Rainwater harvesting using plastic-lined doba technology for orchard establishment in the eastern plateau and hill region of India

Water is a vital component that determines the full potential of the agriculture sector of any country. The practice of rainwater harvesting (RWH) in ponds and reusing the stored water for life-saving irrigation of crops is prevalent in India since ancient times. One can find efficient management of water in a region in traditional farming systems like kattas and surangams in North Kerala and Karnataka, and zabo system and bamboo drip system of Nagaland[1].

The present study area, Jharkhand, receives 1200–1600 mm/annum rainfall and precipitation is variable. Winter season precipitation is meagre and highly variable. There are on an average 130 rainy days in a year and rainfall is below 2.5 mm for about 75 days. On 55 rainy days, evaporation level is more than 2.5 mm/day. According to estimates, out of the average annual precipitation of 10 million hectare metre in the state, about 20% is lost in the atmosphere, 50% flows as surface run-off and balance 30% soaks into the ground as soil moisture and groundwater. Physiographically, the entire state is plateau area, where groundwater resources may not be sufficient for *rabi* and summer crops. Out of 79 lakh ha geographical area in Jharkhand, net cultivated area is around 24 lakh ha of which 22 lakh ha is rain-fed. Productivity of horticulture crops is 8–12 t/ha. Area under forest is 29% (23 lakh ha). The state falls under agro-climatic zone 7 and in zones 12 and 13 according to agro-ecological characterization of the country. About 9% of the area in the state is irrigated. Net profit in horticulture is much lower in Jharkhand compared to other states. The plateau region of Chotanagpur and Santhal Parganas is characterized by undulating hills and mountains and non-existence of perennial rivers. The area under fruit orchards is increasing rapidly in the eastern plateau region. To make profitable use of less productive uplands, farmers of the eastern plateau and hill region have recently shifted their focus from paddy–pulse cropping sequence to cultivation of fruit-based farming systems. Generally the saplings are planted during July to September. Initially there is no dearth of water and the plants grow well with the available monsoon water. As the monsoon withdraws, water drains out of the area and soils of midlands and uplands start losing moisture. During April to May, the plants face severe water stress and unless some watering is done it is practically impossible for them to survive. Although use of soil moisture conservation techniques for groundwater recharge are efficient tools for improving plant growth of fruit trees of more than 2 years of age, the raised water level is not enough for supplying moisture to shallow roots of newly planted trees. To combat such water stress to the newly established orchards, a plastic-lined ‘doba’ technology[2] has been developed at ICAR-Research Complex for Eastern Region (RCER). This is a low-cost technology, easy to understand, construct and maintain. RWH is in reality extending the fruits of the monsoon based on the principle ‘catch the water where it falls’[3].

Plastic-lined doba is a polythene-lined (200 μm UV-stabilized black polythene), small pond for harvesting of direct rainfall (Figure 1). The structure can store 4500 litre of water. The tank is lined with black polythene to check the loss of water due to seepage. The structure is constructed before the onset of monsoon for collection of rainwater. To avoid silting of the doba due to run-off water, a small bund is formed along the border to stop the entry of surface run-off to the tank. The average annual rainfall of the region is about 1400 mm and depth of the doba is 1000 mm. Therefore, there is every possibility that the structure will get water to its full capacity in one monsoon season in spite of evaporation loss of 1.5–2.0 mm/day during rainy season. The size of the doba (3 m long, 1.5 m wide and 1 m deep) has been designed in such a way that it can provide life-saving irrigation to 10 plants for 6 months. The daily average requirement of one mango plant for life-saving irrigation is 1 litre and for 6 months 1800 litre of water is required by 10 mango plants. The raised bunds of doba can be utilized for growing cucurbitaceous crops with the residual moisture. Singh *et al.*[4] concluded that subsistence agriculture in the hilly region could be successfully transformed into a profit-earning enterprise by tapping and utilizing water resources. Polythene of 6 m length and 4.5 m width is required to line the structure. The doba is constructed with simple tools available with the farmers, mainly spade and bucket. Before actual digging of the tanks for the doba, a proper layout of the field is made in such a way that one doba covers nearly ten plants. The spacing of the dobas in orchard is made accordingly. The loose soil from digging of the doba can be dumped around the structure to form a small bund of height 15–20 cm. This bund should be at least 45–60 cm away from the structure. After completion of digging, the sides and bottom are smoothened. Any pointed material that can puncture the polythene should be removed with hand and if necessary, mud or slurry prepared from mixture of soil and water can be applied on the sides and bottom for making the surface smooth. A piece (6 × 4.5 m) of the 200 μm black polythene is cut and placed in the doba structure. There may be formation of wrinkles at the corners; therefore proper folding of the polythene is to be done at corners to avoid excessive wrinkles. For proper anchorage, the polythene is placed in the trench dug on the border of the doba and soil is filled above it. This ensures that the polythene does not slide down due to weight of water. The doba is covered from above with a thatch of size 3.5 m length and 2 m width prepared from locally available material like straw and bamboo. Paddy straw or dry grass is placed between two bamboo frames of size 4 × 2.5 m size. A small opening of about 50 cm × 50 cm is kept in the thatch to take out water for irrigation. The thatch avoids entry of foreign material in the stored water and reduces the loss of water by evaporation. It also prevents the risk of animals falling into the doba. Further, the damage caused by termites and ants can be controlled by spraying insecticide (Biflex @ 2 ml/litre of water) on the walls and bottom of the doba at the time of construction and fixing of the polythene.

The doba technology was demonstrated in Ranchi, Khuti and Gumla districts of Jharkhand as well as in Purulia district of West Bengal during 2008–2010.

Figure 1. A ready-to-use doba.

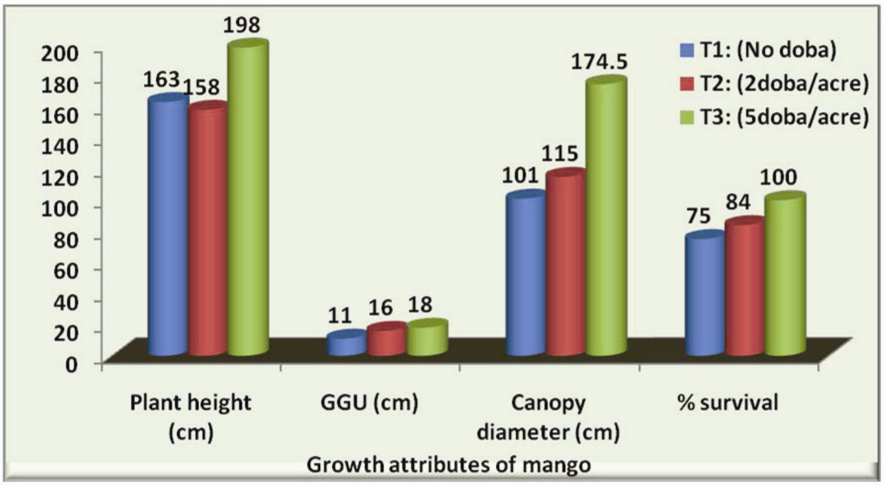

Figure 2. Impact of doba technology on growth attributes of mango in the newly established orchard.

Further, the establishment of mango orchard under doba technology was evaluated in 2014–15. The doba technology was evaluated in farmer's field and water levels in the doba were recorded by the end of May. It was observed that only 15% of the doba was dry, 45% had water level between 5 and 20 cm (i.e. 225–900 litre of water), 25% between 21 and 40 cm (945–1800 litre of water) and 15% between 40 and 50 cm (1800–2250 litre of water). Eighty per cent of the structures retained water to depths ranging from 5 to 45 cm (225–2025 litre) by the end of May, which shows the availability of water throughout the water-stress period. Such a low-cost water-harvesting system is effective in promoting horticultural plantations in the uplands of the eastern plateau region. A study was conducted to evaluate the feasibility of the structure and its effect on crop growth parameters in 2012–15 in the farmer's field. The newly established mango orchard in Bero block of Ranchi district accommodated 60 plants in one acre of land at a spacing of 8 × 8 m. Three different scenarios were tested during the study. The first scenario had no doba structure for irrigation (T_1). Here irrigation was done manually carrying water from a nearby source. The second scenario had two doba structures in one acre of land (T_2), whereas the third scenario had five of dobas in one acre of land (T_3). The growth attributes were recorded at the end of establishment phase of mango orchard (3 years). It was observed that the orchard having five dobas/acre for 60 plants was better in terms of plant height, girth at graft union (GGU), canopy diameter and percentage of survival of plants compared to that with two dobas/acre and no dobas (Figure 2).

A total of two mandays is required for digging of the doba, which costs about Rs 300. The cost of polythene is Rs 780 (6 kg @ Rs 130 per kg) and thatch (roof) may be prepared from farm waste with minimum additional cost of about Rs 120 for paddy straw and bamboo. So the total cost of one doba is about Rs 1200. If a farmer has one hectare area under fruits planted at a spacing of 5 × 5 m (400 plants/ha), the required number of dobas to meet the irrigation requirement will be 40 and the total cost for 1 ha will be Rs 48,000. Water saving through doba technology has been worked out to be 180,000 litre/ha. Initial three years of fruit plants are crucial as water stress during summer may leave the plants wilted. Life of doba structures is 2–3 years, which ensures availability of water during this crucial time span in the life of the plants. It is suited for all orchard fruit crops. Generally, for establishment of newly planted mango orchard, Rs 1 lakh is required for the cost of planting material, fertilizer, pesticide, labour, fencing with locally available material and miscellaneous cost. With the introduction of doba in 1 ha of land, the total cost amounts to Rs 1.48 lakhs during the first year of orchard establishment. The gestation period for mango orchards is 3 years and with doba technology, actual benefit will start to accrue after 4 years at the estimated rate of Rs 1 lakh/ha (yield: 4000 kg/ha). The inter-space between mango plants can be utilized for growing intercrops during the initial period and provides some remuneration to overcome cost incurred in the establishment and management of the orchard. Further, the harvested residue of intercrop is used as dry mulch in the surface of root zone of mango plant to conserve water. The payback period for mango orchard is 4 years, i.e. the cost involved for the establishment is met from the income at the fifth year of establishment. The benefit–cost ratio of 2.3 : 1 is achieved in the sixth year of establishment with doba technology due to 100% survival. In case of conventional method (no doba) of irrigation, the payback period is 5 years with benefit–cost ratio of 0.87 : 1 in the seventh year of establishment due to 50% mortality of the orchard. Owing to its low cost and ease of construction, the doba technology has been readily accepted by the farmers. They have agreed to convert their low productive land into mango orchards and use doba to harvest rainwater during establishment phase of the orchards. Life-saving irrigation from doba has resulted in no mortality of plants, particularly during the summer months and better growth. The plastic-lined doba is also being used by farmers for the purpose of storing water from seasonal streams and using it during the summer season. This technology has helped the farmers to increase their income and to also diversify the crops to meet their nutritional requirements.

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Need to strengthen quarantine between Andaman and Nicobar Islands and mainland India

When an animal or a plant species, unknown in a country, gets introduced, it is termed an exotic species often characterized by its prolific breeding, in the absence of any biotic natural enemies. Frequently, such introduced species end up as a pest/weed. These then become invasive alien species (IAS), threatening the economy. Often only those that acclimatize stay on to cause economic loss like *Parthenium* (*Parthenium hysterophorus*)[1], *Salvinia* (*Salvinia molesta*)[2], serpentine leaf miner (*Liriomyza trifolii*)[3], spiralling white fly (*Aleurodicus dispersus*)[4] and the recent pinworm (*Tuta absoluta*)[5], to mention a few. Only few of the invasives have been curbed successfully. The two best examples are the papaya mealy bug, *Paracoccus marginatus* and water fern, *Salvinia molesta*. The former has been controlled by bouquet of exotic natural enemies, the most important being, *Acerophagus papayae*[6]. The water fern, *Salvinia* which blocked waterways in Kerala, was controlled successfully by a beetle, *Cryptobagous salviniae*[2]. India has been advocating rigorous screening at ports of international entry to prevent exotic introduction. However, national restriction or screening of live materials, between regions/states, as is being done, for example, in Australia (between counties) and USA (between Islands and the mainland) is hardly evident in India, but is becoming a critical need of the hour. The only exceptions are the restrictions put on the golden cyst nematodes which were prevalent in Ooty[7] and apple codling moth (*Cydia pomonella*) which was present in Kashmir[8]. The former perhaps helped in salvaging potato in most parts of North India, where it is almost a staple food. Other insects/diseases with domestic quarantine in India are fluted scale (*Icerya purchasi*), San Jose scale (*Aspidiotus perniciosus*), coffee berry borer (*Hypothenamus hampei*), potato wart (*Synchytrium endobioticum*), banana mosaic (virus) and banana bunchy top (virus)[9]. The movements of these however, seem hardly restricted.

One such 'intra-national' restriction on live material urgently needed is between Andamans and Nicobar Islands and mainland India. Fortunately, much of these islands are maintained natural, and hence an introduced species, even from the mainland may not be noticed to affect agriculture, but can cause some negative biodiversity impacts. However, introduced species in the mainland can be more pronounced, especially if they