

Enhancing productivity of rainfed farms

by adopting *bael* + cowpea horti-agri system
strengthened with water conservation practices

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India ranks first among the countries that practice rainfed agriculture both in terms of extent and value of production. Out of the total geographical area of the country of 329 M ha, about 146 M ha is degraded and 85 M ha is rainfed arable land. It is estimated that even after achieving the full irrigation potential, nearly 50% of the net cultivated area will remain dependent on rainfall. Cultivation of coarse cereals (91%), pulses (91%), oilseeds (80%) and cotton (65%) predominates in these rainfed regions. Moreover, two-thirds of livestock and 40% of human population of the country live in rainfed regions. Again poor nutrient status of soils, land degradation through erosion, salinity etc. are the other constraints that threatens agricultural productivity in rainfed regions.

Key words: *Bael*, Cowpea, Crop, Farms, Horti-agri system, Production, Water

THE low level of farmers' income and year-to-year fluctuations in it are a major source of agrarian distress. This distress is spreading and getting severe over time impacting almost half of the population of the country that is dependent on farming for livelihood. Persistent low level of farmers' income can also cause serious adverse effect on the future of agriculture in the country. The major sources of growth operating within agriculture sector should be improvement in productivity, resource use efficiency, diversification towards high value crops and

horticulture. Besides, water harvesting with *in-situ* water conservation, enhancing soil moisture, soil-health and increasing the soil carbon build up, protecting the land from various types of degradation and diversifying the farming system are important to tackle these problems.

Horticultural crops like citrus (*Citrus* sp.), guava (*Psidium guajava*), *bael* (*Aegle marmelos*) and *ber* (*Ziziphus mauritiana*) play promising role in enhancing farm income in vulnerable rainfed areas. Hardy fruit crops have better choice in these

areas. Utilization of inter-space between trees can improve soil nutrient and biological characteristics, physical properties, enhancing total biomass production and further improve farmers income from a unit land. These benefits of agro-forestry can be improvised by incorporating *in-situ* water conservation practices in horti-agri systems. Legume crops intercropped with fruit trees may provide important source of cash and income. Apart from fixing atmospheric nitrogen(N), recycling nutrients and improving soil nutrient availability



Fig. 1. Trench *In-Situ* water conservation practice in *bael* tree



Fig. 2. Bumper crop of cowpea under horti-agri landuse

and microbial reactions, the system in conjunction with trees and legumes reduce runoff and enhance soil infiltration capacity through an improved surface status and an increased root density. Bengal quince or *bael* (*Aegle marmelos*), one of the important fruit tree species is an integral part of arid and semi-arid regions of India. *Aegle marmelos*, commonly known as *bael*, Bengal quince, golden apple, stone apple, *bili*, is a species of tree native to India. Again legumes contain 22 to 24% protein which is almost twice the protein in wheat and thrice that of rice. India is the largest producer and consumer of legumes in the world, but average yield of legumes in India is lower when compared with the world average. It is due to most of the legumes in India are grown in low fertility, problematic soils and unpredictable environmental conditions. More than 87% of the area under legumes is rainfed. Drought and heat stress reduce seed yields by 50%, especially in arid and semi-arid regions. Therefore, Government of India is also emphasizing for enhancing the legumes production. Cowpea is one of the most ancient crops known to man. Its origin and subsequent domestication is associated with pearl millet and sorghum in Africa. Cowpea is considered more tolerant to drought than soybean and better adapted to sandy soils. All cultivated cowpea varieties are considered warm season and adapted to heat and drought conditions.

Legume production can be increased, if area under legumes can be increased utilizing inter-space between trees which can also improve soil-nutrient and biological characteristics, physical properties, enhancing total biomass production and further improve farmers' income from a unit land. Better survival and establishment of these trees and enhancing legume yield in rainfed and dry lands requires proper *in-situ* moisture conservation.

To find the feasibility of *bael* + cowpea agroforestry system, an experiment was conducted at the site located in the *bael* orchard, near to Research Farm of Water Technology

Centre, Indian Agricultural Research Institute (28° 37' 46.2" N Latitude, 77° 09' 43.8" E Longitude, and altitude of 228.6 m above mean sea level), New Delhi. Deep summer ploughing was done in May (01/05/2015) in the experimental field, before commencement of cropping season, followed by three times disk with the help of tractor and levelled with the help of laser leveling. Then a gentle slope of 2 to 3% was given to the plots under field preparation before layout of the experiment. Ploughing was done again, and experimental layout was done with *in-situ* water conservation practices of trench and no water conservation practices

The treatments were laid inside the *bael* orchard and outside the orchard i.e. without trees to observe the impact of trees on crop yield and comparing the effects without trees. But outside the trees, there were no water conservation measures implemented. The soil-water conservation measures laid were trench (45 cm width × 25 cm depth) and no-water conservation practices, the tree spacing was 6 m × 6 m and in each plots there were four trees, and plot size inside the hort-agri system was 24 m × 6 m, whereas outside the trees, the plot size was 6 m × 4 m, as per the space availability. Pusa Sukomal variety of cowpea was sown during 2015 and 2016 in July at a spacing of 45 cm × 10 cm. Recommended dose of nutrients 30:40:30 kg/ha N: P: K was applied plot-wise at the sowing during first year and no fertilizer application in second year. To have the desired plant population, two weeks after sowing, thinning was done. Two-hand

weeding were done, first weeding 26 days after sowing, second at 40 days after sowing to keep the experimental plots free from weeds. Individual cowpea (green pods) and *bael* (fruit) yields were recorded and then was converted to cowpea green-pod equivalent yield. Total yield of *bael* + cowpea system was converted to total cowpea green-pod equivalent yield.

Depth-wise soil moisture storage

Periodic soil moisture variations at 10, 35, 45, 65 days after sowing and at harvesting in were collected. It was observed that average soil moisture at 10 days after sowing at 0 to 60 cm depth was 9.07 cm and in no moisture conservation practice (7.75 cm). Similar observations were also found during 35, 45, 65 days after sowing and at the harvesting. In cowpea plots, 6 to 17% more soil water availability was observed in trench compared to no-moisture conservations practice, in the agro-forestry system.

Cowpea and *bael* agro-forestry system yield

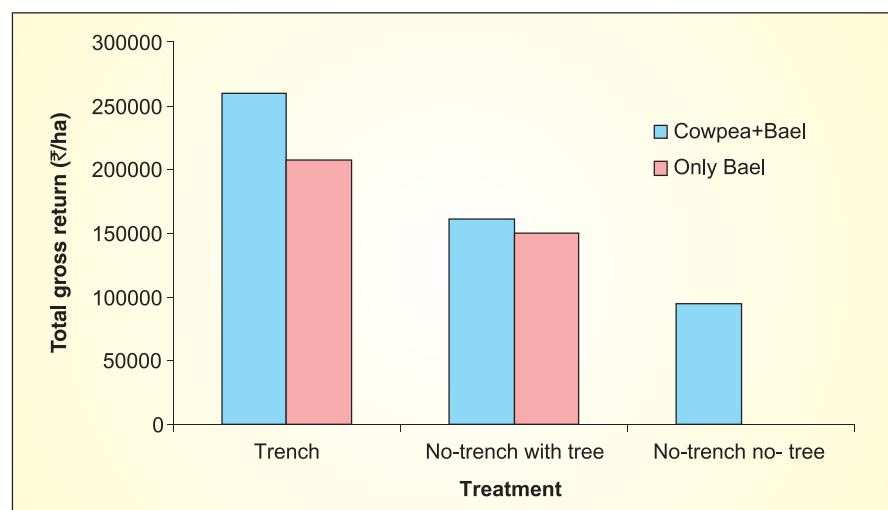
During the experimental period, first time there was the good amount of production of *bael*. Cowpea crop had a profound effect on the yield of *bael* tree yield. Cowpea yield ranged from 25 to 29 q/ha when sown between rows of *bael* tree, but when sown outside the *bael* orchard the cowpea yield was 47.2 q/ha. *Bael* yield ranged from 19 to 34 q/ha in cowpea plots whereas 17 to 25 q/ha in sole *bael* plantation. Construction contour trenches across the slope, at 1 m distance on upper side of *bael* tree rows for rain water conservation, resulted in the yield enhancement of



Fig. 3. Bumper crop of *bael* under hort-agri landuse system

Table 1. Effect of water conservation practices on cowpea and *bael* yield (q/ha)

Treatments	Cowpea yield (q/ha)	Bael yield (q/ha)		Total cowpea green pod equivalent yield (q/ha)	
		Cowpea plot	No-cowpea	Cowpea plot	No cowpea
Bael tree + cowpea with trench	29.3	33.5	24.9	129.7	103.9
Bael tree + cowpea with no-trench	25.0	18.6	16.7	80.4	75.1
Only cowpea (no bael tree, no trench)	47.2	-	-	47.2	-

**Fig. 4.** Total gross returns under different water conservation practices

about 1.5- fold over no-water conservation practice (Table 1). Cowpea green-pod equivalent yield was 2.7- fold compared to sole cowpea yield without any horti-agri system. Total gross return from *bael* + cowpea plot provided with trench for water conservation was ₹ 2,59,300/ha compared to no water conservation practice i.e. ₹ 1,60,700/ha. Sole crop of cowpea gave gross return of ₹ 94,300/ha only (Fig. 1). Sole *bael* tree plantation resulted in higher gross return than sole cowpea. Combination of *bael* and cowpea

yielded higher gross return than either of the sole components. Such horti-agriculture systems can surely help the farmer to double their rainfed farm income in the hot semi-arid regions of India.

SUMMARY

Rainfed agriculture constitutes the source of food and livelihood security of millions of people worldwide. However, production of rainfed areas is constrained by the extreme variability in rainfall, poor nutrient status of soils, land degradation

through erosion etc. Under such situations, horti-agri and other agroforestry land use systems are the best options to protect the land from various types of degradation, diversifying the farming system and increasing the soil carbon build up and moisture storage. These benefits of agroforestry can be improved by incorporating *in-situ* moisture conservation practices and legume crops intercropped with fruit trees may provide important source of cash and income. In a field experiment carried out at Research Farm, Water Technology Centre, Indian Agricultural Research Institute, New Delhi during *kharif* of 2015 and 2016 with cowpea grown in *bael* tree orchard provided with contour trench on its upper side of *bael* tree rows for water conservation, inclusion of cowpea enhanced the *bael* fruit yield and also the total yield (*bael* + cowpea) expressed as cowpea green-pod equivalent yield, when the plots were provided with contour trench treatment for water conservation. The study demonstrated that *bael* tree or any other hardy horticulture intercropped with cowpea and the system supported with contour trench water conservation practice in the upstream of tree can immensely increase farm productivity and income under rainfed conditions of arid and semi-arid climate.

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Jai Kisan, Jai Vigyan

- A total of ₹ 788.33 crores have been sanctioned for opening six new agricultural colleges for eastern India under Central Agricultural University, Imphal, and a new Central Agricultural University in Meghalaya.
- For the establishment of two new agricultural research institutes in Asom and Jharkhand, a sum ₹ 100 crores is allocated.
- First academic session of the Rani Lakshmbai Central Agricultural University has been allocated for four new agricultural colleges in Datiya and Jhansi.
- An Memorandum of Understanding was signed for transforming the Rajendra Central Agricultural University, Pusa, Samstipur, Bihar. A proposal of ₹ 400 crores is submitted in EFC.
- Post-Graduate Institute of Horticulture is being established in Amritsar, Punjab.
- Foundation stone of the Indian Institute of Agricultural Biotechnology is laid at Ranchi for promoting agricultural biotechnology.