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Impact of Front Line demonstrations on yield and Economics of Okra [*Abelmoschus esculentus* (L.) Moench] in Eastern Uttar Pradesh

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ABSTRACT: Okra or okro (US: /'oukrə/, UK: /'ɒkrə/), *Abelmoschus esculentus*, known in some English-speaking countries as lady's fingers,^{[2][3]} is a flowering plant in the mallow family. It has edible green seed pods. The geographical origin of okra is disputed, with supporters of West African, Ethiopian, Southeast Asian, and South Asian origins. Cultivated in tropical, subtropical, and warm temperate regions around the world, okra is used in the cuisines of many countries.^[4] *Abelmoschus* is Neo-Latin from Arabic أَبُو الْمِسْك ('abū l-misk, "father of musk"),^[5] while *esculentus* is Latin for being fit for human consumption.^[6]

The first use of the word *okra* (alternatively; *okro* or *ochro*) appeared in 1679 in the Colony of Virginia, deriving from the Igbo word *ókùrù*.^[7] The word *gumbo* was first used in American vernacular around 1805, deriving from Louisiana Creole,^[8] but originates from either the Umbundu word *ochinggômbô*^[9] or the Kimbundu word *ki-ngombo*.^[10] Despite the fact that in most of the United States the word *gumbo* often refers to the dish, gumbo, many places in the Deep South may have used it to refer to the pods and plant as well as many other variants of the word found across the African diaspora in the Americas.^[11]

KEYWORDS: Okra, Bhenidi, seed pods, cultivation, Uttar Pradesh, front line, yield, economics

I. INTRODUCTION

Okra is an allopolyploid of uncertain parentage. However, proposed parents include *Abelmoschus ficulneus*, *A. tuberculatus* and a reported "diploid" form of okra.^[12] Truly wild (as opposed to naturalised) populations are not known with certainty, and the West African variety has been described as a cultigen.^[13]

Humans have known okra since ancient times, and in the Greek and Roman eras that passed through Egypt, okra was planted and carved images of it were found on Pharaonic temples, and it is endemic in generally hot regions in Africa and Asia. Okra originated in tropical Africa and was cultivated in the Middle East and India for a long time, and in the nineteenth century AD wild okra plants were seen on the banks of the White Nile in Sudan. Okra was introduced for the first time to Europe by the Umayyad conquest of Hispania. One of the earliest European accounts is by Abu al-Abbas al-Nabati who visited Egypt in 1216 and described the plant under cultivation by the locals who ate the tender, young pods with meal.^[14] From Arabia, the plant spread around the shores of the Mediterranean Sea and eastward.^[15]

The plant was introduced to the Americas by ships plying the Atlantic slave trade^[16] by 1658, when its presence was recorded in Brazil. It was further documented in Suriname in 1686. Okra may have been introduced to southeastern North America from Africa in the early 18th century. By 1748, it was being grown as far north as Philadelphia.^[17] Thomas Jefferson noted it was well established in Virginia by 1781. It was commonplace throughout the Southern United States by 1800, and the first mention of different cultivars was in 1806.^[14]

The species is a perennial, often cultivated as an annual in temperate climates, often growing to around 2 metres (6 ft 7 in) tall. As a member of the Malvaceae, it is related to such species as cotton, cocoa, and hibiscus. The leaves are 10–20 centimetres (4–8 in) long and broad, palmately lobed with 5–7 lobes. The flowers are 4–8 centimetres (1+⁵/₈–3+¹/₈ in) in diameter, with five white to yellow petals, often with a red or purple spot at the base of each petal. The

pollens are spherical and approximately 188 microns in diameter. The fruit is a capsule up to 18 centimetres (7 in) long with pentagonal cross-section, containing numerous seeds.

Abelmoschus esculentus is cultivated throughout the tropical and warm temperate regions of the world for its fibrous fruits or pods containing round, white seeds. It is among the most heat- and drought-tolerant vegetable species in the world and will tolerate soils with heavy clay and intermittent moisture, but frost can damage the pods. In cultivation, the seeds are soaked overnight prior to planting to a depth of 1–2 centimetres ($\frac{3}{8}$ – $\frac{13}{16}$ in). It prefers a soil temperature of at least 20 °C (68 °F) for germination, which occurs between six days (soaked seeds) and three weeks. As a tropical plant, it also requires a lot of sunlight, and it should also be cultivated in soil that has a pH between 5.8 and 7, ideally on the acidic side.^[18] Seedlings require ample water. The seed pods rapidly become fibrous and woody and, to be edible as a vegetable, must be harvested when immature, usually within a week after pollination.^[19] The first harvest will typically be ready about 2 months after planting, and it will be approximately 2–3 inches (51–76 mm) long.^[18]

The most common disease afflicting the okra plant is verticillium wilt, often causing a yellowing and wilting of the leaves. Other diseases include powdery mildew in dry tropical regions, leaf spots, yellow mosaic and root-knot nematodes. Resistance to yellow mosaic virus in *A. esculentus* was transferred through a cross with *Abelmoschus manihot* and resulted in a new variety called *Parbhani kranti*.^[20]

In the United States much of the supply is grown in Florida, especially around Dade in southern Florida.^{[21][22]} Okra is grown throughout the state to some degree, so okra is available ten months of the year.^[21] Yields range from less than 18,000 pounds per acre (20,000 kg/ha) to over 30,000 pounds per acre (34,000 kg/ha).^[21] Wholesale prices can go as high as \$18/bushel which is \$0.60 per pound (\$1.3/kg).^[21] The Regional IPM Centers provide integrated pest management plans for use in the state.^[21]

Okra is one of three thickeners that may be used in gumbo soup from Louisiana.^[24] Fried okra is a dish from the Cuisine of the Southern United States. In Cuba and Puerto Rico, the vegetable is referred to as *quimbombó*, and is used in dishes such as *quimbombó guisado* (stewed okra), a dish very similar to gumbo.^[23] It is also used in traditional dishes in the Dominican Republic, where it is called *molondrón*.^[24] In the Brazilian state of Bahia, okra is known as *quiabo* and is used to prepare *caruru*, a dish of cultural and religious importance - in addition to being a symbol of Afro-Brazilian cuisine.^[28] In South Asia, the pods are used in many spicy vegetable preparations as well as cooked with beef, mutton, lamb and chicken.^{[29][30]}

Pods



Stir-fried sliced okra fruits

The pods of the plant are mucilaginous, resulting in the characteristic "goo" or slime when the seed pods are cooked; the mucilage contains soluble fiber.^[25] One possible way to de-slime okra is to cook it with an acidic food, such as tomatoes, to minimize the mucilage. Pods are cooked, pickled, eaten raw, or included in salads. Okra may be used in developing countries to mitigate malnutrition and alleviate food insecurity.

Leaves and seeds

Young okra leaves may be cooked similarly to the greens of beets or dandelions, or used in salads. Okra seeds may be roasted and ground to form a caffeine-free substitute for coffee.^[14] When importation of coffee was disrupted by the American Civil War in 1861, the *Austin State Gazette* said, "An acre of okra will produce seed enough to furnish a plantation with coffee in every way equal to that imported from Rio."

Greenish-yellow edible okra oil is pressed from okra seeds; it has a pleasant taste and odor, and is high in unsaturated fats such as oleic acid and linoleic acid.^[34] The oil content of some varieties of the seed is about 40%. At 794 kilograms

per hectare (708 lb/acre), the yield was exceeded only by that of sunflower oil in one trial.^[35] A 1920 study found that a sample contained 15% oil.

Industrial

Bast fibre from the stem of the plant has industrial uses such as the reinforcement of polymer composites. The mucilage produced by the okra plant can be used for the removal of turbidity from wastewater by virtue of its flocculant properties. Having composition similar to a thick polysaccharide film, okra mucilage is under development as a biodegradable food packaging, as of 2018. A 2009 study found okra oil suitable for use as a biofuel.^{4,5,6}

Raw okra contains 90% water, 2% protein, 7% carbohydrates and negligible fat. In a 100 gram reference amount, raw okra is a rich source (20% or more of the Daily Value, DV) of dietary fiber, vitamin C, and vitamin K, with moderate contents of thiamin, folate and magnesium^{1,2,3}

II. DISCUSSION

Varieties

MDU 1, Arka Anamika, Arka Abhay and Parbhani Kranti

Hybrid

CO 3, CO BhH 1



Bhendi hybrid COBhH 1:

It is a cross between Varsha Uphar selection and PA 4 (T). It has resistance to yellow vein mosaic virus disease with high level of market preference. The fruits are dark green, slender, less fibrous and sparsely pubescent. Yields about 22.1 /ha under normal conditions.



CO.1 (1976):

It is a pureline selection from Red Wonder introduced from Hyderabad. Fruits are pinkish red in colour. It has a yield potential of 12 tonnes/ha in 90 days. It has a flesh content of 72 % and crude fiber content of 14.06%.



CO. 3 (1991):

It is a F1 hybrid between Parbhani Karanti x MDU.1. Yields about 16-18 tonnes/ha. Moderate resistance to Yellow Vein Mosaic disease^{7,8,9}

CO.2 (1987):

It is a F1 hybrid between A.E. 180 x Pusa Sawani. Fruit surface is less hairy with a better consumer's appeal and market preference. Fruits are very long with 7-8 ridges. It has a yield potential of 15-16 tonnes/ha in 90 days^{10,11,12}

Soil

It is adaptable to a wide range of soils from sandy loam to clayey loam.

Season

Planting can be done during June - August and February



Seed rate

Varieties : 8.0 kg / ha

Hybrids : 2.5 kg / ha

Seed treatment

Seed treatment with Tricoderma viride @ 4 g/kg or Pseudomonas fluorescens @ 10 g/kg of seeds and again with 400 g of Azospirillum using starch as adhesive and dried in shade for 20 minutes. Sow three seeds per hill at 30 cm apart and then thin to 2 plants per hill after 10 days.

Preparation of field

Plough the land 4 - 5 times and apply FYM 10 kg, neem cake 1 kg, super phosphate 100 g and Furadon 10 g/sq.m during last ploughing. Form ridges and furrows at 45 cm apart.^{13,14,15}

Sowing

Sow three seeds per hill at 30 cm apart and then thin to 2 plants per hill after 10 days.

Spacing

Seeds are sown at a spacing of 45 x 30 cm.

Layout and sowing for drip irrigation and fertigation

- Apply FYM @ 25 t / ha as basal before last ploughing.
- Apply 2 kg/ha of Azospirillum and 2 kg/ha Phosphobacteria by mixing with 50 kg of FYM.
- Apply 75 % total recommended dose of super phosphate ie 469 kg / ha as basal.
- Form raised beds of 120 cm width at an interval of 30 cm.
- Install the drip irrigation with main and sub main pipes and place lateral tubes at the centre of the each bed at an interval of 1.5 m.
- Place the drippers in lateral tubes at an interval of 60 cm and 50 cm spacing with 4 LPH and 3.5 LPH capacities respectively.
- Before planting, wet the beds using drip system for 8-12 hrs.
- Sowing to be done at a spacing of 90 x 45 x 45 cm in the paired row system, using ropes marked at 45 cm spacing.
- Spray Oxyflourfen at 0.15 kg ai / ha or Fluchloralin @ 1.0 kg ai / ha or Metolachlor @ 0.75 kg a.i / ha as pre emergence application on third day of sowing.
- Gap filling to be done at 7th day after transplanting.^{16,17,18}

Irrigation

Irrigation is done at weekly intervals.

Application of Fertilizers

Apply Azospirillum and Phosphobacteria each at 2 kg/ha mixed with 100 kg of FYM before sowing.

Varieties

Basal dose FYM @ 25 t/ha, N @ 20 kg, P @ 50 kg and K @ 30 kg/ha as basal and 20 kg N/ha at 30 days after sowing.

Hybrids

Basal dose FYM @ 40 t / ha, N @ 100 kg, P @ 100 kg and K @ 100 kg/ha as basal and 100 kg N / ha 30 at days after sowing.



III. RESULTS

Foliar nutrition

1 % urea (10 g/l) + muriate of potash (10 g/l) on 30 and 45 days after planting.

For hybrids, foliar application of water soluble fertilizer 19-19-19 three times @ 0.5% (5 g/l) at 10 days interval from 30 days after planting.^{19,20}

Fertigation schedule for hybrids

Recommended dose: 200:100: 100 kg / ha

Stage	Crop stage	Duration in days	Fertilizer grade	Total Fertilizer (kg/ha)	Nutrient applied			% of requirement		
					N	P	K	N	P	K
1	Sowing to plant establishment stage	10	19:19:19	26.30	7.50	5.00	5.00	10.00	5.00	10.00
			+MN	5.50	11.10	-	5.00			
			13:0:45	25.65	29.48	-				
			Urea	Subtotal	20.00	5.00	10.00			
2	Flower initiation to flowering stage	30	12:61:0	16.39	1.97	10.00	-	30.00	10.00	30.00
			13:0:45	88.88	11.55	-	40.00			
			Urea	144.52	66.48	-				
			Subtotal	80.00	10.00	40.00				
3	Flowering to fruit set	30	19:19:19	26.30	5.00	5.00	5.00	30.00	5.00	30.00
			+MN	55.55	7.22	-	25.00			
			13:0:45	103.87	47.78	-				
			Urea	Subtotal	60.00	5.00	30.00			
4	Alternate day from picking	30	12:61:0	8.20	0.98	5.00	-	30.00	5.00	30.00
			13:0:45	44.44	5.78	-	20.00			
			Urea	72.26	33.24	-				
			Subtotal	40.00	5.00	20.00				
	Total duration	100			200.00	25.00	100.00	100	25	100

75% RD of Phosphorus applied as super phosphate = 469 kg/ha.

1. 19:19:19 = 54 kg / ha
2. 13:0:45 = 200 kg / ha
3. 12:61:0 = 25 kg / ha
4. Urea = 350 kg / ha

Weed control

Spray Oxyflourfen at 0.15 kg a.i./ha or Fluchloralin at 1.0 kg a.i./ha or Metolachlor at 0.75 kg a.i./ha as pre emergence application on third day after sowing. Herbicide application should be integrated with one hand weeding on 30 days after sowing.^{21,22}

Plant protection

Pests

Fruit borers

1. Set up pheromone trap at 12 Nos./ha.
2. Collection and destruction of affected fruits.
3. Release of egg parasite *Trichogramma* at 1.0 lakh/ha.
4. Release of 1st instar larvae of green lace wing bug *Chrysoperla carnea* @ 10,000/ha.
5. Dust carbaryl 10 % DP @ 25 kg /ha or spray *Bacillus thuringiensis* @ 2 g/lit.or spray any one of the following insecticide^{23,24}

Insecticide	ml or g/lit,
Azadirachtin 0.03% WSP (300 ppm)	5.0 g/lit
Azadirachtin 5% Neem Extract Concentrate	5.0 ml/10 lit
Emamectin benzoate 5 % SG	3.0 g/10 lit
Phosalone 35 % EC	1.5 ml /lit
Pyridalyl 10 % EC	1.0 ml/lit
Quinalphos 20 % AF	1.5 ml / l.
Quinalphos 25 % EC	8.0 ml/10 lit

White fly and Aphids

White fly and Aphids can be controlled by spraying. Dimethoate 30 EC 2 ml/lit combined with Neem Seed Kernel Extract 5 %.

Leaf hopper

Treat the seeds with imidacloprid 48 % FS or 70 % WS @ 7 g/kg or Thiamethoxam 70 % WS @ 2.8 g/kg of seed. Dust carbaryl 5 % DP @ 20 kg /ha or carbaryl 10 % DP @ 25 kg /ha or apply carbofuran 3 % G @ 33 kg /ha or spray any one of the following insecticide²⁵

Insecticide	ml or g/lit,
Imidacloprid 70 % WG	0.7 g /10 lit
Imidacloprid 17.8 % SL	2 ml/10 lit
Thiamethoxam 25 %WG	1.0 g/10 lit
Azadirachtin 0.03 % WSP	5.0 g/lit
Azadirachtin 5% Neem Extract Concentrate	5.0 ml/10 lit
Dimethoate 30 % EC	2.0 ml/lit
Malathion 50 % EC	1.25 ml/lit
Oxydemeton –Methyl 25 % EC	1.6 ml/lit
Quinalphos 25 % EC	1.0 ml/lit



White fly

Ash weevil

Ash weevil can be controlled by the application of Carbofuran 3 G @ 12 kg/ha.

Nematode

Application of Carbofuran 3 G 1 kg a.i./ha or Phorate 10 G 1 kg a.i./ha and Neem cake 400 kg/ha at sowing in furrows along with fertilizers.^{24,25}

Diseases

Yellow vein mosaic virus

Spray systemic insecticides like Methyl demeton or Dimethoate @ 2 ml / l to kill the insect vector, whitefly.



Yellow vein mosaic virus

Powdery mildew

Dust Sulphur 25 kg/ha or spray Dinocap 2 ml/lit or Tridemorph 0.5 ml/lit or Carbendazim 1 g/lit or Wettable sulphur 2 g/lit immediately after noticing the disease and repeat after 15 days or four sprays of Triademphon (0.5%) at 10 days interval from 30 days after sowing.

Harvest

Harvesting can be done 45 days after planting. Fruits are harvested in tender stage at 1 – 2 days intervals.^{23,24,25}

Yield

12 - 15 t/ha

Market information

Crop Growing districts	Vellore, Salem, Coimbatore, Dindigul
Major markets in Tamil Nadu	Periyar Vegetable Market Koyambedu, Chennai Gandhi Market, Oddanchathiram Natchipalayam vegetable market, Coimbatore
Grade Specification	Light green or dark green, hairy or tender smooth surface, 5-ridged and remain tender for a longer period, medium length.

IV. CONCLUSIONS

IPM practices Package for Bhendi

- Seed treatment with Trichoderma viride (4g/kg) and Pseudomonas (10 g/ kg)
- Soil application of Pseudomonas and Trichoderma (each 2.5kg/ha)
- Soil application with Neem cake @250 kg/ha
- Maize as border crop against movement of whiteflies/ Liriomyza
- Use of yellow sticky traps
- Periodical removal of yellow vein mosaic virus infected plants
- Helicoverpa and Earias adult monitoring with pheromone traps
- Trichogramma release after each brood emergence of Helicoverpa and Earias



- Application of Neem oil formulations 10000ppm @1% / Neem seed kernel extract (5%)²⁵

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