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FISH AND FISHERIES RESOURCES OF GUJARAT STATE - AN INTRODUCTION

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Introduction

Gujarat is fifth largest state by area and ninth largest state by population of India, situated on the west coast of India. Fish and fisheries are the most important components for the financial growth, employment and development of Gujarat as it has largest costal line in India, its maritime climate, creek, marshy land mangrove forest etc. are gift of nature which provide great potential for the development of aquaculture. It pretentions of 1600 km long coastline, 1.64 lakh sq. km continental shelf and 2.14 sq. km exclusive economic zone. From these marine water resources it produced about 8.35 lakh tonnes of fishes and ranked 1st position in the country. In last few year Inland fish production also shown remarkable growth (1.34 lakh tonnes) in that leading district are Vadodara, Tapi, Surat and Narmada.

The people residing along the coastal belt of the state the river lake and reservoirs have been found traditionally engaged in fishing for immemorial time. In Gujarat total 1058 fishing villages are there out of that 280 are marine fishing village, 116 are inland fishing village and 82 are estuarine fishing village. As per 2007 census population of fisherman is 5.59 lakh out of that 2.18 lakh are active fisherman. For the smooth functioning of the fish landing process 107 marine fish landing centers developed by the state all along the coast.

Fishery resources of Gujarat

Fishery resources of Gujarat broadly classified as marine fishery resources inland fishery resources and brackish water fishery resources.

Marine fishery resources

The day when Gujarat acquired its constitutional existence that time fishery department had started for fisheries development in the state. After long journey and many ups and downs Gujarat fishery is known by its own contribution in Indian economy. Gujarat cover about 20.00 % coastline, 32.03 % of continental shelf of the country and gulfs (gulf of Cambey and Gulf of Kutch) created suitable environment for the fisheries development. Exclusive economic zone of Gujarat is estimated to be 2,14,060 sq.km and among the biggest ports of India Kandla and Porbandar port is also situated in Gujarat. Nowadays, Gujarat acquired first position in marine fish production and in the export of marine product and considering top most state among all maritime state of the country. The marine catches of the state is mainly consisting of Bombay duck, Ribbon fish, Shrimp, Pomfret, Cat fish, Squid cuttlefish, Jew fish, Lobster, Seer fish, Silver bar, Hilsa, Shark etc.

Inland fishery resources

Gujarat has about 2.28% water resources and 6.39% geographical area of India. The inland fisheries resources is mainly accomplished by rivers and canals with 4.81 lakh km followed by 347659 ha reservoir, 12000 ha derelict water and only 1.00 lakh ha of brackish water. The central and southern part of Gujarat containing about 80% surface water resources while remaining 20% resources

contained by rest of three-quarters of the state. All the major river of the state like Narmada, Tapi, Mahi, Sabarmati, and Poorna are originated from eastern part of the state and ended up in Arabian Sea in the west. The total length of the river of the state is estimated to be 3865.00 km. People who live near this river used to depend on fishing for their livelihood and use traditional mean of fishing. Sardar Sarovar on Narmada, Vallabh Sagar on Tapi are one of the biggest projects in southern Gujarat and these are primarily constructed for power generation and irrigation purpose but currently they playing important role in fisheries production. State has its own fish seed hatchery near Vallabhsagar reservoir (Ukai) and near Sardar Sarovar reservoir (Nana Kakdi Amba). These inland fishery resources of Gujarat mainly comprises of fish fauna commercially very important are major carps *Labio rohita, Catla catla* and *Cirrhina mirgala*, minor carps *Tor tor, Labeo frimbriatus, Labeo calabasu*, *Labeo bata* and Catfishes (*Mystus senghala, Mystus aor, Mystus cavasius, Wallago attu, Clupisoma garua* etc.

Brackish water fishery resources

The water current tidal amplitude or oceanic movement of Gujarat cost is comparatively high than other parts of western coast which create vast stretches of marshy and saline lands creek lands all along the coastal part of the state. Preliminarily it is revel that 89,341 ha is found more suitable for development of brackish water fish culture in the state whereas it having good brackish water fish culture potential with 3.76 lakhs coastal fallow land. For the sustainable development of brackish water fish culture land lease policy of the state was framed in the year 1987 and it was revised in 1994 and 2007.

Infrastructure

The majority of the fishermen of the state follow traditional and old fishing method design and type of gear and craft depend on the need, climate and local condition of the fishing areas. Fishermen use dug out canoes, plank, build loadhya, machhavas, wahans etc. With the help of this old and traditional craft fishermen can catch fish up to 5 km and 20 m depth. Use of motorized traditional crafts began in 1953 at Jaleshwar village (Veraval) of the state. The state of Saurashtra receives some low H.P. OBMs and IBEs under technical cooperation mission (TCM) aid from the USA. The first OBMs introduced were of 3 HP only subsequently from 1961 to 1966 introduction of higher HP OBMs was very intensive with an average rate of addition of about 98 boats per year. OBMs hardly received any policy support in any other state. Introduction of OBMs not only increased the production and raise the income but also improve the living standards of the poor sections of the fishermen. The seventh plan confined with the motorization of the traditional crafts. As per 2003-2004 census the state has 31000 boats of which 18635 boats were mechanized and 12365 boats were non-mechanized. In this year annual growth rate of mechanized boats were -5.25 while the growth rate of non-mechanized were 18.55%. In all 35532 boats operate near Gujarat coast in year 2017-2018 out of which 25612 boats were mechanized and 9920 boats were non-mechanized. In this year growth rate of mechanized boats was 0.027% while for non mechanized growth rate was -0.01. The growth rate of mechanized boats in 2010-2011 was 65.39% and for non mechanized boats were 34.60%.

Landing center and harbor facilities

From ancient time Gujarat was the developed port for the business and triad. Its geographical location favorable climatic condition made it the busiest treading centre and port. As we know fish is highly perishable food item. Quality control of fish basically depends on landing centre, harbor facility and cold storage facility. Beside this important infrastructure facilities other facility like repairing and maintenance of the boats, processing and freezing plants, fish meal manufacturing

plant, boat building yard, terminal division of fish harbor to keep watch on the movement of boats are included under the infrastructure. Government had developed many harbor and landing center to boost up the fishery industry in Gujarat. Today Gujarat has total 1058 landing centre including marine, inland and estuarine center. The first harbor in Gujarat was built in Veraval with the help of fund provided by UNDP and FDA international organization. In fifth year plan more emphasis was laid on the construction of harbor and fishing harbor. Under the World Bank project Mangrol and Veraval were develop as full fledged harbor. In 1991 another full fledge harbor was develop at Porbandar. All three harbors are provided with terminal division facility to channelize their activity and increase their function. Government has sanctioned Jakhao fishery project with 100% central support and Mangrol phase-11 with 50% central support.

Fisher flocks

People of Gujarat who live near the coast or river basically engaged themselves with fishing or other profession related with fishing. We can classify fishing profession as Actual fishing 73.04 %, marketing 16.62 %, net marketing repairing 9.93% hatchery 0.22% ornamental fishing 0.05 % and miscellaneous is 0.09 % Though Gujarat is traditionally vegetarian state but it is one of the most important fish producer state in India. It is noted that the exploitation of the resources is limited by the weakness of fish catching methods and inadequacy of the fishing harbors and fish landing facilities.

Government understand the important of this industry for the economical growth of state hence announced as well as launched many schemes for the rapid development of fisheries to uplift fishermen social life increase export of marine products and develop fish-based industry. The main objective of first three-year plan was to increase fish production by mechanization of traditional fishing craft while the exploitation of unstrapped resources was under taken during the fourth plan by introducing small and medium sized trawlers. From 1978 onwards subsidies on mechanized boats of 14.8 m and above were discontinued and an interest loans with moratorium was concentrating its attention on the development of harbors and jetty facilities and ice plants, freezing plants and approach roads.

Fish production and export

Gujarat rank first in marine fish production among all the maritime state of the country. In last two decades marine fish catches in Gujarat has gone up by three times. The total fish production was 654572 tons in 2003-04 while in 2017-18 it reaches to 8.35 lakh tones. Out of that 1.34 lakh tones was the contribution of the inland fisheries and rest (7.01 lakh tones) from marine. Shrimp culture has also shown remarkable growth in Gujarat fishery. Its contribution is very important as it is directly exported to the foreign country due to its demand so it stands as a source of foreign currency. During 2005-2006 shrimp production were 66520 metric tons which was the record production of shrimp from its beginning that time its contribution was 10.02% in Gujarat fishery. In 2017-2018 shrimp production was 55323 metric tons with 6.62% contribution in Gujarat fishery.

At the time of separate state formation of Gujarat, fishery sector of the state was very confined fish product which was exported to its neighboring country were either dried or in the fresh form. Gujarat fishery export trade has undergone great change over the year. In 1973 first time export of processed marine fish was started when a processing plant came into existence at Veraval. After that the drastic change came in the processing, freezing, fish curing sector which not only increase the quality of export fish but also increases the demand of Indian sea food in the overseas country. In the initial stage the surplus fish mainly sundried or salt cured were sent to Mumbai, from where

they were exported to neighboring country like Sri Lanka, Malaysia, Hong Kong, Singapore etc. The exported fish product mainly consists of Ribbon fish, Jew fish, Cat fish, Bombay duck etc. the system was changed after 1971 when trawl fishing was totally introduced in the state. Last 10 years were the golden year for the Gujarat fishery as state gives its consistent contribution in Indian export fishery. The state has exported 188 metric tons of processed fish worth Rs. 1264.61 crore in the year 2006-2007. That year contribution of Gujarat in the export fish was 30.71% in term quantity while 15.12% in term of money value with respect to Indian export fishery. In 2017-2018 marine product exported from Gujarat was 312586 metric tons amounting 955.68 crores money value. This year contribution of Gujarat was 22.7% in term of quantity while 11.24% money value with respect to Indian export fishery.

Government schemes for fishery development

The state government has introduced new schemes, programmers from the year 2006-07. Special attention has been given to provide infrastructure facilities to this activity. Plan provisions made in the last three years are given below. The GFCCA was set up in 1956 as apex fishery cooperative institution. It is engaged in different fishery activities like fish procurement and marketing, fish processing, storage export, boat building fishing gear, running net marketing plants, dry fish trade, sale of diesel etc. the member ship of GFCCA consist of 72 primary cooperative societies and individual fisherman in 1985-86. In the year 1995-96 primary cooperative 197 and 2225 individual fishermen were the member of GFCCA. The authorized capital is Rs.3 crore and paid up is 85.46 lakh. GFCCA has branches in Veraval, Delhi, Daman, Valsad, Diu, Jamnagar, Valod and Bilimora. Fishery society of Gujarat at district level is very active organization as it involves tribal as well non-tribal member. As per the 2011 census 232 district cooperative are working in the state.

Table 1. Fisheries resources of India and Gujarat

S.N.	Item	Unit	Details	
			India	Gujarat
1	Total geographical area	Square Kilometer	3287263	196024
2	Coastline	Kilometer	8118	1600
3	Continental shelf	Square Kilometer	530000	184000
4	Area of EEZ	Square Kilometer	2020000	214000
5	Brackish water Area	Hectare	1240000	376000
6	Fishing villages / towns	Numbers (2003)	3322	970
7	Fishermen house hold	Numbers	756212	88,358
8	Fishermen population	Person	16096975	140327
9	Active fishermen	Person	4000000	218000
10	Marine landing centers	Numbers	1537	217
11	Inland landing centers	Numbers	-	665
12	Estuarine landing centers	Numbers	-	88
13	Mechanized fishing fleet	Numbers (2003-04)	53684	18,369
14	Non-Mechanized fishing fleet	Square Kilometer	-	11,784
15	Reservoir Area	Million Hectare	3.15	0.286
16	Ponds/ Tanks	Million Hectare	2.414	22,000
17	Rivers and canals	Kilometer	195210	3685

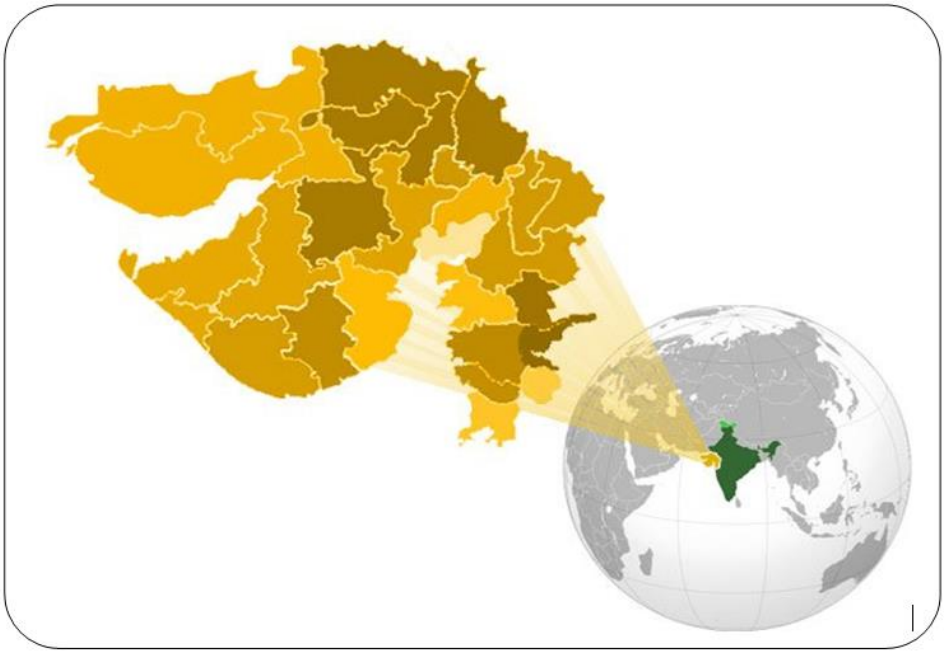

Figure 1. Map of Gujarat

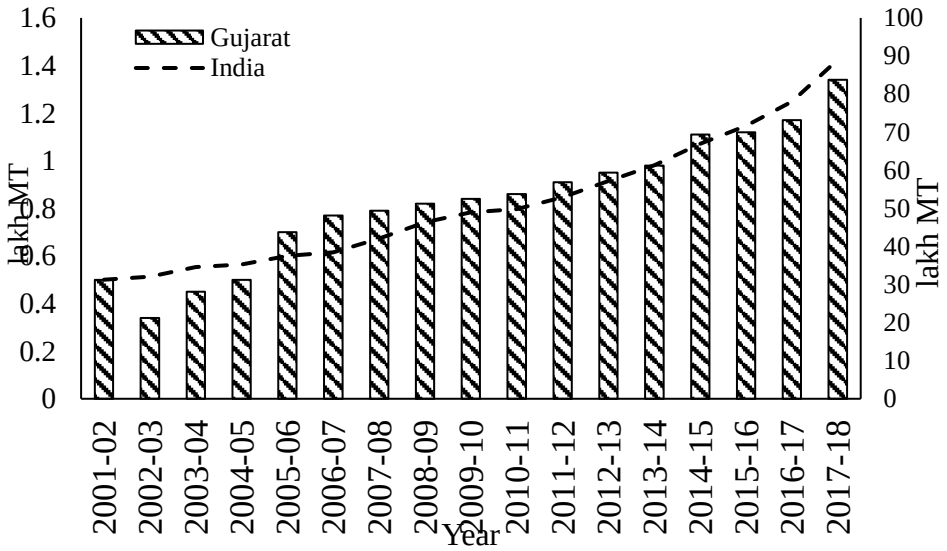

Figure 2. Inland fish production (Lakh MT) of India and Gujarat

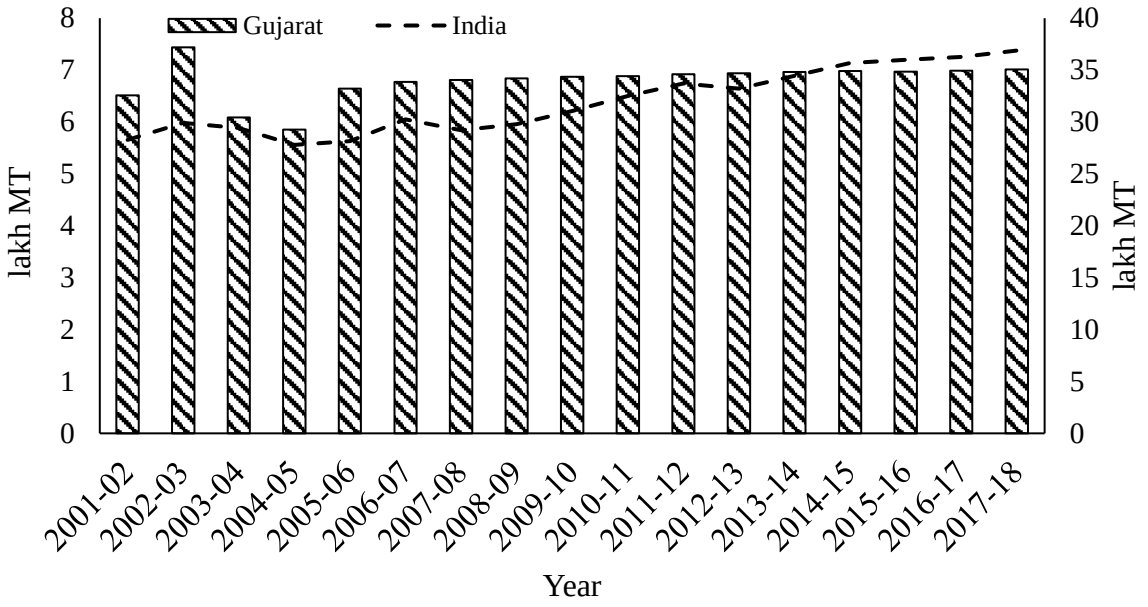

Figure 3. Marine fish production (Lakh MT) of India and Gujarat

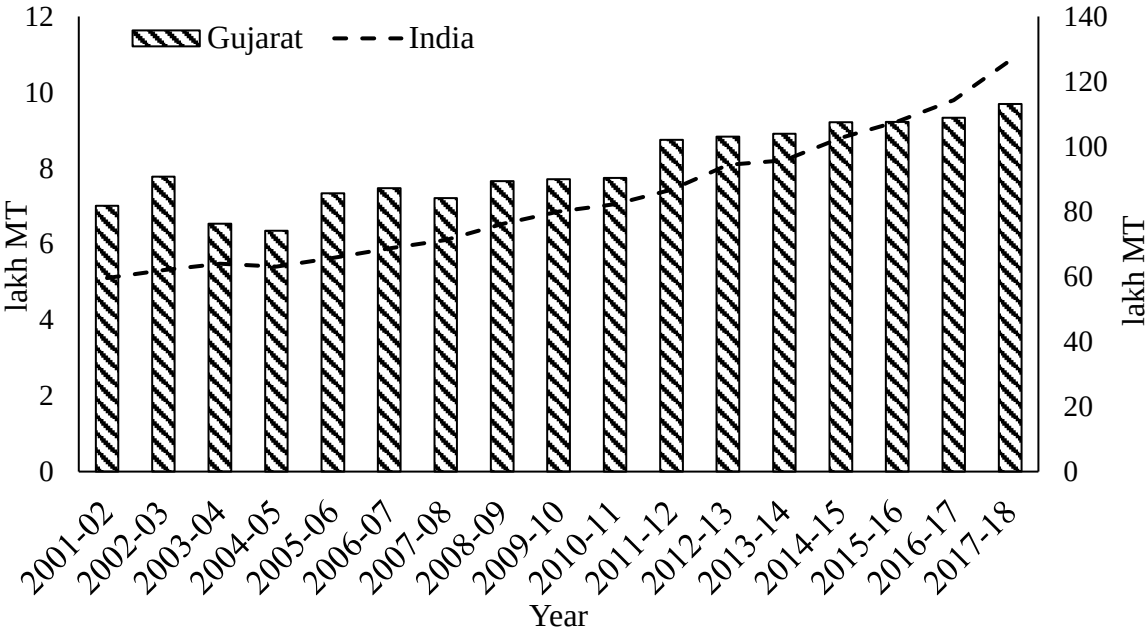

Figure 4 Total fish production (lakh MT) of India and Gujarat

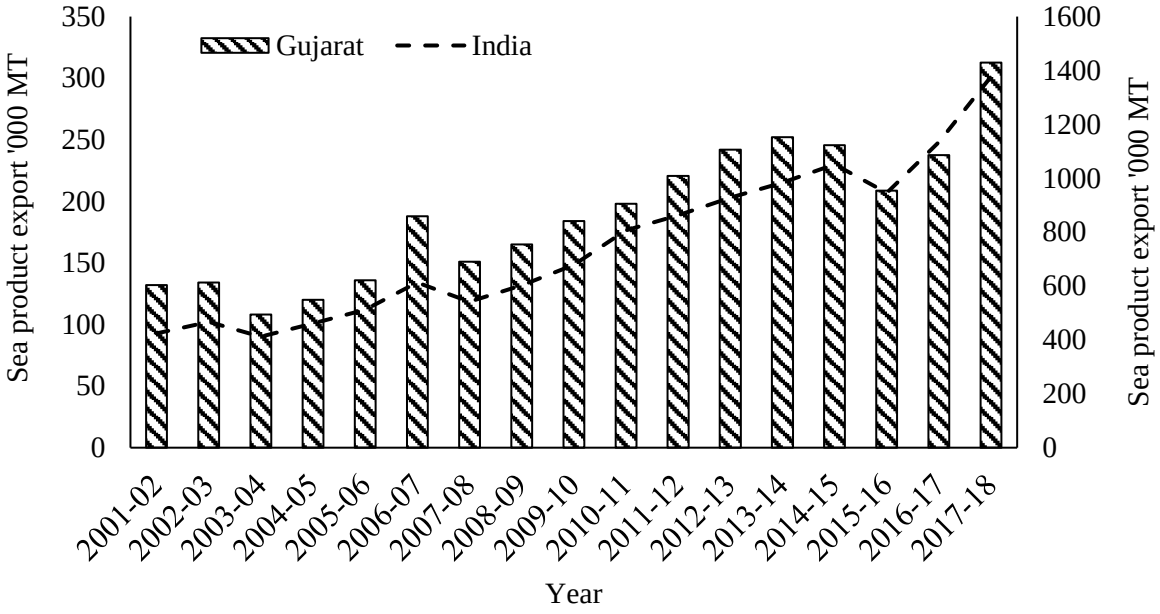

Figure 5. Sea product export (quantity) of India and Gujarat

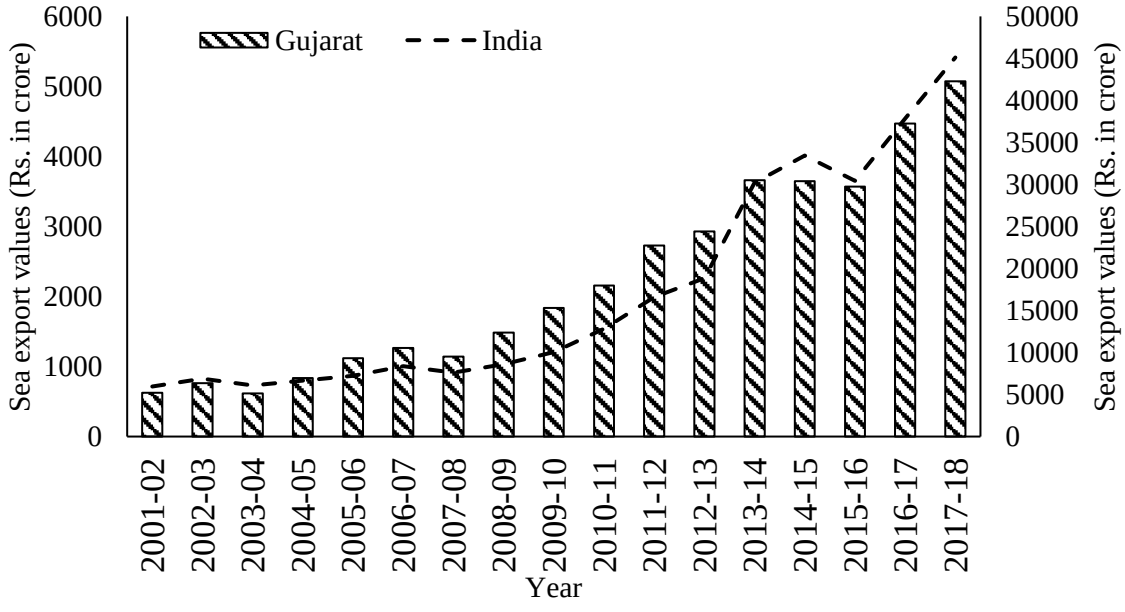

Figure 6. Sea product export (values) of India and Gujarat

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STUDIES ON INSECTS' PEST OF OKRA AND IPM PRACTICES'- A REVIEW BY AKKABATHULA NITHISH

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Abstract

Okra may be a good representative of the vegetables grown throughout India along with other crops. It stood as an essential vegetable of the tropical countries and most widespread in India. One among the key constraints in okra cultivation is its susceptibility to variety of insects' pest during different phases of its growth. Sucking pest are the most limiting factor for production of marketable fruit yield of okra. Aphid (*Aphis gossypii*), jassid (*Amrasca biguttula biguttula*) whitefly (*Bemisia tabaci*), Red cotton bug (*Dysdercus cingulatus*) and Green stink bug (*Nezara viridula*) etc. were the foremost prominent insects causing damage in okra at various growth stages of the crop. The sucking pests' movement will start when the crop is in vegetative phase. Fruit borer (*Helicoverpa armigera*) and shoot and fruit borer (*Earias vittella*) were the foremost prominent pests causing damage during the reproductive stage and are more active throughout the fruiting stage. To lessen the damage caused by these pests, farmers depend upon the utilization of an huge amount of synthetic insecticides aimed to control the pest, effecting environment, public health and also increase in insecticidal resistance to pest, resurgence in insects which ultimately affecting the interests in the growers. So on beat this problem, it is necessary to adopt IPM strategies which are developing for about eras to minimize the harmful effects of toxic chemical insecticides on atmosphere, eventually upsetting the benefits of the farming community. Numerous bio insecticides are discovered with wide-ranging action besides have the ability to develop as substitutes to toxic pesticides.

Keywords : Okra, insects' pest, IPM practices.

Introduction

Okra is one among the important vegetable crops grown in many countries. India, being largest producer among them is widely grown in West Bengal, Bihar, Gujarat, Odisha, Jharkhand, Haryana, Andhra Pradesh, Assam, Chhattisgarh, Madhya Pradesh, and Telangana. In India, okra is grown to an extent of 0.529 M ha with 61.51 lakh MT production and12.1 tonnes/ha productivity (Anon., 2017). It contributes 5.8 percent of the entire vegetable area and nearly 4 percent of total countries vegetable production. Varieties of insects attacking the crop are one among the factors liable for lower yields in okra. Shoot and fruit borer, jassids, whiteflies, fruit borer, aphids, leaf beetles, Looper, leaf roller, red cotton bug, green stink bug etc. are common insects in okra among which *Amrasca devastans*, *E. vittela, H. armigera* and *B. tabaci*, *Sylepta derogata* are the foremost notorious and major pests which may cause up to 69% yield loss (Dubey *et al*., 1999; Basu, 1995; Lohar, 2001; Rawat and Sahu, 1983). Several types of Scolytid beetles and Lagria beetles which were established in lesser colonies eat away the upper areas of leaves but the injury isn't much serious. Insect pest infestation not only reduces the crop development but also transmits pathogenic diseases (Sheedi, 1980; Dhaliwal *et al*., 1981).Nearly about more than 72 kinds of insect pest are documented in okra (Srinivasa and Rajendran, 2002) among them sucking pest causes substantial harm and losses to okra crop. Among the pests attacking okra, sap sucking insects like aphids,

leafhoppers and whiteflies were described as much severe pests in entire crop growth stages (Channabasavanna 1981; Singh *et al*., 1987). About 16 insect species were found attacking okra in India (Butani and Verma, 1976). Some insects cause serious economic losses by sucking the sap from the plants by piercing the leaves while some insects bore holes on them reducing the photosynthesis in leaves. The holes provide penetration entrance zones to plant pathogens (Pursglove, 1972).

Seasonal incidence and favorable conditions of okra pest

Insects infesting of okra belongs to 5 orders namely Heteroptera, Coleoptera, Orthoptera, Homoptera and. Lepidoptera. Numbers of several insect pests were higher during the minor season (September-December) than during the major season (April-July). The sap sucking insect pests, aphids and jassids made their appearance from third week when the crop was sown. The incidence of whiteflies appeared on around 30 days crop. Gradually, all the pests reached their peak on 42 days crop. Thereafter, pest populations started declining. The incidence of fruit borer started at initial picking and touched its peak on about ten week old crop, Chaudhary and Dadheech (1989). Yadav *et al.* (2007) stated that attack due to borer features a positive association by means of temperature and negative association with R.H. and rainfall. Slosser *et al*. (1998) described that aphids had rose in August and October months. Patel and Rote (1995), Preetha and Nadarajan (2007), Hegde *et al*. (2004), Anita and Nandihalli (2008) and Gulati (2004) stated that Aphids was highest during the second 15 days of October followed by first and second 15 days of November. Watson *et al*. (2003) reported that, temperature above 30°C rise the level of egg laying above 40°C reduce the lifespan phase of *B. tabaci* to less than 2 weeks. Threhan (1944), Ozgur *et al*. (1990) and Rao *et al*. (1989) reported that high temperature and low rainfall favour the rapid reproduction of the insects. Yadav *et al.* (2007) found direct correlation of maximum temperature and indirect correlation of R.H. with jassids on okra and also found direct correlation of both maximum and minimum temperatures and indirect correlation of evening R.H. with the whitefly on okra. Leafhoppers showed indirect correlation with maximum temperature, minimum temperature and with mean temperature and also with maximum relative humidity and minimum relative humidity whereas direct correlation with rainfall. Whitefly showed indirect association with extreme, least and mean temperature and extreme and least ratio whereas showed direct correlation with rainfall. Aphid showed indirect association with least and mean temperature, rainfall and extreme and least relation whereas showed direct association with extreme temperature. (Yajuvendra Singh et al, 2013). Dhamdhere *et al*. (1984), Devraj and Kumar (1987), and Pareek *et al*. (2001) reported that least temperature, relative humidity and rainfall had a significant indirect association in increase in insects. Fletcher (1919) recorded *A. affaber* occurrence during Dec to Jan on cotton, *Hibiscus cannabinus* Linnaeus and bhendi at Coimbatore. Beeson (1919) observed the commencement of the early progeny of the above species during July then another in September. The seasonal incidence of *A. affaber* on bhendi crop under Coimbatore condition was reported by Subramanian (1959). The weevil was more abundant during raining days from Sep to Dec and occurred only on crops raised in August. Only single generation of insects were reported on okra. Thippeswamy *et al.* (1980) observed highest population of shoot weevil during late sowing cotton crop (August). Sharma *et al.* (2012) described that the periodic existence of *A .affaber* in okra field in the first seven days of Aug and remains within the field up to December. The weevil is more in number during rainy season (August to November) at Samba in north India. Maximum oviposition was observed within the month of August and September with no oviposition after 14th of Oct. Thimmaiah *et al.* (1975) from Dharwad, Karnataka, reported a widespread occurrence of *A. affaber* on cotton and bhendi. The infestation on okra was about 82.66 percent recording more than one grub in each gall. The mites' invasion is regularly detected in the hot and dry spells. Gulati (2004), found a direct

association in mite population and extreme temperature, R.H. and sunshine hrs whereas, it had been negatively associated with least temperature. Gupta *et al*. (1998) reported that rise of relative humidity by one unit result in rise of 0.595% shoot infestation and for each one unit rise in precipitation, there was 0.154% decrease in fruit infestation by *E vittella* while **Sharma** *et al.* (2010) described that the number of insects was indirectly associated with the average temperature and also indirectly associated with rainfall in terms of larvae attack and proportion of plants infested.

Symptoms and nature of damage by insects

- **Jassids**

Krishnaiah (1980) found that leafhoppers can cause damage losses of 40 to 56% in okra. Rawat and Sadu (1973) found a decrease about 49.8 and 45.1% in height besides leaves, due to attack of leafhopper. Aphids and leaf hoppers have a tendency to stand as key pest during the initial crop period which decreases the yield by sucking the plant sap and making them weak. Chaudhary and Dadeech (1989) reported that failure to control the jassids in the initial stages can cause yield loss over 54.04%. Nymphs and adults attack during the entire crop period and desap the plant by sucking from lower portions of the leaves. Affected leaves turn yellowish and curl owing to injecting their toxic saliva into plant tissues when feeding (Singh *et al*., 2008).

- **Whitefly**

Both nymphs and adults damage the leaves by sucking the sap. As a result the leaves are curled and dried up. Plants infected with whiteflies are stunted in growth. Whiteflies in addition accountable for transmitting yellow vein mosaic virus.

- **Aphids**

Aphids are also considered as the chief insects of okra. Aphids attack many plants range belonging to 46 families. Both nymph and adult are invade different plant parts for sucking. Heavily infested leaves turn to yellowish in colour, get deformed, curled and dry up causing yield losses. They have ability in transmitting viral diseases on several plant hosts besides causing direct losses (Butani and Verma, 1976).

- **Flea beetles**

Flea beetles were very destructive to the flower, leaf and fruit, and the attack is severe on leaves. Beetles bored numerous holes on leaves by feeding on equally the upper and the lower sides of the leaves.

- **Blister beetles**

The blister beetles occur generally at the time of flowering stage. The adults attack on the flowers and young fruits and feed on them. Their numbers, however, reduced considerably after formation of fruits.

- **Epilachna beetles**

Grubs and adults impart a skeletonized or lacy appearance to leaves by consuming on the fresh matter of the leaf leaving veins and veinlets. Sometimes the leaves were completely eaten but their numbers reduced after flowering. As leaves shrivel and turn brown colour, severely attacked crop looks in to a dusty appearance.

- **Cotton stainer**

Nymphs and adults pierce and sucked sap from the fruits and leaves causing shriveling of both the pods and leaves.

- **Cotton leaf roller**

The newly emerged larvae roll the leaf and eat away the green tissue during initial stage and eats up much of the leaf as it grows. Severe attack indicates the occurrence of more leaf rolls and therefore such plants are ultimately stunted in growth.

- **Red spider mite**

Red spider mite has expected the status one of the key insects' pest causing crop damage loss of 17.45% in okra (Sarkar *et al.,* 1996). Both nymphs and adults were found in large colonies on underside of leaves cause damage by feeding on the lower surface of the leaf. On close examination of the lower leaf surface, mites smaller than a pin point may be seen. Attached leaves have characteristic blotches which become whitish then brown patches appear. Later the entire affected leaf become discolored and dried up. Under severe infestation, the top canopy of the plantis covered by webbing of mites. Mites attacked leaf curled up rapidly, become mottled, hard, and crisp and finally drop off. The mite infested plants are often recognized by the characteristic mottling symptom on the leaf lateral surfaces.

- **Mealy bug**

Damage is caused by both adults and nymphs by sucking from leaves, floral parts, fruits, also occasionally from the stems of plants even. Bugs profoundly suck the sap from the plant and make it fragile, delicate and responsible for yellowing, withering and drying of plants. Under much severity, sooty mould grows on honey dew released by bugs which decreases the photosynthesis in plants. Bugs infested fruits have less marketability.

- **Thrips**

Adults and nymphs suck the sap from flower buds and leaves as a result leaf margins are slightly curled up in affected leaves and therefore the leaf blades are having irregular surfaces. If infestation happens during flowering phase, such attacked flowers can wilt or fade. If population is high leaves could also be distorted.

- **Shoot and fruit borer**

In India *Earias insulana* and *Earias vittella* attack shoot and fruits of okra besides *Earias vettelle* has been identified as the key pest in other countries (Gapud, 1993). The larvae eat away smooth and developing tissues particularly terminal buds of main stem, and fruits, which in due course fall off. Brownish small caterpillars feed the contents by boring into the topmost fresh shoots and makes tunnels downwards through the main axis, resulting in shoot wither, droops down, wilt and dry. After boring the fruits, they feed within the fruits completing the growth inside the shoots and then in fruits. The infested plant bears smaller with deformed pods.

- **Shoot weevil**

The weevils lay their eggs in the nodal axil. The young tender plants are more vulnerable for attack. The grubs bore into tip of shoots and leaf axils due to which young plants are died. In severity, tunneling reaches the lowermost part of the main which stem results in breaking of the tree branches. Affected plants exhibit withering of shoot tips initially and future, holes with excreta can be noticed in the leaf petiole and shoot tip. The affected portion with fresh excreta is the sign of the existence of the grubs (Bhuvaneswari, 2006).

- **Fruit borer**

After hatching from eggs the newly emerged larvae eat away leaves for certain time and then bore into the developed fruits by hanging their bodies outside the fruit.

IPM in okra

Sardana *et al.* (2005) evaluated impact of IPM programmes to lessen pest infestation on okra and tested different IPM modules including bio-intensive, cultural and chemical treatments provided optimum control of pests. Al-Eryan *et al.*, (2001), Bindu *et al*., (2003), Paulraj and Ignacimuthu, (2005) reported bio agents and extracts of neem to be eco-friendly choices for regulatory of insects in okra. Botanical insecticides like Neem pesticides, microbials like *Bacillus thuringiensis*, *Metarrhizium anisopliae*, *Beauveria bassiana* and *Verticillium lecanii* and bio agents like spiders, *Chrysoperla* and *Trichogramma* should be integrated for financial control of insect in okra (Arora *et al*., 1996 and Abro *et al*., 2004). According to Kumar and Singh (2002) variety Arka Anamika harbored lesser population of jassids with minimum leaf injury. Broad usage of insecticides resulted in issues like pest resistance, resurgence, pesticide residues, destruction of beneficial fauna and environmental pollution (Adilakshmi *et al*., 2008).

Role of botanicals

Botanical insecticides are broad spectrum in nature for pest controlling and much of them are safe to use, unique in action and should be easily processed for using. Plant extracts, commonly called botanicals are secondary plant products synthesized by plants to safeguard them from pests, herbivores and diseases. Extracts from many plants are using to guard cultivated crops from insect pest attack. Three of the effective known plants with pest control properties are *Azadirachta indica, Lantana camara* and *Melia azedarach*. Leaf extracts of *Lantana camara* are shown to exhibit antimicrobial, fungicidal, insecticidal and nematicidal activities. Begum *et al*., (2000) reported that allelopathic compounds exist within the flowers, stem, leaves and roots of the plant. As per Dua *et al* (2003) these phytochemicals shows adverse effects on microorganisms, plants, and insects. Baidoo *et al*., (2017), evaluated the effect of ethanolic compounds of roots and leaves of *Lantana camara* in managing sucking pest of okra. Schmutterer, (1990) described that neem products have insecticidal, repellent, antifeedant, sterilising and growth inhibition effects against several insects spices. Treatment with neem oil alone and or in mixture with chemical insecticides for shoot and fruit borer reduces its damage (Samuthiravelu and David 1991, Sardana and Kumar 1989). Chitra *et al.* (1993) found reduction in okra shoot and fruit borer infestation by applying leaf extract of *Argemon mexicana* (0.10%), *Azadirachta indica* (0.10%) and Neemguard (0.50%). Temurde *et al.* (1992) reported that extract of neem leaf with mixing cypermethrin or fenvalerate gave better result in controlling okra shoot and fruit borer than did extract alone. Hajeri *et al*. (2007) described that neem based formulation achook as effective insect repellent causing reduction of whitefly population. Borkar *et al*. (2012) reported that neem oil 1 % amalgamated with insecticides is effective treatment for reducing whitefly population. Patel *et al*., (1990) found that Vilayati mehendi (*Clerodendrum inerme*) was very effective in minimizing the losses due to root-knot nematodes in okra. Neem oil-cake for soil amendment @ 1.5 t/ha in okra (Reddy and Khan, 1990), yellow mustard de-oiled cake @ 2.5t/ha in tomato and okra (Singh and Sitaramaiah, 1971), showed effectiveness in defending the crop against root-knot nematodes.

Role of bioagents

Beneficial insects or the **natural enemies** were considered as **farmers' friends**. Various beneficial organisms can help the farmer to retain pest under check and stop them from causing economic damage. So as to see the damage initiated by insects and for producing quality crop, it become necessary to control the insects at appropriate time with suitable measures because increase of the insects has been found as favoured by ecological elements. Spiders are general predators present in agro ecosystem feeding on phytophagous insects. Predatory spiders and coccinelids are the

foremost important defenders for insects of okra fields (Mishra and Mishra, 2002). Kumar *et al*. (2004) describe the predatory potential of spiders against insect pest and recorded 13 types of spiders in okra crop. Kubar *et al*. (2006) witnessed various spider species in okra crop feeding on phytophagous insects. Aphidophagous predators like *Chellomonos lunata*, *Chellomonos vicina*, *Coccinella septumpunctata* and *Menochilus sexmaculata* are recognized as key regulating factors in managing aphids. They also prey on mites, whiteflies, small insects and eggs of insects etc. The parasitoids of hymenoptera order, *Aenasius bambawalei* is extremely active against mealy bug and about 70-80% parasitization has been documented in some places.

Role of insecticides

Chemical pesticides have to be applied used based on the recommendation of CIB & RC (www.cibrc.gov.in) as a last alternative. Sinha and Sharma (2007) recorded that the spraying thiamethoxam 25 WG @ 20 g a.i. per hectare at 30 days of sowing was best in leaf hopper control and also spraying thiamethoxam 25 WG @ 25 g a.i. per hectare showed effective control at 50 days after sowing against leafhoppers in okra. Sinha and Sharma (2008) found that spraying thiamethoxam 25 WG @ 20 g a.i. per hectare at 15 days interval effectively reduced the jassid population in okra. Sinha *et al*. (2007) concluded that foliar application of thiamethoxam @ 20 g a.i. per hectare at 15 days interval was best in reducing the leaf hopper population. Bhalala *et al*. (2006) reported that foliar applications of thiamethoxam 25 WG at fortnightly interval at two higher doses (50 and 37.5 g a.i./ha) showed higher effectiveness in controlling sucking pests of okra. Mishra and Senapati (2003) found thiamethoxam 25 WG @ 50 g a.i. per hectare gave significant control over jassids in okra when sprayed at an interval of 15 days. Subhadra *et al.* (2002) found thiamethoxam @ 25 g a.i./ha as best insecticide against okra leaf hopper when sprayed at 15 days interval. Pathan *et al*. (2010) found that need based (ETL) spray of thiamethoxam 25 WG @ 0.0125% was best and protected the okra crop from sucking insects. Mitalilal *et al*. (2005) reported that imidacloprid at 40 g a.i. per ha was effective treatment in decreasing the jassid population in okra. Bhargava and Bhatnagar (2001) found that seed treatment with imidacloprid 600 FS at 9 ml/kg seeds and 70 WP at 10 g/kg seeds was found to be efficient for jassids. Rohini *et al* (2012) described that thiamethoxam 5 SG @ 0.2 pram per litre was best against whiteflies. Such outcomes were reported by Mohansundaram and Sharma (2011) by using thiamethoxam 25 WG. Raghuraman and Ajanta (2011) found that imidacloprid 17.8 SL @ 80 gm a.i./ha had significantly inhibited whiteflies due to which the yield in okra is increased. Leeuwen *et al*. (2006) observed spinosad as effective insecticide against whitefly nymphs at doses of 2 mg active ingredient per plant. Ghoshal *et al*. (2013) found that thiamethoxam 25 WG was effective against aphid in okra. Gavkare et al. (2013) found that, thiamethoxam was the foremost toxic insecticide against green peach aphid *Myzus persicae*. Mishra (2002) declared that thiamethoxam at @ 25 g a.i. /ha when sprayed after 40 and 60 days of sowing effectively manage the aphid incidence in okra. Anitha and Nandihalli (2009) applied thiamethoxam 25 WG @ 0.2 gm/l as foliar spray and registered highest fruit yield. Similarly, Venkataravanappa *et al*. (2012) found that thiamethoxam 25 WG gave highest fruit yield in okra.

Conclusion

It is needed to conclude that IPM practices provide operative managing actions on the insects' pest complex of okra on large scale. IPM in okra is an appropriate tool of wise use of bioagents, botanicals and lastly the synthetic chemical insecticides. Moreover, IPM could also be suggested as a virtuous substitute for the solely chemical dependent agriculture. Botanicals give effective control just like the synthetic insecticides and can remain encouraged overcoming the issues related to insecticides.

The incorporation of bio insecticides in IPM technology is additionally gaining importance during current days. Hence more studies on IPM practices on okra crop against insects must be explored.

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SCOPE OF KARONDA (CHRIST'S THORN), A SEMI WILD FRUIT CROP IN NORTH EAST INDIA

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Abstract
Karonda (*Carissa carandas*), a fruit of dryland which is an indigenous shrub widely grown in India is able to flourish well in marginal and wasteland where other crops of commercial importance are unsuitable. These hardy, evergreen, spiny shrubs widely grown in India have the richest of iron mineral among the fruit crops. Further research work on varietals selection among the different morphotypes which are widely found in India and value addition for preparation of commonly accepted products are needed for this underexploited minor fruit crop. Therefore, there is scope for the introduction of karonda in the tropical and subtropical areas of North East India due to its medicinal value and great demand in the international market.

Key words : Karonda, hedge plant, iron mineral, nutritional value

Introduction

Karonda (*Carissa carandas*) which is popularly known as 'Christ Thorn Tree' is a hardy, evergreen, spiny belonging to Apocynaceae family and indigenous shrub widely grown in India. It is found wild in Bihar, West Bengal and South India. It is grown commonly as a hedge plant and regular plantation are very common in Varanasi district of Uttar Pradesh. In North East Region of India this shrub is rarely grown. However, it is now started introduced as homestead garden in East Siang district of Arunachal Pradesh and performing well. It is a non-traditional fruit crop which thrive well as a rainfed crop, once established, the plant hardly needs any care and gives yield with minimum management. It is very hardy and drought, it thrives well throughout the tropical and subtropical climates. Heavy rainfall and waterlogged conditions are not desirable. It can be grown on a wide range of soils including saline and sodic soils. Therefore, this medicinal value underutilized fruit crop can be introduced in the tropical and subtropical region of North East India to boost the marginal farmer income generation from this semi wild underexploited fruit crop.

Uses and its medicinal value

Fruits are sour and astringent in taste, are the richest source of iron containing good amount of vitamin C and very useful to cure anaemia. Its fruits have antiscorbutic properties and very useful to cure anaemia also. Ripe fruits are sub-acidic to sweet in taste with peculiar aroma and can be used in the preparation of fruit products such as jelly, sauce and Carissa cream or jellied salad. The unripe fruits are sour and astringent and can be used for pickles, sauces and chutneys as reported by Bose *et al*. (1999). Besides, nowadays ripe processed products in sugar syrup are sold in name of cherry in local market.

Table 1: Proximate composition of fresh karonda fruit

Constituent (values/100 g edible portion)		Minerals (mg/100g)	
Moisture	91.00	Calcium	21.00
Protein	1.10	Phosphorous	38.00
Carbohydrates	2.90	Iron	39.10
Fat	2.90		
Fibre	1.50		
Calorific value	42.00		

Source: (Anon, 1950)

Varietals development of karonda in India

In India, there is genetic diversity of karonda are found which need screening for superior genotype. There are no well established varieties of karonda although the cultivated types classified according to fruit colour a green-fruited, pink-fruited and white-fruited by Singh (1969). However, the differences are not much in shape and size of fruits in all the three types. At Konkan krishi Vidyapeeth (KKV), Dapoli, three plants namely No. 2, No. 5 and No. 2 (from another location) were reported to be promising by Bhagwat (1984). In Eastern Uttar Pradesh (India) identified 4 types of fruit, viz. green, white with pink blush, green with purple blush and maroon as reported by Kumar and Singh (1993).

Soil and climate

Karonda being very hardy and drought resistant, it thrives well throughout the tropical and subtropical climates. Heavy rainfall and waterlogged conditions are not desirable. It can be grown on a wide range of soils including saline and sodic soils (Bose *et al*., 1999).

Propagation

It is commonly grown from seeds. The fresh seeds are sown in nursery during August-September after extraction fron ripe fruit. One year old seedlings are transplanted in the mianfield when seedlings propagation is done (Banik *et al*., 2012).

Post harvest management of karonda fruit

The fruits harvested at maturity can be stored for a week at room temperature whereas fruit harvested at ripe stage are highly perishable and can be stored only for 2-3 days and it can be stored for 6 months in sulphur dioxide (SO_2) solution @ 2,000ppm as reported by Chadha (2003). Besides, nowadays ripe fruit of karonda are processed with sugar syrup and sold in the market as karonda cherry which is a popular processed product. Moreover it is use as ingredients for making pickle.

Scope of karonda in North East India

Karonda being hardy, evergreen, spiny and widely grown in India and performing well in the foothill region of Arunachal Pradesh, it can be introduced in North East Region of India in the tropical and subtropical region since it the richest of iron mineral among the fruit crops and processed products like pickle, karonda cherry are high demand in the market. Besides it is decorative and useful as live fencing as hedge plant.

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Fig 1. Karonda shrub bearing ripe fruit

Fig 2. Karonda cherry (Processed product)

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WATER USER ASSOCIATIONS AND ITS ROLE IN IRRIGATION MANAGEMENT IN INDIA

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Abstract

Establishment of Water Users Associations (WUAs) is one of the most promising approach for improving the productivity and sustainability of irrigation. Improved management of irrigation can help tap the tremendous potential which the Indian agriculture sector holds. This will ultimately contribute to the overall economic development of the country. The Government of India, since the 1987 National Water Policy, has identified Participatory Irrigation Management (PIM) through WUAs as a key vehicle for achieving this end. Till date, around 85,000 WUAs covering an area of 14.5 mha have been formed in India across 24 states of India through the initiatives undertaken by the central and state governments. To realize the full benefit of WUAs, several constraints such as lack of a systematic organizational framework, insufficient awareness and trainings of farmers and technical staffs etc needs to be addressed.

Introduction

Water is a critical input in agriculture and has an influential effect on crop yield. Indicators of water stress and scarcity mirror the water availability in a region. A country is classified as water stressed and water scarce if the per capita availability of water falls below 1700m^3 and 1000m^3, respectively (Kummu et al., 2016). The annual per capita water availability in India declined from 1816m^3 in 2001 to 1544m^3 in the year 2011 (Dhawan, 2017). Therefore, our country falls under the 'water-stressed' category. Further challenged by the impact of climate change coupled with enormous wastage owing partly to poor management and distorted water pricing policies, it is rapidly moving towards water scarcity.

Combating over use of water consumption in the agriculture sector is crucial for the growth and sustainability of the sector. Optimizing water consumption and adopting efficient management strategy is the need of the hour. The implementation of a participatory management of water resources in the rural areas and the creation of Water User Association (WUA) can be a successful approach towards this management. Recognising this importance, states have been trying to encourage farmer participation in the management of irrigation systems in India particularly through establishment of Water Users Associations (WUAs) for raising the productivity and sustainability of irrigation systems. It helps address common issues with publicly-managed irrigation schemes, in particular poor upkeep of physical system, underutilization of irrigated area developed, high fiscal cost, low water productivity, and poor irrigation service.

What is Participatory irrigation management?

This refers to the involvement of irrigation users in all facets of irrigation management particularly through the establishment of WUAs. PIM approach is central for managing irrigation projects so as to conserve water resources and ensure its optimal utilization. It involves the participation of farmers, irrespective of gender, in the new irrigation system by letting farmers to participate in the design.

- Reduce the recurrent government expenditure on operation and maintenance by replacing financially self-reliant water service providers.
- Reverse the increasing rate of deterioration of irrigation infrastructure.
- Provide transparency in management and accountability of the service from provider to water use.

What are WUAs?

A Water Users Association (WUA) is a co-operative association of individual water users who wish to undertake water-related activities for their mutual benefit. WUAs are user-based and participatory ways to manage water resources. It is generally formed within the command areas of irrigation schemes (major, medium or minor) and help bring about farmer participation in irrigation systems management. They are aimed at achieving efficient and equitable water distribution for increased agricultural production and farm incomes. WUAs are intended to improve water delivery, enhance crop production by giving the farmers the chance to involve in the irrigation management process. It is important in managing and maintaining the irrigation system for effective and reliable supply and distribution of water. However, the specific nature WUA services varies as per situation as member needs also vary from one location to another.

Working of WUAs

Under the PIM system, WUAs has been formed within the command area of government irrigation schemes to hand over these irrigation schemes to WUA. WUAs are self-governed organisations of farmers who pool their financial, technical and human resources for the use and maintenance of a defined watershed, including irrigation agriculture, livestock production and fisheries. The daily functioning of WUAs is supervised by a managing committee which comprises of a president and managing committee (4-10 in number) who are elected by the members. Any dispute arising among members or between members and the managing committee members or among the WUAs is resolved by the apex committee

Importance of WUAs

WUAs acts as an interface between farmers and the main management system. This ensures optimal and equitable distribution of irrigation water in a phased manner. The farmer members of the WUAs are engaged in optimizing cropping systems to save water. It helps in creating a sense of ownership of water resources and the irrigation system among the users, so as to promote the economy in water use and preservation of the system thereby warranting its sustainability. Additionally, formation of WUAs aids in recommending cropping patterns and packages of agricultural practices suitable for the WUA's farmers. Moreover, the association helps in arrangement of inputs for its members for undertaking irrigated agriculture and assist in propagation of better on-farm water application.

Status of WUAs in India

Due to various awareness efforts taken up by the Ministry of Jal Shakti, GoI, the need for actively involving farmers in management of irrigation system has been recognised by the state governments. Presently, 16 Indian states have formulated legislation to support PIM and to enable the formation of WUAs. Punjab, Haryana and Manipur have drafted their PIM bills which are in the process of enactment. There is prospect of Arunachal Pradesh and Himachal Pradesh following the PRI Acts. Thus, most of the states have decided to move towards PIM. According to the Ministry, till date, around 85,000 WUAs covering an area of 14.5 mha have been formed in India across 24 states of India (Table 1) and are functioning with various degrees of success and impediments. The process

of formation of WUAs as a vehicle for better irrigation water management is gradually gaining momentum in the country.

Table 1: State-wise number of Water Users' Associations (WUAs).

Sl. No.	State	No. of WUAs	Area covered ('000 hectare)
1	Andhra Pradesh	10884	4179.25
2	Arunachal Pradesh	43	10.97
3	Assam	847	95.02
4	Bihar	80	209.47
5	Chhattisgarh	1324	1244.56
6	Goa	84	9.54
7	Gujarat	8278	662.99
8	Haryana	8490	1616.27
9	Himachal Pradesh	1173	140.56
10	J & K	383	32.794
11	Jharkhand	0	0
12	Karnataka	2787	1418.66
13	Kerala	4398	191.22
14	Madhya Pradesh	2062	1999.64
15	Maharashtra	2959	1156.22
16	Manipur	69	29.4
17	Meghalaya	159	20.17
18	Mizoram	390	18.23
19	Nagaland	24	3.44
20	Orissa	20794	1757.71
21	Punjab	4845	610.29
22	Rajasthan	1994	1144.45
23	Sikkim	0	0
24	Tamil Nadu	1910	935.664
25	Telangana	0	0
26	Tripura	0	0
27	Uttar Pradesh	802	318.69
28	Uttarakhand	0	0
29	West Bengal	10000	37
Total		**84779**	**17842.208**

Government Initiatives

There has been an increased awareness in our country for the need to actively involve farmers in management of irrigation system. Accordingly, the following states have enacted exclusive legislations for involvement of farmers in irrigation management:

- "Andhra Pradesh farmers" management of irrigation systems Act, March 1997.
- The Assam irrigation water users Act, 2004.
- "The Bihar irrigation, flood management and drainage rules, 2003" under Bihar irrigation Act, 1997.
- "Chhattisgarh Sinchai Prabandhan Me Krishkon Ki Bhagidari Adhiniyam, 2006".
- "Goa command area development Act, 1997"

- Gujarat water user's participation management Act, 2007.
- Karnataka state promulgated an ordinance on 7th June 2000 for amendment of the existing Karnataka irrigation Act, 1957.
- "The Kerala irrigation and water conservation Act, 2003".
- "Madhya Pradesh Sinchai Prabandhan Me Krishkon Ki Bhagidari Adhiniyan, 1999.
- "The Maharashtra management of irrigation systems by farmers Act, 2005".
- Nagaland farmers participation in management of irrigation systems Act, 2013.
- "The Orissa Pani Panchayat Act, 2002".
- The Rajasthan Sinchai Pranali Ke Prabandh Me Krishkon Ki Sahabhagita Adhiniyan, 2000".
- "Sikkim irrigation water tax, 2002" and "Sikkim irrigation water tax Act, 2000".
- The "Tamil Nadu farmers" management of irrigation system Act, 2007.
- The 'Uttar Pradesh irrigation management Act, 2009".

Constraints in formation of WUAs

Several constraints are faced by farmers in the implementation of PIM and formation of WUAs. Mention may be made of lack of a strong legal framework for formation and working of WUAs, lack of sufficient awareness campaigns and trainings for the farmers, poor coordination with local authorities and state government, lack of leadership ability and administrative skills, uncertainty of water availability etc.

Conclusion

Efforts towards development, planning, conservation, utilization and management of both surface and ground water, in a judicious, equitable, sustainable and sound economic manner is of utmost importance, especially in a water stressed agriculture-based country like India. The role of PIM and efficient working of WUAs is of paramount importance in this regard. Farmer's participation will play a vital role in water conservation by optimal use of water. Apart from the continued effort made by the central government for development of WUAs, concrete steps towards overcoming the various constraints faced by the farmers and local authorities needs to be addressed with urgency.

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DNA MARKERS AND ITS USE IN CROP IMPROVEMENT

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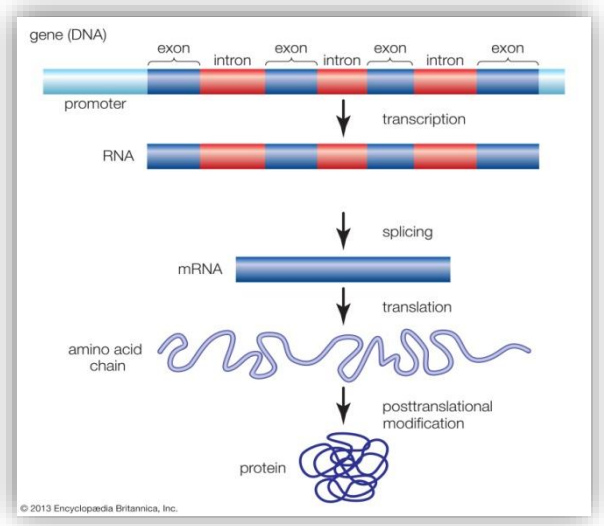
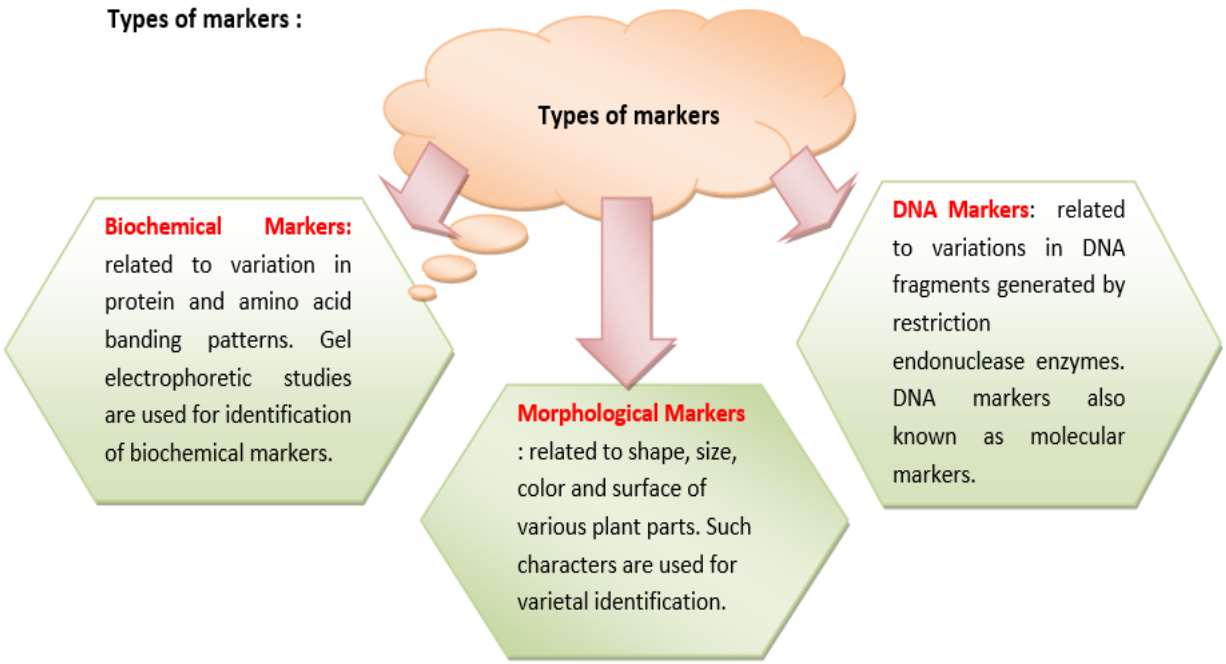
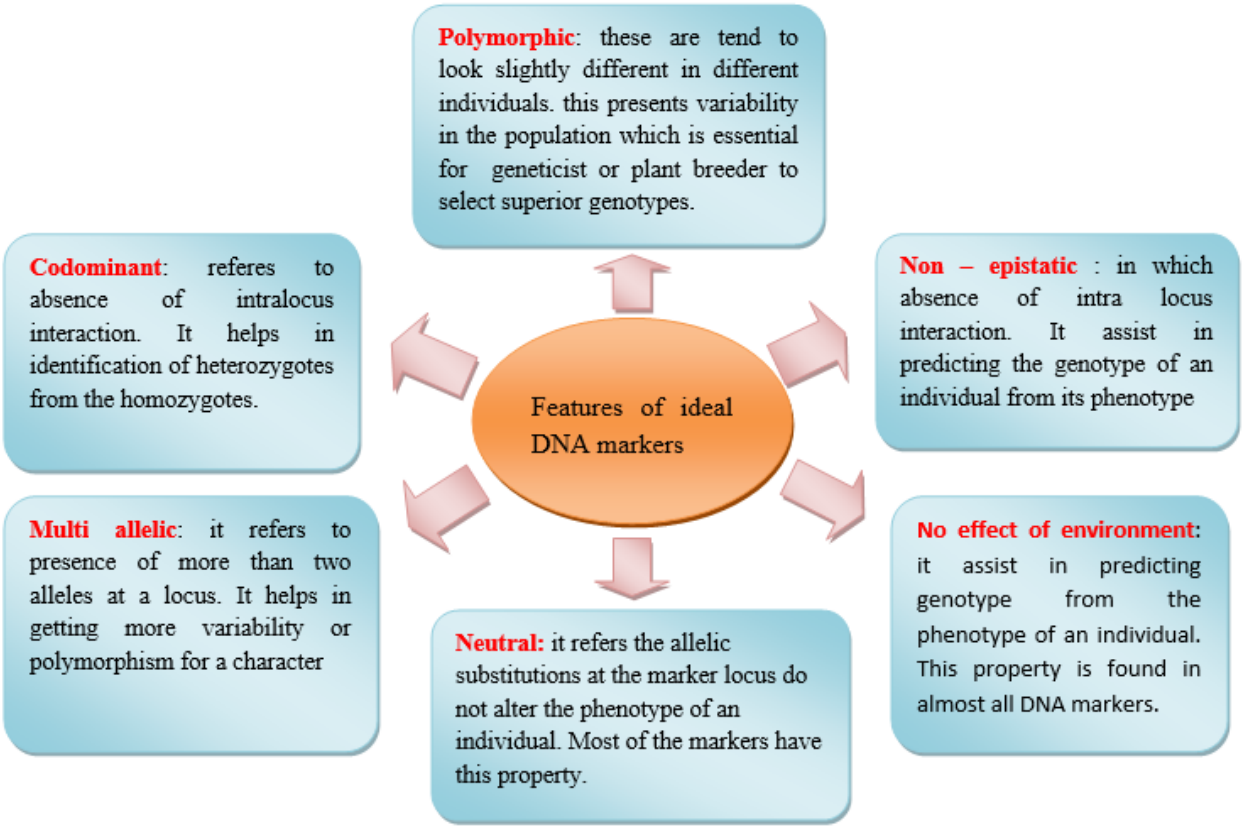
Introduction



The property of an individual which shows heritable variation is known as a character. It is a unique (DNA sequence), occurring in proximity to the gene or locus of interest. It refers to any unique DNA sequence which can be used in DNA hybridization, PCR or restriction mapping experiments to identify that sequence. DNA markers are also known as molecular markers or genetic markers. It includes morphological, physiological and biochemical properties in plant. plant characters are of two types that are qualitative (governed by one or few genes) and quantitative (governed by several genes) . To overcome problems associated with morphological markers, the DNA-based markers have been developed. those characters which can be easily identified are called as marker characters.



Features of Ideal DNA Marker



Types of DNA Markers:

1. Restriction Fragment Length Polymorphisms (RFLPs):

RFLPs known as variations found within the length of DNA fragments of a species generated by specific endonuclease. RFLPs are first type of DNA markers generated to distinguish individuals at the DNA level. RFLP technique was developed before the invention of Polymerase Chain Reaction (PCR).

2. Amplified Fragment Length Polymorphism (AFLP):

AFLPs are differences in restriction fragment lengths becuase of SNPs or INDELs that create or abolish restriction endonuclease recognition sites. AFLP assays are conducted by selectively amplifying a pool of restriction fragments with the help of PCR. The selective restriction fragment amplification (SRFA) is another name of RFLP technique.

3. Random Amplified Polymorphic DNA (RAPDs):

RAPD is known as polymorphism found within a species in the randomly amplified DNA generated by restriction endonuclease enzyme. RAPDs are PCR based DNA markers. RAPD marker assays are carried out using single DNA primer of arbitrary sequence.

4. Cleaved Amplified Polymorphic Sequences (CAPS):

CAPS polymorphisms are differences in restriction fragment lengths because of SNPs or INDELs that make or abolish restriction endonuclease recognition sites in PCR amplicons produced by locus-specific oligonucleotide primers.CAPS assays are carried out by digesting locus-specific PCR amplicons with one or more restriction enzymes and separating the digested DNA on agarose or

polyacrylamide gels.CAPS analysis is versatile and can be combined with single strand conformational polymorphim (SSCP), sequence-characterized amplified region (SCAR), or random amplified polymorphic DNA (RAPD) analysis to increase the chance of finding a DNA polymorphism. Michaels and Amasino (1998) developed a variant of the CAPS method known as dCAPS based on SNPs.

5. Simple Sequence Repeats (SSRs):

Simple sequence repeats (SSRs) or microsatellites are tandemly repeated mono-, di-, tri-, tetra-, penta-, and hexanucleotide motifs. SSR length polymorphisms are due to differences in the number of repeats. SSR locus is individually amplified by PCR using pairs of oligonucleotide primers specific to unique DNA sequences flanking the SSR sequence.

Jeffreys (1985) revealed that some restriction fragment length polymorphisms are due to VNTRs. The name "mini satellite" was coined due to the similarity of VNTRs to larger satellite DNA repeats.

6. Single Strand Conformational Polymorphisms (SSCPs):

SSCPs referred as DNA polymorphisms generated by differential folding of single-stranded DNA harboring mutations. The conformation of the folded DNA molecule is generated by intra-molecular interactions and thus it is a function of the DNA sequence. SSCP marker assays are generated by using heat-denatured DNA on non-denaturing DNA sequencing gels. Special gels (e.g., mutation detection enhancement gels) are developed to reinforce the invention of single-strand conformational polymorphisms caused by INDELs, SNPs, or SSRs.

7. Heteroduplex Analysis (HA):

It is known as DNA polymorphisms produced by separating homo-duplex from heteroduplex DNA using non-denaturing gel electrophoresis or partially denaturing high performance liquid chromatography. Single-base mismatches between genotypes results hetero-duplexes; thus, the presence of hetero-duplexes signals the presence of DNA polymorphisms. Heteroduplex analyses are often rapidly and efficiently carried out on numerous genotypes before specific alleles are sequenced, thereby greatly reducing sequencing costs in SNP discovery and SNP marker development.

8. Single Nucleotide Polymorphism (SNP):

The variations that found at one nucleotide position are referred to as single nucleotide polymorphisms or SNP. Such variation results because of substitution, deletion or insertion. This type of polymorphisms has two alleles and also known as bialleleic loci. This is the foremost common class of DNA polymorphism. It has observed in both in natural lines and after induced mutagenesis.

9. Expressed Sequence Tags (EST):

Expressed Sequence Tags (ESTs) are tiny pieces of DNA and their location and sequence on the chromosome are known. The variations that found at a single nucleotide position are known. The term Expressed Sequence Tags (ESTs) was first employed by Venter and his colleagues in 1991.

10. Sequence Tagged Sites (STS):

In genomics, a sequence tagged site (STS) is a short DNA sequence which has a single copy in a genome and whose location and base sequence are known.

Uses of DNA Markers in crop improvement:

1. Assessment of Diversity:

Molecular markers are often used for assessment of genetic diversity in cultivars, germplasm collection and advanced breeding material. This information can be used for germplasm characterization and developing varietal information system and PGR information system. This will also help in patenting plant material with special characters. The knowledge of genetic diversity will help in selection of parental lines for development of high yielding hybrids and cultivars. Crosses between distantly related parents can be made to obtain highly heterotic combinations.

2. Gene mapping:

Genetic linkage maps are important tools in plant and animal genetics. Molecular markers can be used to locate important genes or QTL in the genome. In other words, DNA markers may be used for construction of genetic linkage maps. Molecular markers are also convenient in identification of new useful alleles in the germplasm or wild species of crop plants. A tight linkage between a trait and molecular marker will assist in indirect selection of such alleles based on molecular marker. This knowledge can be used in selection programmes.

3. Marker assisted selection:

Marker assisted selection known as indirect selection for a desired plant phenotype on the basis of linked molecular marker. Selection of parents is an important step in the plant breeding. The OTL based selection helps to increased selection efficiency. Marker assisted selection is very productive for quantitative characters with low heritability. For efficient use of MAS, reliable and complete QTL products are used. The knowledge of OTLs and linked molecular markers can assist in introgressing specific segment of DNA containing gene of interest. This often achieved by marker assisted backcrossing. MAS limits the amount of linkage drag and requires less generation of backcrossing than conventional backcrossing for obtaining desired genotypes.

4. Crop evolution:

Molecular markers are convenient in the study of crop evolution. Molecular markers help in in tracing the genetic origin of crop plants. It will assist in identification of the wild species involved in the genetic evolution of different crops.

Conclusion:

DNA markers are extensively used in crop improvement because of its simplicity, reproducibility and precise location. It is not influenced by environmental effect decrease breeding cycle. Newly many DNA markers are accessible, out of this SSR, SNP are essentially used in breeding programme and other study. Application of DNA marker technologies also other areas of plant biology such as systematic, population genetics , evolutionary biology and conservation genetics, assist in genomics and identification of the wild progenitors of domestic species, the foundation of patterns of the genetic diversity

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COTTON LEAF CURL DISEASE (CLCUD) AND ITS MANAGEMENT STRATEGIES

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Abstract
Cotton is an important fibre and cash crop in Punjab after paddy. Cotton is cultivated on about 2.45 lakh hectares (lha) of South-western districts of Punjab. It is also known as "White Gold". Cultivation of cotton poses more problems than other agricultural commodities. Yield of crop is affected by number of factors *viz.,* soil fertility, climate conditions, varieties and rainfall. For this reason, Indian farmers are facing many difficulties in cultivation of cotton. Moreover, it is attacked by a number of biotic agents causing diseases and insect-pests. Among all biotic constrains, cotton leaf curl disease (CLCuD) is considered as a major threat for the cotton production in three Northern states of country *viz.*, Punjab, Haryana and Rajasthan.

Introduction
Cotton leaf curl disease (CLCuD) is the major disease of cotton in Northern India. Cotton production during the 1990s was severely curtailed by CLCuD across the sub-continent. Leaf curl disease is caused by complex of viral species which belongs to genus begomovirus and are popularly called as cotton associated begomoviruses (CABs). Association of satellite molecules which contains single-stranded DNA (ssDNA) and are almost half the size of major virus ~1.4kb, is of frequent occurrence. The satellite molecules play important role in symptomatology of the CLCuD. This viral disease which is transmitted by a polyphagous pest *i.e* whitefly. Whitefly can transmits the disease in plant population as well as among the different fields.

Symptomotology of CLCuD
Infected cotton plant shows typical symptoms of disease such as upward or downward curling, vein thickening giving netted appearance, stunting of plant and twisted internodes. In severe disease conditions, a leaf outgrowth (enation) emerges on the underside of the leaves. Infected plant bears less number of fruis (balls).

(a) Upward curling of leaves

(b) Downward curling of leaves

(c) Severe vein thickening (Netted appearance)

(d) Mild vein thickening

(e) Enation formation

(f) Stunting of cotton plant

Losses due to CLCuD

This disease can lead to devastating yield losses depending upon the stage of infection on crop plants. If crop is affected in early crop growth stage, then plants are severely stunted resulting in very low yields. CLCuD can cause the seed cotton yield loss upto 80 per cent. Further the disease also reduces the quality of cotton fibre (Arora and Singh 2019). The disease can severely debilitate susceptible cultivars thereby resulting in complete yield loss.

Integrated Management of disease

Unavailability of chemical or physical interventions that can have curative effect on this disease, poses the major challenge to manage the disease and yield losses. Disease incidence of CLCuD can be brought down by keeping in account the following major points during the planning of cotton cultivation.

- Ensure that cotton seeds are sown before May 15.

- Sowing of susceptible varieties and hybrids should not be adopted.
- Varieties of *Desi* cotton should be cultivated as it is the best option to adopt in high infestation areas of leaf curl and whitefly. These varieties offers resistance against leaf curl disease.
- Cultivation of moderately resistance varieties should be done *i.e* PAU Bt 1
- Cotton cultivation should be avoided in/and around these crops viz., citrus, *bhindi, or moong* as these crops can harbour the virus as well as are host of vector of CLCuD.
- Recommended/optimum dose of the nitrogenous fertilizer should be applied. Excessive fertilizer may attract the other pests including whitefly.
- Monitor the crop regularly and if infected plants are spotted in the field, uprooting and burying of these plants should be done.
- Following clean cultivation of crop and destruction of alternate weed hosts such as *kanghi butti, peeli butti, itsit, puth kandha* and congress grass should be done to avoid further spread of whitefly.
- To check the vector population, installation of yellow sticky traps @ 40 per acre in the early phase of crop plantation should be done.
- Chemical control can be used in case of severe vector infestation.

Table 1: Insecticides (Recommended) for control of whitefly (Anonymous 2021)

Name of Insecticide	Dose/ acre
Sefina50 DC (afldopyropen)	400 ml
Osheen 20 SG	60 g
Polo/Craze/Ruby Ludo/ Shoku 50WP (diafenthiuron)	200 g
Lano/Daita 10 EC (pyriproxyfen)	500 ml
Oberon/Voltage 22.9 SC (sipromesifen)	200 ml
Ulala 50 WG	80 g
Applaud 25SC	400 ml
Dantotsu 50 WG	20 g

Note: **S**ynthetic pyrethroids *viz.,* cypermethrin, fenvalrate, deltamethrin, should not be used to minimize resurgence of whitefly after September 15.

- Neem based bio pesticides *i.e* Nimbecidine or Achook @ 1 litre/acre should be sprayed on first appearance of whitefly in early growth stage of crop. These are safe for the natural enemies.
- Population of whitefly can also be managed by using homemade neem extract. To prepare that 4 kg of terminal parts of neem shoots (including leaves, green branches) and fruits should be boiled in 10 litres of water for 30 minutes. Then it should be filtered via muslin cloth and can be used @1200 ml of filtrate per acre.

Conclusion

The disease still poses greatest threat to sustainable cotton cultivation even after almost 3 decades of its first appearance. The major challenge posed to field resistance against CLCuD in cotton varieties and hybrids is rapidly evolving CABs. Due to high rate of recombination, the viral complex offers greatest diversity. Hence, it is essential to introduce broad-spectrum resistance in the field for longstanding.

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LOCUST PLAGUE AND ITS MANAGEMENT STRATEGIES

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Introduction

Alongside corona pandemic in the beginning of the year 2020, many countries around the globe including India have fought another battle for food security caused by the desert locust, which is small in size but millions in number. Though locust do not attack human or animals, historically it has been affecting mankind since ancient times and continue to be the world's most devastating pest as they can pose a major threat or challenge to our agriculture, food security and to the livelihoods of about 10% of the world's population which finally can lead to famine and starvation. Locust attacks have been mentioned as a curse to mankind in almost all ancient manuscripts, right from wall paintings on ancients Egyptians pyramids to the Bible and Quran. Furthermore, ancient Greeks also mentioned about locust attacks and so did Sanskrit poems date back to 747 BC. In some cases, they have often been called as piranhas of the skies which were typically originated in the desert regions across North Africa, the Middle East, and Southwest Asia as early as 2420 BC in Egyptian tombs (Nevo, 1996). The only reason that seems to be surprised by the recent locust swarms is that they have become the worst infestation in 25 years in Ethiopia and Somalia, in 26 years in India and the worst in 70 years in Kenya as per the UN Food and Agriculture Organization (Factsheet, 2020). In Indian context, there had been many locust attacks or plagues, uprisings and incursions during last two centuries approximately 12 locust plagues until 1962 and most of the attacks have been localised to Rajasthan since 1993. Though cycle of locusts is a routine phenomenon that follows its breeding and swarm movement after the rainy season, yet last year, 2020's outbreak of locusts was not in its normal routine and far more problematic to be managed. Many scientists and researchers have linked this outbreak to the climate change. Locust outbreak coincides with the cyclones of 2018 and warm weather at the end of 2019 with a supplementary effect from the heavy rains in areas including Ethiopia, Eritrea, Iran, Pakistan, Saudi Arabia and Yemen. But this time, favourable weather conditions have facilitated locust outbreak and further spread or travel from Rajasthan to Gujarat, Madhya Pradesh, Uttar Pradesh and even Maharashtra.

What are locusts?

They are actually the short- horned grasshoppers belonging to family Acrididae with highly migratory nature and a voracious feeding behaviour. So far at present there are ten important species of locusts in the world, out of that only four species are found in India namely: Desert locust (*Schistocerca gregaria*), Migratory locust (*Locusta migratoria*), Bombay locust (*Nomadacris succincta*) and Tree locust (*Anacridium* sp.). Out of these ten species, the desert locust is the most important and also the dangerous migratory pest species in India as well as in the world.

Locust swarms consume everything in their path, leaving behind ruined cropland and barren pastures. While they are not known to impact forests or natural tree cover, their voracious

consumption of most species of crop creates food scarcity for native fauna and other insects. Locust is an insect which is quite similar in appearance to grasshopper and cricket as these insects belong to the same family but differ in many ways like the latter one does not have gregarious phase and no long- distance migration. This means locusts exists in two phases (which is a unique trait)- solitary and gregarious phase. They are usually solitary, but under certain circumstances such as wet soil with frequent rainfall, good vegetation, they become more abundant and transform themselves completely in their appearance, colour, behaviour and habits, becoming gregarious to form large swarms. Problem arises only when they are in gregarious phase as they have high appetite with more endurance and their movements become more rapid. Generally, one swarm contains billions of insects per square kilometre which has the capacity to eat everything that falls in its flight path. The magnitude of the damage caused is very gigantic due to its polyphagous feeding nature, devouring the leaves, flowers, fruits, seeds, bark and growing points of almost all types of crops or non- crops plants and also by breaking down trees because of their weight when they settle down in masses and thus, leading to complete destruction wherever they pass by. It was estimated that on an average a single locust swarm eats as much food in one day as about 10 elephants, 25 camels or 2500 people.

Locust life cycle and biology

Life cycle of a locust has three distinct stages -Egg, Hopper or nymphs and Adult.

Egg: Locusts lay eggs in pods in moist sandy soil at a depth of about 10 cm at an interval of 7 – 10 days. In comparison, gregarious female usually lay lesser eggs (which may be in 2-3 egg pods having 60-80 eggs in average), than the solitary phase female that mostly lay 3-4 times having 150-200 eggs in average. The rate of development of eggs is mainly depending on soil moisture content and temperature. No development takes place below 15°C and they require 10-12 days of incubation period when the optimum temperature is between 32-35°C.

Nymph/ Hopper: Nymph or hopper (young ones) emerges from the eggs when incubation period is completed. There are 5 instars in gregarious and 5- 6 instars in the solitary phase where in each instar there is a change in its growth and characteristic colour.

The rate of development in hopper depends mainly on the temperature. It takes 22 days when the mean air temperature is hot of about 37°C and may be delayed up to 70 days when the mean temperature is cold of about 22°C.

Adult: The 5th instar adult moults into adult stage. This young adult is called 'fledgling' or 'immature adult' means they are sexually immature. The period of sexual maturity varies. In suitable condition the adult may mature in 3 weeks and under cool and /or dry condition it may take time of 8 months. Young immature adults are pink in colour but on maturation the adults become bright yellow. Males mature early as compare to females. Adults fly in search of favourable breeding ground and during this act, they may cover thousands of kilometres for search of suitable breeding condition. Oviposition commences within two days of copulation (http://ppqs.gov.in/divisions/locust-control-research). Locust swarm usually lasts in a given place for 17-24 hrs, but if the winds are strong, locusts tend to move to next place before that. It is estimated that a single locust can fly up to 3000 miles in its lifetime and their swarms always tend to move within a delimited area.

Locust control in India

In regard to control the locust attack, farmers have tried many ways to scare locusts away. Such activities like burning vegetation, collectively beating loud drums, tin containers, utensils and using even loudspeakers to make loud noises, barriers, smoking and battues were tried but did not give

effective results. Some have even come up with the idea of releasing poultry to feed on the insects. However, in the face of a locust outbreak, the ingenuity and hard work put in by farmers to save their crops are to no avail. The chemical insecticides currently used are more effective but it is environmentally hazardous on large-scale use. This is why research is under way to find safer, in other words less chemical, products, for instance biopesticides based on pathogenic fungi, plant extracts, etc (Lecoq, 2001).

In India, the locust control and research are governed through Locust Warning Organization (LWO) with its headquarters at Jodhpur, Rajasthan). It was established in 1939 and amalgamated in 1946 with Directorate of Plant Protection Quarantine and Storage (DPPQS) of Ministry of Agriculture and Farmer's Welfare. They undertake regular surveys in the scheduled desert areas of Rajasthan and Gujarat to monitor the presence of desert locust and ecological conditions. An assessment is made during the survey to determine, if the locust numbers have crossed the economic threshold level (ETL) which is 10,000 adults/ha and 5-6 hoppers/bush and it may require to control if the locust numbers is beyond the ETL (Sharma *et al*., 2020).

LWO is responsible for regular, timely monitoring and planning for locust eradication and providing assistance to state governments in controlling the locust invasions. Regular vigil and necessary control measures will remain a concern in view of the global status and scenario of locusts. However, it is usually very difficult to control a locust swarm because of its huge population density. For example, locusts swarm found in Kenya in 2020 was 40 km x 60 km in dimension – 2400 km^2. It is estimated that even a very small swarm of 1 km^2 contains around 1 – 1.5 billion or more than 150 million locusts and therefore, any control measures will be futile against such a large population. Already efforts have been initiated in the aspect as the central government has advanced its preparations that include procurement of specialized sprayers equipped with latest technology, and use of helicopters, drones and aircraft sprayers aided aerial spraying to combat the situation. Because of its huge population density, reports of crop damages have been pouring in from these states, so farmers tried their best effort to get rid of locusts by smoking them out, scaring them away by making loud noises or spraying chemicals. Even the state and central machineries, including the LWO, are actively trying to control the invading locusts in India through Pakistan, but their efforts may not be enough. So far three different methods are being used for management of locust menace namely- mechanical methods, baiting and dusting or spraying insecticides. In Mechanical methods, digging trenches, beating and burning activities were done for controlling locust and in baiting method, scattering locust food impregnated with insecticide were practiced. According to the latest reports, the best carriers for locust bait were found to be maize meal, wheat bran, maize bran, cotton seed husk and rice bran and the ratio of the carrier to insecticide should be prepared in the ratio of 20:1. In dusting or spraying method, dusting are mainly done by applying a fine dust impregnated with insecticide and spraying is done with liquid insecticides.
In this current scenario, the primary or most commonly used method of controlling locust swarms is mainly dependent on organophosphate chemicals which are applied in small concentrated doses or ultra-low volume (ULV) formulation and are sprayed with the help of vehicle-mounted and aerial sprayers and to a lesser extent by knapsack and hand-held sprayers.

Currently insecticides used in locust control, approved by CIBCR are for Scheduled desert area, Dust formulation recommended are Malathion 5% DP, Fenvalerate 0.4%DP or Quinalphos 1.5% DP @25 kg/ ha using duster and in liquid formulation important ones are malathion 96% ULV @1 litre/ha or chlorpyriphos 45% ULV @0.5 litre/ ha. In cropped area of Rajasthan and Gujarat, Fenitrothion 50 EC and Chlorpyrifos are used for spraying. However, at present, when this locust plague becomes

imminent or approaching, for a quick result/ impact its control is heavily dependent on the use of fast- acting, broad spectrum and environmentally harmful insecticides as mentioned above. Instead, an alternative strategy can be implemented which focuses on pre-gregarious locusts and its main objective should be in keeping the locusts permanently in solitary phase with the use of environmentally benign tactics and good understanding of locust biology and life cycle. Eco-friendly management of locusts can be applied with the use of pheromone technology or by using bioagents like *Metarhizium sp.* Potential management techniques for locust plagues may also include using wind as a marker, monitoring the swarms and their range expansion, and biological control for pest management.

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MEDICINALLY IMPORTANT MUSHROOMS

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Abstract

Mushrooms are being used by mankind since prehistoric period due to their nutritional as well as nutraceutical values. Many mushrooms contain medicinal properties including *Agaricus blazei*, *Auricularia* sp., *Coprinus comatus*, *Fomes fomentarius*, *Grifola frondose, Ganoderma lucidum*, *Hericium erinaceus*, *Lentinula edodes* and *Coriolus versicolor* and *Cordyceps* sp. Pharmacological properties of these medicinal mushrooms are mainly conferred by some bio-active compounds like polysaccharides, protein, triperpenoids, phenols, ergosterol, etc. and many enzymes like laccase, glucose oxidase, superoxide dismutase, and peroxidase. These compounds help as anti-inflammatory, anti-allergic, antioxidant, anti-aging, anti-infection, cure cardiovascular, hepatoprotective, neuroprotective, enhance bone strength and even cure carcinogenic reactions in human body. In addition, certain compounds derived from medicinal mushrooms are being used in drug-discovery pathway. Incorporation of regulatory amount of such mushrooms in diet can reduce many diseases especially oxidative stress related issues. There is a need to increase the awareness of such natural foods among people to promote the cultivation and consumption, so the overall health and new emerging diseases can be regulated in our daily routine.

Keywords : Medicinal Mushrooms, Nutraceutical values, Oxidative stress, Immune system.

Introduction

Fungi have great importance in human's life as well as the environment. Mushrooms are macro fungi with a distinctive fruiting body which can be either hypogeous (underground) or epigeous (above ground) and large enough to be picked by hand and to be seen with the naked eye. For thousands of years, Mushroom have been reversed and regarded by humans as edible as well as medicinal food in which different mushrooms such as Reishi or Lingzhi, *Cordyceps* and Shitake have been discussed in ancient Asian traditions for their nutraceutical properties.

Traditionally, mushrooms were used to treat and prevent diseases and to maintain good health, mainly by regulating the immune system. Nowadays, more than 50 mushroom sp. are used for more than 100 therapeutic properties including anti-inflammatory, antitumor, anticancer, antioxidant, antiviral, anti-diabetic, antifungal and anti-parasitic and the ability to lowers the cholesterol levels and modulate the immune response. Medicinal mushrooms also protect the liver, brain and heart from various diseases.

Along with medicinal benefits and physiological characteristics also great aroma and taste. Medicinal mushroom contains a rich source of nutrients such as fibers, carbohydrates, protein, vitamins, polyunsaturated fats and minerals. They also produce secondary metabolites, which are largely responsible for their therapeutic effects. These bio-active metabolites are low molecular weight compounds, these compounds are produced by an organism in response to certain stress conditions as a signaling and defense mechanism necessary for its survival.

Different medicinal mushrooms

Some of the medicinal mushrooms are listed below along with their therapeutic use.

***Agaricus blazei* (Royal Sun Agaricus):** It is a recently discovered culinary and medicinal mushroom and widely popular worldwide. The therapeutic properties include anti-allergic, anti-cancerous properties along with antiviral and hepatoprotective (liver protective) activities. It mainly cures leukaemia, ovarian, cervical, alimentary tract, endometrial and breast cancer in conjunction with chemotherapy via elevation in the immune response.

2.2 *Auricularia* sp. (Wood ear): Two main species i.e., *Auricularia polytricha* (black fungus, cloud ear) and *Auricularia auricula* (Jew's ear) of this mushroom are well known for their rubbery and crunchy texture. Therapeutic values are due to high levels of antioxidative compounds such as polyphenols and polysaccharides that help as cardiovascular protective, however they are not recommended during pregnancy.

2.3 *Coprinus comatus* (Shaggy Mane): *Coprinus comatus* is a delicious mushroom is suitable as edible only in young stage. It is not generally considered medicinal mushroom but is known for its high antioxidants such as γ-aminobutyric acid (GABA), relieve anxiety and insert relaxing effects in muscles and nerves. Its role in reducing blood sugar levels is also reported.

***Cordyceps* spp. (Caterpillar Fungus):** *Cordyceps* is a genus of unique fungal species that are parasitic primarily on arthropods and insects, and includes two species, *Cordyceps militaris* and *Cordyceps sinensis* (caterpillar fungus, *Ophiocordyceps sinensis*). The main bio-active compounds in *Cordyceps* sp. are cordycepin, lovastatin, various polysaccharides, ergosterol and melanin. *Cordyceps* is traditionally used as a tonic against fatigue, for fertility and prevention and cure of osteoporosis, cancer and respiratory diseases such as bronchitis, asthma and chronic obstructive pulmonary diseases. This mushroom also protects heart, kidney and liver and hence called as anti-aging mushroom.

2.5 *Fomes fomentarius* (Tinder Fungus): *Fomes fomentarius* is an inedible fungus, where its fruiting bodies are used as tinder for wounds and to stop bleeding, cure rheumatism, body pain, haemorrhoids, painful menstruation, uterine cancer and bladder disorder (Valverde 2015).

2.6 *Ganoderma lucidum* (Reishi, Lingzhi): *Ganoderma lucidum* is one of the most famous medicinal mushrooms and is called Reishi or Lingzhi denoting "mushroom of immortality", divine and miraculous due to its extraordinary therapeutic properties. They contain certain polysaccharides that enhance the immune system and Triterpenes that act as anti-inflammatory and antitumor agents. Furthermore, the sedative effects of Reishi help to relieve anxiety and insomnia and are recommended for mental stabilization.

2.7 *Grifola frondosa* (Maitake, Hen of the Woods): It is a medicinal mushroom, also known as maitake. It contains polysaccharide extracts, maitake MD-fraction and maitake D-fraction, used for the treatment of various types of cancer. These polysaccharide improves the immune response, hypertension and diabetes along with antiviral, antioxidant, antimicrobial properties and hence increases vitality.

2.8 *Hericium erinaceus* (Lion's Mane): This mushroom is well known for its neuroprotective properties and that is why called as "natural's nutrient for the neurons". It improves brain function, relieves anxiety, depression, prevents dementia and other neurodegenerative diseases via antioxidative properties and lowering cholesterol and sugar level. It also stimulates immune system and exerts its antitumor activities against oesophageal and gastric cancer.

2.9 *Lentinula edodes* (Shiitake): *Lentinula edodes* or shiitake is a very popular and delicious mushroom with medicinal properties and high nutritional value. It is named as "elixir of life" which

promotes energy and vitality. Shiitake is the most studied medicinal mushroom and it is valued for its nutritional, therapeutic as well as culinary properties. Shiitake strengthens the immune response, prevents diabetes and cardiovascular diseases, exhibit anti-inflammatory, antitumor and hepato-protective activity. It also helps in skin and respiratory allergies.

2.10 *Trametes versicolor/ Coriolus versicolor* (Turkey Tail): *Trametes versicolor* or *Coriolus versicolor* is clinically important and one of the most studied medicinal mushrooms used for the prevention and treatment of a variety of cancers due to two polysaccharide-protein complexes, called asPolysaccharide- Peptide) and Polysaccharide-K or Krestin, the compounds effective as immunotherapeutic in oesophageal, uterine, colorectal, nasopharyngeal, breast and lung cancer management.

Cultivation and production

Overview of medicinal mushroom cultivation and its requirements is given in Table no.1.

Table 1.: Requirements of medicinal mushroom cultivation

Name of mushrooms	Substrate for Spawn	Raw material/ Compost	Temperature	pH
Agaricus blazei	WC, SD	WC, Ba, Ba + WS+ RS	23-27°C for My, 22-25°C for FB development	7.5 for compost, 7.7 for casing
Auricularia spp.	Sorghum grain	SD (72%) + RB (28%)	28°C for My, 27°C for FB development	6.0
Coprinus comatus	Rye Grain	Cotton Waste, Corn Cobs, RS	21-27°C for My and 16-21°C for FB development	6.5-7.5
Cordyceps Spp.	PDB, Novel Liquid Culture	Rice, Soya bean, Wheat	21-27°C for My and 16-21°C for FB development	6.5-7.5
Ganoderma lucidum	Rice, Wheat, Barley	Blocks of hardwood, Straw	25-30°C for My and 24-28°C for FB development	6.5-7.5
Grifola frondose	Grains, SD, Cotton seed hulls	Blocks of Hardwood, SD	18-22°C for My and 15-20°C for FB development	5.5-6.5
Hericium erinaceus	Rye, Wheat, Millet	Hardwood + SD, RS, WS, RS + WS	22-27°C for My and 20-25°C for FB development	7.0
Lentinula edodes	SD		25-28°C	Near 7.0
Coriolus versicolor	Sorghum grains	Hardwood, SD + WB	28 °C	Near 7.0

WC= WoodChips, SD= Saw Dust, Ba= Bagasse, WS= Wheat Straw, RS= Rice Straw, RB= Rice Bran, WB= Wheat Bran, My = Mycelium (Zhou 2021, Shin et al. 2021)

Conclusion

As we have so many species of medicinal mushrooms with well demonstrated evidences of their therapeutic properties. In the present era of life, our health issues are increasing day by day with

new emerging diseases. So, there is a need to add natural value-added food products such as mushrooms with nutraceutical values in our daily diet. As we have discussed different therapeutic properties, consumption of these medicinal mushrooms will enhance our immune system, reduce cholesterol levels and hence cardiovascular problems. Anti-cancerous mushrooms will help in relieving and curing tumour formations. Even their regulated amounts can improve the overall health and vitality. So, there is need to enhance the awareness and promote the cultivation and consumption of theses mushrooms in India, which are traditionally consumed in other countries.

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