities exist:

- Can be used to develop crop having uniform dioecious, better pollination in isolated individuals and in-bred progenies develop desired characteristic, genetic purity.
- It is also used to develop fruit of good quality, short stature, precocity, long peduncles to avoid over population of fruit, elimination of female sterile - hermaphroditism and carpellody of the stamens, production of homozygotic diploid via anther culture and embryo rescue.
- It can be used for grafting of scion from desirable plants, with desired characteristics of seedling is possible.
- In this technology pistillate selection is used for colonial propagation, way to maintain fruit size and quality characteristics. Somatic mutation disrupt the gamete production.
- It may be used to control fruit size, total soluble solid contents, expression of carpellody and carpel abortion in hermaphrodites.

- It has another application in this study restriction fragment length polymorphism (RELPs) and random amplified polymorphic - DNA (RAPD) help to study genetic relationship in a germ plasm collection.

b) To develop resistant against infection and diseases.

- Genetic engineering can be used in somaclonal selection include resistance to pathogen that attack papaya, or tolerant to environmental stress.
- It is used to develop plasmid containing the genes necessary to synthesise nikkomycin which is used to developed anti-fungal papaya.
- It is used in embryo culture, ovule culture and somatic cell fusion to develop varieties with resistance to various diseases.
- The mosaic virus ,(its vector Aphis Spiraecola). (Ref.5)
- Dioecious cultivar name Cariflora, strong tolerant to papaya ring spot virus (PRSV). (Ref.20)
- It is used coat protein (CP)-mediated resistance gene of pathogenic virus, some time immune to infection of potex virus group. This results in to developing a virus resistant papaya.
- It is used to develop better nutritive and medicinal values, diseases resistant to; ascochyta, rhizopus, botryodiplodia, phytophthora, cercospora, fusarium, phomopsis and diplodia.
- It is used in nikkomycin, chilinese, cowpea trypsin inhibitors and Bacillus thuringiensis (Bt) enodotoxin genes to develop papaya resistance to fruit-fly and other insect and pest infections.
- Cultivar Cariflora, Tainung and No.5 are formed to be some what resistant to ring spot and the gene transfer can be achieved .
- In this technology the gene that code fungicidal, bactericidal protein and polypeptide that is low molecular weight peptide having structure of lytic peptides, will lead to successfully control bacterial blight caused by Erwinia species.
- It is used to isolate gene code for chitinases, isolated from bacteria and higher plants and clone papaya against fungal attack.
- To produce ring spot virus resistant papaya. It destroy leaves, diminishing the quality of fruit, eventually kills the entire tree. Papaya is infected by ring spot virus, which is rapidly transmitted by number of aphid species. Transgenic papaya, in which pathogen-derived resistant so transforming plant with pathogen gene become resistant transgenic plant. Sunset-Hawaiian Solo cultivar, transformed with coated protein gene of PRSV. This gene is shot into the cells of papaya. Future varieties UH Sunup and UH Rainbow by special gene gun, which result papaya resistant to virus.

c) To boost papain industry.

Papain enzymes was first separate by Theodore Peckholt (Ref.19)

- It is used for isolating and cloning genes and make it possible to transform a bacterial host with papain gene. This gene can perform bio-reactor process. It is also used in leather, wool, rayon and beer industries. Papain also used as remedy in dyspepsia and Kindred ailments (Ref.19)

d) To develop better nutrition, quality and post-harvest life.

- Genetics is used for micro-propagation of selected genotypes for colonel multiplication and embryo or ovule culture to produce desired characteristic like sex, gene manipulation to obtain true breeding hermaphrodite and develop cold-tolerant cultivars, and those not need a refrigerated lorries for their transportation.

- Papaya must have 11.5% sugar for proper flavour, varieties, timing of harvesting and ripening stage of fruit effect on final sugar composition of papaya. Putative complete invertase gene and sucrose synthetase gene is used to study sugar. South Asian Papaya has only 6-7% sugar. Hawaian papaya Solo has 14% sugar, 11.5% can be accebtible.
- It is used to develop fruit having high table quality, high in papain content, dwarf varieties, and varieties resistant to leaf curl disease, root and collar rot.
- It is used to slow ripening period, so fruit can be kept longer time with good fruit quality on the tree before harvest. The translocation sugar accumulation at the time of harvest, this affect on ripening period and genetic engineering one can increase post-harvest life of papaya fruit.
- It is used antisense inhibition of polygalacturonase expression for increasing papaya shelf-life.
- It is used Antisense suppression of ethylene production in transgenic tomato plant, this reduce fruit ripening and colour change and extend the papayas shelf life.

Scientist are trying anti-freezing/or cold tolerant gene and used in recombinant DNA technology.

Future papaya will have uniform fruiting, fruit size, quality, cold tolerance, fruit precocity and tolerance to various environmental conditions, with dwarf tree size.

Highly tolerant hermaphrodite Solo , more rapid growth, tolerance is achieved by using molecular biology and transformation of papaya, with a virus coat protein of mild virus strain that conifers resistance. Two resistant Solo lines, one with yellow flesh, Rain-bow, with red flesh and Sunup varieties have been release recently in Hawaii. (Ref.20).

Uses of Papaya:

Stem and leave

- The stem and leaves contains small amount of alkaloid Carpain , a heat stimulant. (Ref.

Vitamins

- Papaya is a fair source of calcium, pro-vitamin A, riboflavin and ascorbic acid, but a poor source of phosphorus, iron, thiamine and niacin.

Pain killer

- Papaverin extracted from the fruit is a powerful pain killer.

Chemical industry

- Papaya is used in clarification of beer, in tannin industry and in manufacture of chewing gum.

Pharmaceutical

- Carpaine, an alkaloid present in papaya, can be used as heart depressant, amoebicide and diuretic.

Papain uses.

2 kgs of fresh latex yield ½ kg Papain. It is a protein splitting enzyme, is used to tenderise meat. Papain is a proteolytic enzyme also used in chill-proofing beer and softening wood.

For papain production latex is collected by tapping the green unripe fruit. Four longitudinal incisions, skin-deep and 2-3 cm apart is made with sharp, non-corrosive rod. Latex is collected in porcelain container and dried. Tapped fruit can be processed or used as animal feed.

Papain sometimes called papayotin, is one of the most powerful plant proteolytic enzymes. This compound is distributed throughout the plant parts except, roots but is most concentrated in the latex of the fruit, commercial papain, obtained by drying the latex of mature but still green fruits is consumed in various industries

- A modern development is the injection of papain in to beef and cattle., an half-hour before slaughtering to tenderise more of the meat than would normally be tender. (Ref.1)
- It applied on tuna liver before extraction of oil, which is thereby made richer in Vitamin A and D2.
- It enters in to toothpaste, cosmetics, and detergents industries.
- Chemo papin some time injected to increase of slipped spinal disc or pinched nerve .
- Papain is also used in the fellmongering of sheep skins (separating the wool from the skin), pr-shrinking wool, tanning, the manufacture of chewing gum and the clarification of brewed beverages, 80% of beer is also treated this way.
- Manufacture of proteolysed preparations of meat, liver and casein.
- Processing of meat, veal and other pre-cooked foods and the manufacture of meat tenderising preparation.
- As a substitute for rennet in cheese manufacture.
- De gumming of natural silk, especially when mixed with rayon or wool.
- Wool treated with papain takes a silk-like sheen and becomes soft to touch, Papain treatment of wool, imparts shrinkage resistance and renders it washable like cotton fabrics.
- Tanning industry utilises papin for bating skins and hides.
- Clarification o fruit juices and fermented liquors.
- In the preparation of tooth pastes and cosmetics. Applied in weak solution externally. It removes freckles and blemishes from the skin and is a solvent of false membranes on warts.
- Manufacture of chewing gums.
- It us a component of many pharmaceutical preparation used for combating dyspepsia and other digestive disorder, various digestive mixtures and liver tonics contain papain also used for reducing enlarged tonsils. Used for medicinal purposed it is allergic to some person causing sere paroxymal cough, vasomotor rhinitis and dyspnoea. It is powerful poison when injected intravenously.
- Brewing , food industry, ordinary beer contain proteoses (partially split proteins).Which are soluble in beer at room temperature but precipitate as a cloud when the beer is chilled in the ice-box. The additions of a little papain breaks down three precipitable protein fragments still further so that they will no longer fall out of solution in the ice-box. The beer then may be chilled without turning turbid. (Ref.16)

Antibiotic activity of papaya.

Studies at the University of Nigeria have revelled that extract of ripe and un-ripe papaya fruit sand of the seeds are active against gram-positive bacteria. Strong doses are effective against gram-negative bacteria. The substance has protein-like properties. The fresh crushed seeds yield the Aglycone of glucotropaeolin benzyl-iso-thio-cyanate (BITC), which is bacterio-static, bactericidal and fungicidal. A single effective dose is 4 to g g seeds (25-30 mg BIT).

In London hospital in 1997, a post-operative infection in kidney-transplant patient was cured by slips of papaya, which were laid on the would and left for 48 hours, after all modern medication failed. (Ref.1)

Although some people are allergic with papaya-latex, flower smell, and papain activities. (Ref.1), but Scientist are working on developing a new varieties , showing no allergies reaction.

Conclusion.

Genetic engineering is used to develop papaya having, medium height, precocious cropping, uniform fruit size, moderate to long fruit stalk, multiple fruit stalks, tree and fruit resistance to mildew, fruit rot and other fungal diseases. Fruit should blemish free appearance, having small cavity, thick flesh, sweet and good flavour. Genetically evolved future papaya varieties like Solo, Bouestem, Graham, Fairchild, Betty, Kissimme, Co-1, Co-2, Rannchi, Barwani, and Halflong, have great potential in Pakistan. This technology will help to boost our agriculture economy of the country.

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