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In-situ moisture conservation techniques for productivity and quality in Jackfruit (*Artocarpus heterophyllus* Lam.)

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ABSTRACT

An investigation was taken up on 8 years old seedlings trees of jackfruit, to know the effect of different *in-situ* moisture conservation techniques on fruit production and quality improvement with economic return. Results indicated that rainwater harvesting by circular trench along with basin mulching with back polythene resulted in maximum fruit production with better fruit quality. Highest net profit (₹ 36,615 ha^{-1}) with BCR (1.67) was estimated from the tree with circular trench along with black polythene mulching.

1. INTRODUCTION

The Jackfruit (*Artocarpus heterophyllus* L.) is one of the most important minor fruit crops in tropical and sub-tropical regions and perhaps the most widespread and useful tree in South and Southeast Asian countries. Every part of the tree and fruit is used for various purposes. The green ripe fruit is consumed as vegetable while ripe one is used as fresh fruit due to its nutritional value and delicious taste. Systematic jackfruit plantation in the country is very rare. Most of the cases it is found in homestead garden and in roadside plantation. In most of the cases, jack trees are grown with little care and no irrigation is provided for its growth or production. Flowering and fruit development of jack is occurred during dry period *i.e.* January-February to May-June when soil moisture stress is natural phenomenon. Although, supplementary irrigation during flowering and fruiting of jack is the best option for getting good fruit set and yield (Ghosh and Bera, 2006) but it may not be possible in areas where such facilities do not exist or there is a scarcity of underground water. In such situation, *in-situ* moisture conservation around each tree would be the feasible alternative. There are many reports of *in-situ* moisture conservation with the aid of mulching or rain-water harvesting in fruit crops like aonla (Ghosh *et al.,* 2002), mango (Ghosh and Bauri 2002), Ber (Ghosh and Tarai 2007), pomegranate (Ghosh *et al.*, 2001), *etc.* but such report in jackfruit is meager. Hence, an investigation was taken up to find out the effect of different mulching materials and rainwater harvesting structures on fruit production and quality improvement in jackfruit grown in new alluvial zone of West Bengal.

2. MATERIALS AND METHODS

The experiment was conducted on 8 years old seedling jackfruit trees planted at 10 x 10 m spacing having uniform growth at the H.R.S. of B.C.K.V. Mondouri, Nadia, West Bengal during 2010-2013. The site is situated at 23.5^0 North latitude and 80^{0}34' East longitude having an altitude of 9.75 m above mean sea level (msl). The experimental site has gangetic new alluvial soil with sandy clay loam in texture. Available N, P and K of the soil were 178.2, 19.7 and 302.2 kg^{-ha} and pH was 6.60. The climatic condition of the Research station was humid sub-tropical. Monthly rainfall data during the period of investigation has been presented in the Table 5.

There was nine treatments *viz.,* basin mulching with dry leaves of 8-10 cm thick (available in the field) and black polythene (200 guage thickened); *in-situ* rain water harvesting by circular trench and semi-circular trench. The details of nine treatments have been mentioned in each table. Mulching was made around the tree basin up to 3 feet away from the trunk. The semi-circular trench and circular trench were prepared at 3-feet away from the trunk against the slope having one feet depth and one feet width. Mulching and *in-situ* rainwater harvesting structures were applied separately and in combination including control (hoing around the basin) during October each year. The treatments were applied every year during October when there was good soil moisture. The treatments were applied randomly in the trees having uniform plant vigour following randomized block design having 3 replications with three plants in each replication. Annual application of 400 g of nitrogen, 200 g of phosphorus (P_2O_5) and 200 g of potassium (K_2O) per tree was made in two splits during June and September. The fertilizers were applied at 3-feet away from the trunk in a circular trench having one feet depth and covered with the soil every year.

Observation on fruit yield, physico-chemical characteristics of fruits were taken. Fruit setting was determined by dividing the total number of fruits set with total number of female spike. It was expressed in percent by multiplying with 100. Fruit retention was determined by dividing the number of fruits at harvest and initial number of set fruits. It is expressed in percent by multiplying with 100. TSS of fruit was estimated by hand refractrometer while acidity, reducing sugars, total sugars and vitamin C content of the fruit flakes were determined following standard method (AOAC, 1990). To know the soil moisture status, soil samples from each treatment were collected at 0-30 cm depth with the help of soil auger starting from December to May in each year. Fresh and dry weight (oven dried) of the soil were recorded and calculated moisture percentage with help of following formula:

$$\text{Moisture \%} = \frac{\text{Fresh weight of the soil - Dry weight of the soil}}{\text{Dry weight of the soil}} \times 100$$

The data collected were analysed statistically following the method, as described by Panse and Sukhatme (1985).

3. RESULTS AND DISCUSSION

Fruit Setting and Retention

A significant difference in fruit setting and its retention was observed due to implementation of different *in-situ* moisture conservation practices around each jackfruit tree (Table 1). All the methods gave higher fruit setting and fruit retention as compared to control tree. In general, black polythene mulching singly and in combination with water harvesting structures resulted in higher fruit setting and their retention as compared to dry leaves mulching irrespective of its application with water-harvesting structures. Again circular trench around the tree gave better result as compared to semicircular trench irrespective of mulch materials used in the structure. Maximum fruit setting of 77.8% and fruit retention 67.7% was observed from the tree with circular trench + black polythene mulching as against 59.9% and 48.4%, respectively in control. Higher fruit setting and fruit retention in black polythene mulching or circular trench was due to higher moisture availability as observed in different months (Table 3) of fruit growth period. It has already been established that jack tree required a considerable amount of moisture in the soil during fruit setting and fruit development period as these growth periods are coincide with soil moisture stress period as because there was no or little rainfall as observed in Table 5. Similar observation was noted by Ghosh and Bera (2006) who noted supplementary irrigation during January to May (fruit setting and fruit development period) resulted in higher fruit set and their retention. Mannan (2000) while conducting a survey to identify the problems of jackfruit cultivation in Jessore, Bangladesh, reported that one of the main problems of fruit drop in jack was due to water deficiency at fruit setting stage.

Table: 1
Effect of *in-situ* moisture conservation on fruit setting, retention, yield and foliar NPK content of jackfruit

Treatment	*Fruit setting (%)	*Fruit retention (%)	Fruit yield (kg tree^{-1})			
			2011	2012	2013	Average
Mulching with dry leaves	65.7(54.15)	57.0(49.02)	33.9	40.7	44.9	39.8
Mulching with black polythene	75.7(60.47)	60.0(50.77)	44.2	48.7	53.3	48.7
Water harvesting by circular trench	68.0(55.55)	55.5(48.16)	32.3	46.1	54.6	44.3
Water harvesting by semi-circular trench	68.8(56.07)	54.3(47.47)	29.4	43.3	53.3	42.0
Water harvesting by circular trench + dry leaves mulching	69.7(56.60)	58.4(49.84)	38.8	42.8	52.7	44.8
Water harvesting by circular trench + black polythene mulching	77.8(61.89)	67.7(55.37)	45.0	62.0	74.7	60.6
Water harvesting by semi-circular trench + dry leaves mulching	70.3(56.98)	58.4(49.84)	23.7	32.4	39.3	31.8
Water harvesting by semi-circular trench + black polythene mulching	72.3(58.24)	61.5(51.65)	32.0	38.4	41.7	37.4
Control (hoing around tree basin)	59.9(50.71)	48.8(44.31)	21.0	22.7	28.3	24.0
S.Em ±	1.79	1.77	4.51	4.48	6.09	3.13
C.D. at 5%	3.79	3.76	9.56	9.50	12.92	6.63

*Average of 3 years; Figures in the brackets are angular transformed value

Fruit Yield

Jackfruit yield was significantly improved due to adaptation of different *in-situ* moisture conservation methods (Table 1). Degree of effectiveness of mulch materials and *in-situ* water harvesting structures on yield increment followed the same pattern as observed in fruit setting and fruit retention as because of yield is directly related with fruit setting and fruit retention. Highest fruit yield of 45.0, 62.0 and 74.7 kg^{-tree} were noted in 2011 2012 and 2013, respectively in tree with circular trench + black polythene mulching (Fig. 1) as against 21.0, 22.7 and 28.3 kg^{-tree}, respectively in control tree. It was calculated that the tree with black polythene mulching coupled with *in-situ* water harvesting by circular trench resulted in 152.5% yield increment over control tree. Yield increment in black polythene mulching/and or *in-situ* water harvesting by circular trench may be due to more moisture availability around micro-catchment area of each tree. Similar results were also reported by Rejani and Yadukumar (2010) in cashew nut and Kumar *et al.* (2013) in apple. It is established fact that the nutrient from the 'source' is the key factor of synthesis of assimilates for 'sink' (fruit) where moisture is the 2nd component needed for transportation of nutrients/and synthesis of assimilates for the giant fruit 'jack'. Effectiveness of circular trench in better *in-situ* soil moisture conservation as compared to semi- circular was due to its higher surface area of rainwater collection. Superiority of circular trench in yield increment was also noted in mango (Ghosh and Bauri, 2002) and sweet orange (Ghosh, 2002). Beneficial effect of rain water harvesting and mulching was also reported by Kumar *et al.* (2014) in apple, Kumar and Ahmed (2015) in almond and Kumar (2016) in almond.

Fig. 1. Rainwater harvesting by circular trench along with basin mulching by back polythene

Between the mulch materials, black polythene was better then dry leaves mulching as it resulted in higher yield (48.7 kg^{-tree}) as compared to dry leaves (39.8 kg^{-tree}). Similar result was also noted in mango (Ghosh and Bauri, 2003) where black polythene mulch stood the first as compared to paddy straw and dry leaves mulching in respect of yield and other parameters of fruit quality improvement. Covering of micro-catchment area of a fruit tree with any type of mulch material proved to be effective in *in-situ* moisture conservation, checking weed growth and also have several other beneficial effects which ultimately resulted in higher fruit yield and improved fruit quality. But effectiveness of mulch material depend not only on the agro-climatic condition of the area where crop is to be grown but also nature or type of the fruit crop and that should be determined through proper investigation.

Physical Characteristics of Fruits

Fruit weight of jack was significantly varied due to adaptation of different *in-situ* moisture conservation techniques (Table 2). Maximum fruit weight (6.07 kg) was recorded from the tree; where circular trench and black polythene mulch were used followed by circular trench + dry

Table: 2
Effect of *in-situ* moisture conservation on physico-chemical characteristics of jackfruit (Average of 3 years)

Treatment	Fruit weight (kg)	Edible flake (%)	Seed weight (%)	TSS (^{0}B)	Acidity (%)	Total sugar (%)	Vitamin C (mg 100 g^{-1})
Mulching with dry leaves	4.82	38.4	11.7	22.0	0.28	14.6	9.8
Mulching with black polythene	5.34	41.4	11.9	23.6	0.27	15.6	10.2
Water harvesting by circular trench	5.20	38.8	13.9	23.4	0.27	15.7	9.7
Water harvesting by semi-circular trench	5.31	39.2	12.7	22.6	0.26	14.2	9.5
Water harvesting by circular trench + dry leaves mulching	5.74	39.3	13.6	24.2	0.30	15.6	9.7
Water harvesting by circular trench + black polythene mulching	6.07	42.3	13.9	24.9	0.34	17.1	10.7
Water harvesting by semi-circular trench + dry leaves mulching	5.19	40.8	12.6	22.5	0.33	15.7	10.2
Water harvesting by semi-circular trench + black polythene mulching	5.47	41.3	13.2	23.5	0.29	15.8	10.3
Control (hoing around tree basin)	4.68	37.3	11.3	21.4	0.26	12.6	9.2
S.Em ±	0.16	1.03	0.77	0.46	0.01	0.53	1.74
C.D. at 5%	0.34	2.18	1.63	0.98	NS	1.12	NS

*Average of 3 years; Figures in the brackets are angular transformed value leave mulching (5.74 kg). Minimum fruit weight (4.68 kg) was recorded from the control tree. It was clear from the results that circular trench along with mulch materials was very effective to meet the moisture demand for gigantic growth of jack. Beneficial effect of *in-situ* moisture conservation by circular trench/along with dry leaves mulching for improving fruit growth was also noted by Ghosh (2002) in sweet orange and Ghosh and Bauri (2002) in mango.

Edible Flake and Seed Content

In ripe jack, flake is the edible part which is sweet, aromatic and delicious in taste. The edible flake content was maximum (42.3%) in the fruit of the tree with circular trench + black polythene mulching and minimum (37.3%) in control tree (Table 2). Seed of the jack is also edible. In green jack, which is very popular as vegetable jack, seeds are soft and consumed alongwith the hard flake while in ripe jack, seeds are discarded but consumed as vegetable and preparation of many by products. The seed content in jack was varied due to different *in-situ* moisture conservation methods. Black polythene mulch alone or in combination with circular trench gave highest seed content (13.9%) and lowest (11.3%) was noted from the control tree (Table 2).

Fruit Quality

The chemical parameter of fruit in respect of TSS and total sugar was significantly improved due to adaptation of different *in-situ* moisture conservation techniques (Table 2). Maximum TSS (24.9^0 brix) and total sugars (17.1%) were recorded from the fruit of tree with circular trench + black polythene mulching and minimum was recorded in control tree (21.4^0 brix in TSS and 12.6% total sugar). In general, fruit quality was better in the trees with *in-situ* moisture conservation as compared to control trees irrespective of method of conservation technique adopted and this was due to more available soil moisture which ultimately caused mobilization of soluble carbohydrates to the fruit. Fruit quality improvement due to mulching/and *in-situ* water harvesting also reported by various workers *viz.*, Ghosh and Bauri (2002) in mango; Ghosh and Tarai (2007) in ber; Ghosh and Bera (2015) in Pomegranate, etc. Acidity and Vitamin C content of fruit however, did not vary significantly due to *in-situ* moisture conservation practices (Table 2).

Soil Moisture Status

Improvement of moisture status in the soil profile is the main objective of *in-situ* conservation techniques. In the present investigation as shown in Table 3, revealed that moisture status in the soil was improved in different months irrespective of the technique applied as compared to the control plot. Among the different *in-situ* moisture conservation treatments, black polythene mulching exerted strong influence in conserving more moisture as compared to dry leaves and its effectiveness was further enhanced when used in micro-catchment structures. Maximum soil moisture content was estimated from the tree having circular trench + black polythene mulching irrespective of month of sampling and minimum in control tree. Higher soil moisture retention in circular trench with black polythene was possible due to greater impounding of rainwater and slowing down of runoff velocity because trenches may act as speed breaker to the run off. This helps in increasing the amount of water percolating down the soil profile and reduced the water loss by mulching, which is happened through soil evaporation. Superiority of circular trench in soil moisture conservation as compared to other rain water harvesting structures was also observed by Ghosh and Bauri (2002) in mango and Ghosh (2002) in sweet orange.

Table: 3
Effect of *in-situ* moisture conservation on soil moisture status (%) at 0-30 cm depth in jackfruit orchard during different months (Average of last 2 years)

Treatment	December	January	February	March	April	May	Average
Mulching with dry leaves	5.3	3.4	10.2	5.8	7.9	6.5	6.5
Mulching with black polythene	8.5	7.6	10.7	6.9	9.2	9.0	8.7
Water harvesting by circular trench	6.7	7.8	12.1	10.6	9.2	7.7	9.0
Water harvesting by semi-circular trench	6.2	4.7	9.8	8.9	8.8	7.4	7.6
Water harvesting by circular trench + dry leaves mulching	7.3	7.0	10.1	8.8	11.4	9.5	9.0
Water harvesting by circular trench + black polythene mulching	8.7	8.1	12.0	9.9	12.5	12.0	10.5
Water harvesting by semi-circular trench + dry leaves mulching	7.1	5.1	10.0	7.2	9.9	8.3	7.9
Water harvesting by semi-circular trench + black polythene mulching	8.4	8.0	11.6	7.7	10.2	9.8	9.3
Control (hoing around tree basin)	4.4	3.0	7.1	4.3	5.0	4.9	4.8
S.Em ±	1.00	1.35	2.17	1.78	1.11	0.94	-
CD at 5%	2.11	2.85	4.61	3.78	2.35	1.99	-

Economics of Different *in-situ* Moisture Conservation Methods

Calculation of economic viability of the treatments is considered to be the last step for final recommendation of any package and practices related to agricultural/horticultural crop production. In the present investigation, saleable product was ripe jackfruit. Production capacity of a tree was varied due to adaptation of different *in-situ* moisture conservation practices. The fruit yield/tree has been converted to a hectare considering 100 trees at 10 x 10 m spacing (Table 4). The cost of application of each treatment, gross return and net return per hectare are presented in Table 4. It was observed that highest expenditure of ₹ 54,285/- was incurred in the treatment of circular trench+black polythene mulching which gave highest yield and resulted in maximum gross income of ₹ 90,900/- ha^{-1} and this treatment showed highest net profit of ₹ 35,142/- over control with highest BCR of 1.67 followed by circular trench + dry leaves mulching (BCR of 1.66) and circular trench alone only (BCR of 1.65).

4. CONCLUSIONS

Harvesting of rain-water by circular trench was found to be a viable approach in the non-irrigated areas for profitable production of quality jackfruits. However, where additional fund is available for commercial cultivation of jackfruit, the tree basin should be covered with black polythene for getting more profit.

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Table: 5
Monthly rainfall data during the period of investigation (September, 2010-June, 2013)

Month	Rainfall (mm)			
	2010	2011	2012	2013
January	-	0.00	0.00	0.03
February	-	0.00	12.80	0.21
March	-	2.64	0.00	0.00
April	-	3.72	45.90	23.56
May	-	4.37	112.00	15.96
June	-	11.98	184.00	17.62
July	-	390.88	264.00	-
August	-	487.20	5.27	-
September	3.98	451.80	7.90	-
October	2.40	76.80	2.46	-
November	0.03	0.00	1.01	-
December	0.64	0.00	0.22	-

Table: 4
Economic of different in-situ moisture conservation methods

Treatment	Fruit yield $tree^{-1}$ (kg) (Av. of 3 years)	Yield ha^{-1} (kg) (Considering 100 trees)	Gross income ha^{-1} (₹) (Sealable @ ₹15 kg^{-1})	Cost of treatments (₹ ha^{-1})	Net return (₹ ha^{-1})	Net return over control (₹ ha^{-1})	Benefit cost ratio (BCR)
Mulching with dry leaves	39.8	3980	59,700	38,952	20,748	19,275	1.53
Mulching with black polythene	48.7	4870	73,050	51,613	21,437	19,964	1.42
Water harvesting by circular trench	44.3	4430	66,450	40,205	26,245	24,772	1.65
Water harvesting by semi-circular trench	42.0	4200	63,000	38,702	24,298	22,825	1.63
Water harvesting by circular trench + dry leaves mulching	44.8	4480	67,200	40,455	26,745	25,272	1.66
Water harvesting by circular trench + black polythene mulching	60.6	6060	90,900	54.285	36,615	35,142	1.67
Water harvesting by semi-circular trench + dry leaves mulching	31.8	3180	47,700	38.952	8,748	7,275	1.22
Water harvesting by semi-circular trench + black polythene mulching	37.4	3740	56,100	52.782	3,318	1,845	1.06
Control (hoing around tree basin)	24.0	2400	36,000	34.527	1,473	-	1.01

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