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Diara land cultivation of cucurbitaceous crops

In the present time when there is a constant pressure on the land mass exerted by rapidly increasing population and there is negligible scope to expand the cultivable land horizontally, diara land or riverbed are in focal point for growing vegetable crops specially cucurbits, as these stretches of lands have not been optimally utilized till now, which is extensively available in the country and can be exploited with scientific interference for growing cucurbits to supplement the total vegetable production.

A piece of land created inside a river due to deposition of sand is known as riverbed or Diara land. Cultivation in diara land facilitates off-season production which is a type of vegetable forcing in many cucurbitaceous vegetables which is purely an indigenous and innovation of vegetable grower. The term "Diara" has been extracted from the word "Diya" meaning earthen lamp. Keeping in conformity with the shape of the "Diya", the bowl like systems on the surface (depressions) situated between the natural levees on either side of the river appear like small *Diyas* when rainwater gets accumulated in them during the rainy session. It is observed that out of total area under cucurbits cultivation, 68% area is under riverbed cultivation. During the summer season, around 70-75% of total cucurbits production is being produced in river beds or diara land area which is available in market from February–June and October–January. Such land is also known in different areas of India as khaddar lands, char lands, dariayi, kachhar, doab, kochar, nad, riverine area, nadiari, diara lands and tal lands. The river-beds of Yamuna, Ganges, Gomati, Saryu and other tributaries in Haryana, Uttar Pradesh and Bihar; river-bed Banas in Tonk district of Rajasthan; Narmada, Tawa and Tapti river beds of Madhya Pradesh and Maharashtra; Sabarmati, Panam, Vartak and Orsung of Gujarat; Tungabhadra, Krishna, Hundri, Pennar river-beds of Andhra Pradesh are some of the important areas where cucurbits like cucumber, bitter gourd, long melon, sponge gourd, ridge gourd, water melon, muskmelon, bottle gourd, pumpkin, etc. are extensively grown. In Kerala in the river-beds of Pamba and Manimala, cucurbits like bitter gourd, snake gourds, etc. are grown. The subterranean moisture seeped from adjacent river, streams, makes the upper layers of land more suitable for growing early vegetable crops.

Features

- The technology works well on marginal lands, in topographically flat areas with river beds that are dry for one crop cycle (approximately 6 months) with arable land silted over and or washed away by floods.
- Distance/Adjoining to village: Not more than 30 minutes on foot.
- Sand must be fine and small-grained and the groundwater table should be < 1 m.
- Riverbeds or riverbanks may be cultivated. Riverbeds have a higher soil moisture content compared to riverbanks.

Table 1. State wise, the main river beds for diara land cultivation

State	Main riverbed
Uttar Pradesh	Ganga, Yamuna, Sarayu, Sharada, Ramganga, Gomati, Rapti river beds
Bihar	Ganga, Gandak, Sone, Kosi, Burhi Ganga
Madhya Pradesh	Narmada, Tapti, Tawa, Mohana
Gujarat	Sabarmati, Vatrak, Panam-Orusung, Mohi-Banas, Tapti
Andhra Pradesh	Tungbhadra, Krishna, Pennar, Papagni

Properties of riverbed soil

The soil in river beds contains mostly sand and moisture that has seeped from the adjacent river. Well-drained loamy soils are preferred for cucurbit cultivation. Sub-terranean moisture of river streams and alluvial substrate in sandy river-beds support the growth of cucurbits. The soils should not crack and should not be water-logged in summer and rainy season, respectively. It should be provided with adequate organic matter. For proper growth and development, the optimum temperature range should be around 18-22°C. In fact, a long tap root system is adapted to the growth of cucurbits in river-beds. Most of the cucurbits prefer a soil pH between 6-7.

Classification of diara land based on precise location from the main stream

Main riverbed (low land) diara: The actual riverbeds, which have fine sand to coarse deposits on surface, become available during non-monsoon seasons, i.e. December-January to May-June until early rains set in.

Main land (medium land) diara: These areas are located on the bank of the river and its width varies

considerably. They are frequently inundated during rainy season by the swelling of flood water. The depth of the main diara region varies considerably at different locations.

Upland diara: Due to continuous deposition, such areas have been elevated and are relatively less frequently flooded than the mainland diara areas. For all operational purposes these areas are not very different from the normal (non-diara) lands.

Advantages of diara land cultivation

- High net returns per unit land area
- Early and high yield
- Low cost of cultivation, highly fertile land reduces the external mineral requirements
- Limited weed growth
- Pest and disease are controlled by cultural practices and cost effective
- Income and food security of landless and marginal farmers
- Local adaptation to climate change

Pit preparation by Trolley Earth Auger

Traditional method of irrigation

Cultivation

Land preparation: Riverbed plots are chosen by farmers, with plots perpendicular to the river's flow. After recession of flood during October-November and the cessation of the south-west monsoon, pits or trenches or channels are prepared.

Systems of planting: Majority of farmers choose the following system of planting depending on personal preferences and availability of labour. Common planting systems are:

Pit system of planting: For the pit system, pits of 0.5 m diameter are dug 1 m deep and 1 to 3 m apart depending on the crops, and planted with numerous seeds, the feeble of which are thinned out. Sometimes circular pits with diameter of about 35-45 cm and a depth of 90 cm are prepared.

Ditch system of planting: To manage the availability of moisture and higher temperature, the trenches are dug in North-West direction. To use the ditch system, a trench 1 m deep is dug along the row, with 1 to 2 m (cucumber, bitter gourd) or 3 m (watermelon, bottle gourd, pumpkin) space between rows. Seeds are planted/spaced 1 m (watermelon, bottle gourd, and pumpkin) and 0.5 m (cucumber, bitter gourd) apart in the ditch. The pits/ trenches are filled with organic decomposed waste or oil cakes or FYM or any other which is mix in the soil. Most of the cucurbits are sown in November and December. Before sowing, the trenches are manured with FYM or any other organic decomposed waste or oil cakes. In North-Western India, when winter temperature goes down very low, the protection is provided by planting grass stubbles (*mainly Saccharum spontaneous*) species. This protection has following uses:

- It checks the sand drifting on the dug up trenches, and covering the hills sown with seeds.
- It provides partial protection against chilly wind.
- The grass is also available for spreading over the sand when the vines grow and covers the sand.
- It helps to prevent the sand being blown off with the vines, especially in summer due to hot winds.

Crops and cultivars: Some of the important river-bed cultivated crops and their cultivars are described here.

Cucumber: Cucumber cultivars are usually classified on the basis of how they are used, fresh market (slicer) and picklings. In general, fruits of slicers are larger than picklings. Some of important cultivars are Kashi Nutan, Japanese long green, Straight eight, Pusa sanyog (Fl hybrid) and Poinsette.

Musk melon: The most popular cultivars are Kashi Madhu, Arka rajhans, Arka jeet, Pusa sharabati, Pusa madhuras.

Water melon: The important varieties are Sugar baby, Improved shipper, Asahi yamato and Durgapura meetha. There are several cultivars, locally grown which are named after the region in which they are grown, such as Farukhabadi, Moradabadi, Faizabadi of Uttar Pradesh. Most of them have fruits with dark green colour or pale green with black strips, moderately sweet with large seeds, weighing 6 to 8 kg, with thick rind. There is a local cultivar of Yamuna river-bed called as Kalagolan, whose flesh is not sweet, but it keeps well for over 2 to 3 months at drastic temperature.

Pumpkin and squashes: In pumpkin, a large number of varieties are available in India. They may vary according to colour from white or green, according to shape round or long. The most common varieties are large red, large green, large round, yellow flesh and red flesh. The varieties and cultivars available are Kashi Shishir (Hybrid), Kashi Harit and Kashi Subhangi in Chappan Kaddu (*C. pepo*) is popular varieties available at ICAR-IIVR, Varanasi.

Bottle gourd: A large number of varieties are available for cultivation is Kashi Ganga, Kashi Kiran, Kashi Kundal, Kashi Kirti and Kashi Bahar (Hybrid) is popular varieties.

Other vegetable crops: Vegetables, viz. long melon, sponge gourd, ridge gourd, bitter gourd etc. are successfully grown in the riverbed cultivation.

Seed rate, seed treatment and sowing/ transplanting: Seed rate varies according to crops to be grown. Sowing is usually done for early crop in 1st fortnight of November and 1st week of December. 1st week of January is the best time for late sowing. The seeds are sown in trench at a distance of 45-60 cm and at a depth

Monitoring of ICAR-IIVR, Varanasi project site in riverbed cultivation

of 3 to 4 cm. Two seeds are usually sown at one place. Pre-sprouted seeds are sown for smooth germination when the temperature is very low. For this, pre-soak the seeds for 24 hours and place the moist seeds on a gunny bag and cover them with a cotton cloth and keep them in a warm place for about a week for sprouting to start. Sometimes the moistened seeds wrapped in gunny bags are left near the fire for quick germination and in this way sprouting starts after 5-6 days. As soon as sprouts emerge outside the seed coat they are planted. Generally, 2-3 pre-germinated seeds/hill area sown in pits.

Nutrient management: Well decomposed FYM or compost, caster cake or groundnut, neem cake is applied first. To enhance moisture retention in the feeding zone, river silt is generally used. Germinating seeds or growing transplants are provided with warmth from the organic manure. At the time of thinning, 30-60 g urea per pit will be useful. After 25-30 days of sowing, depending on weather conditions and growth, chemical fertilizers are top dressed in two split doses, especially fertilizer mixtures or nitrogenous fertilizers like urea. This top dressing is applied in shallow trenches away from the plants.

Water management: The deep root system in cucurbits enables the plant to survive in diara land. Pitcher irrigation is given in the initial stages of germination and growth till the roots of the plants touch the water regime below the sand or left as such. Trickle or sprinkler irrigation system is quite advantageous to avoid leaching losses of the nutrients in sandy soils.

Weed management: Major weeds in diara land areas are *Euphorbia hirta*, *Polygonum* sp., *Eclipta prostrata*, *Fimbristlylis dichotoma, Sida* sp., etc. These weeds can be eradicated manually by pulling, since soil is quite loosened due to excess sand. Herbicides should be avoided completely as it may prove to be hazardous to human, animal and fishes when mixed with running river water.

Thatch preparation: In north-west India, when the temperature goes down to 1-2°C in December-January, young plants should be protected from low temperature and frost in their early stages. The thatch screen made of locally available material like paddy straw, Saccharam grass or sugarcane leaves provides protection for the young seedlings. Grass is spread in the month of February over the sand as a bedding and mulch, to protect the tender and young plants and fruits from scorching heat of sand during summer and also stops the vines to drift during strong winds.

Cropping pattern: Mixed cropping is usually practiced in riverbeds. Water melon and Musk melon generally go together. Other cucurbits mainly grown together are summer squash, bottle gourd, round melon, cucumber, sponge gourd, bitter gourd, long melon in north India, ridge gourd in Rajasthan, Madhya Pradesh, and Uttar Pradesh and pointed gourd in Bihar.

Harvesting and yield: Harvesting should be done when fruits are quite tender and edible. Fruits which attain edible maturity should be harvested at 2-3 days interval, or else, the quality deteriorates and fruits are hardened due to seed maturity. By the end of June to end of October, harvesting at regular interval can be done. Harvesting of fruits starts in February-March (off-season) and gives early yield and higher return. After harvest, crops are transported to local market centers for sale.

Role of pollinators

The cucurbit crops are highly cross-pollinated and yield of crops are influenced by the pollinators. Honey bees are the main pollinating agent of cucurbit crops. In Diara land, visit of honey bees are restricted due to dry weather, non-visibility of flowers as crop is lying on surface. Hence, Sunflower sowing @100-150 plants per hectare was done for better pollination.

Harvested produce and ready for marketing

Nematode infestation in diara land cultivation in cucurbits

Sunflower plant for more pollination in riverbed cultivation

Important Insects-pests

The insects like aphids, mites, white flies, root knot nematode and red pumpkin beetle are usually noted in early stages of crops. The fruit-fly incidence is more in pointed gourd and bitter gourd and mite infestation increases in arid situations, as the day temperature rises above 40°C.

Management

- Spray of Azadirachtin 300 ppm @ 5-10 ml/L or Azadirachtin 5% @ 0.5 ml/L for red-pumpkin beetle.
- Use cuelure pheromone trap @25 trap/ha and change these traps after 35-40 days for fruit flies management.
- Spraying of water on the plant can manage the spread of the mites.
- Spray the mixture of *Verticillium lecanii* @ 2.5 g/L and neem oil @ 2.0 ml/L for control of white flies.
- For biological control of nematode, 50 g neem cake per pit at the sowing time and drenching of *Trichoderma harzianum* (2 g) + *Paecilomyces lilacinus* (2 ml) + *Pseudomonas fluorescens* (2 ml) in per litre of water three times at 30 days interval (first dose at sowing time) is found to be effective for nematode management.

Important diseases

The important diseases observed in cucurbit crops under diara land cultivation are downy mildew, gummy stem blight, powdery mildew and viral diseases.

Management

- Crop should be grown with wide spacing. The air movement and sunlight exposure helps in checking the disease initiation and development for management of downy mildew.
- Gummy stem can be managed by using healthy seeds, and quick decomposing of plant debris.

Table 2. Net profit from Cucurbitaceous crops under Diara land and normal field condition

Crop	Net profit ₹ Lakhs/ ha (Diara land cultivation)	Rate (₹ /kg) Min- Max	Net profit ₹ lakh/ ha (Normal field condition)
Pumpkin	2.05	3.0-30.0	1.80
Sponge gourd	2.98	4.0-60.0	2.36
Bottle gourd	3.34	3.0-25.0	2.60
Water melon	2.09	7.0-20.0	1.64
Muskmelon	2.80	10.0-30.0	2.10
Longmelon	1.99	10.0-40.0	1.66
Bitter gourd	2.09	10.0-30.0	1.83
Ridge gourd	1.38	10.0-25.0	1.08

- Integrated management practices, i.e. avoidance of source of infection, control of vectors, modification of cultural practices and resistance of host plant.

Mineral deficiencies

Non-pathogenic diseases mostly caused by mineral deficiencies are also prevalent in some situations. This is a special problem in river-beds. Absence of rich sub-soil, silt or alluvium beneath the sandy layer and leaching of nutrients due to sandy substrate sometimes cause deficiencies of macro and micro-nutrients.

Harvesting and marketing

The melon fruits come to the market in February-March in Andhra Pradesh, slightly later in April in Maharashtra and Rajasthan, extending to June in West Uttar Pradesh and Haryana. Other cucurbits come earlier because they are picked in edible (vegetable) maturity stage, like bottle gourd in March. The pumpkin is the last to arrive in the market, since it is of longer duration. The mixed cropping has some advantages in that it gives river-bed farmers continuous income from March to June and cushions the losses or failure of any crop. Generally, the cucurbits fruits mature faster, immediately after fruit setting. In salad, on slicing cucumber, dark green skin colour should not turn brownish yellow, or rusting and white spine colour is a suitable indication for edible maturity. The major point in watermelon is the ability to withstand transport especially without cracking or bursting. Most of the cultivars have deep pink or pink (pale) flesh, with reddish tinge containing largely lycopene and anthocyanin pigments. Uniform development of pink colour from centre to rind is necessary. In some cultivars, 'white heart' is seen in central portion. Overmaturity sometimes results in hollowness and fibrous flesh.

SUMMARY

Diara land farming is easy-to-learn, cost effective technology, allowing landless households to produce unused marginal lands. This type of cultivation is best suited for the small and marginal farmers who can work themselves along with their families in the fields, producing a large number of cucurbits and other vegetables economically. ICAR-Indian Institute of Vegetable Research, Varanasi has taken the responsibility and running a project "Identification of Suitable varieties/ hybrids of Cucurbitaceous crops and Development of production protocol for better Livelihood of River bed (Diara land) farming community" funded by Uttar Pradesh Council of Agricultural Research, Lucknow and providing SOPs to growers.

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Multi-Layer Farming Systems (Multiple Cropping)

Shri Akash Chaurasiya belongs to a marginal farmer's family in Tilli village of Sagar District of Madhya Pradesh. After being trained at KVK, Sagar, he adopted multilayer farming system with organic farming, in which he grows at least four to five crops in the same field, like ginger, ivy gourd, leafy vegetable, papaya and potato at the same time. Ginger is planted at the depth of 2.5 inches and width of 6 inches under the surface, as the first crop taking in the month of February. Then he grows any one of the leafy vegetables like Amaranthus or Spinach or Coriander etc. densely on the surface as second crop at the same time, which acts as green mulching and prevents the growth of weeds and moisture. As a third crop, he grows specially ivy gourd (Kundru), having a distance of 5-6 feet from each other on the wire net, locally-made from bamboo and grass, and constructed at a height of 6.5 feet from the surface level. The structure provides protection and partial shade to other crops like ginger and leafy vegetables for better growth at the same time in the month of February. Hence, all three crops are grown at the same time, with the same cost of labour& others expenses materials. As the fourth crop, he grows papaya in the month of April, which gives fruit above the net. After digging of ginger in September-October, potato is also planted in the month of October as a fifth crop. During this time, he sells ginger (as an off-season crop) at a higher price, that is ₹ 60 to 100 per kg, in the market. All of these crops were grown on wire constructed (MANDAP) which are fixed parallels on the bamboos, having a distance of 1.5 feet from each other. So, in this way, by growing of four to five crops together, then it can have 3-4 times more earning. Total expenditure on bamboo and wire-made structure, running up to five to six years, happened to be ₹ 1,50,000/acre, that is, ₹ 30,000/year. Total cost of cultivation of crops was ₹ 2,05,000 for cultivation of all crops, viz. Ginger, Ivy gourd (Kundru), Leafy vegetables (Amaranthus/Spinach/ Coriander/Fenugreek etc.), Papaya and Potato per year per acre. The net income obtained, thus, was found to be ₹ 4,95,000/acre with 3.41 BCR.

Besides income, four-layer multiple cropping model gave other benefits also, such as, reduced insect-pest, no effect of climate change (i.e. from frost cold and heat waves etc.), and less requirement of manures due to multi crops being grown at the same time.

A view of multi crops in four layer farming system

A view of leafy vegetables before emerging of ginger crop in four layer farming system

Source: ICAR Annual Report 2022-23