Original Research Article

Economic Impact of High DensityCottonGrowing System in Telangana

Abstract

Cotton is a globally important crop that plays an important part in the agricultural and industrial economy.Cotton production in India is considered to have a wide impact not only on the livelihood of farmers and economy of the country but also on international trade as it is the only crop that goes with a person throughout his or her whole life. The most often used elements of the cotton plant are cotton lint and cotton seeds. But India's seed cotton production per unit area is still significantly lower than that of several other cotton-growing countries throughout the world. Two of the most prominent factors leading to the country's low cotton crop productivity are a lack of plant population and the use of low-potential cultivars.Several researches are conducted, including maintaining a sufficient plant density, employing the right number of fertilizers, applying growth regulators and so on and released some varieties which are suitable for high density planting system.

The study was taken up in three districts (Adilabad, Warangal and Nagarkurnool) from three different zones of Telangana (Northern, Central and Southern). It evaluated the economic benefit of HDPS cotton by comparing it with non HDPS cotton, variables influencing the adoption of the technology and difficulties faced by adopter farmers. For this study, multistage sampling was used. HDPS adopters and non-adopters were equally picked from each zone based on the proportionate level of technology adoption. In order to create a sample size of 180 farmers, a total of 90 HDPS adopters and 90 HDPS non-adopters from three agroclimatic zones of Telangana were selected during *Kharif,* 2021-2022.

A comprehensive profile of the sample respondents was constructed from selected sample districts of each Agroclimatic zone of Telangana. After the data was analyzed and interpreted, it was found that farmers who had higher levels of farming experience, education, age, number of trainings and family members involvement in agriculture were more likely to adopt HDPS cotton.

Cost of cultivation of HDPS cotton for marginal, small and large farms was found to be ₹ 96,376.74, ₹ 98,607.71 and ₹ 1,00,355.77 and in non HDPS cotton, ₹ 91,229.89, ₹ 93,211.99 and ₹ 95,346.71 for marginal, small and large farms respectively. The cost of cultivation for pooled HDPS and non HDPS farms was ₹ 98,239.49 and ₹ 93,266.07 per hectare respectively. The cost difference between the HDPS and non HDPS cotton was ₹ 4,973.42 per hectare.

Among the selected three districts of three zones of Telangana, cost of cultivation of pooled HDPS cotton farmers was high for Nagarkurnool with ₹ 97,802.37 per hectare followed by Adilabad and Warangal (Urban and Rural) with ₹ 96,320.62 and ₹ 96,121.03 per hectare respectively. The gross returns and net returns were more for Adilabad district with ₹ 1,32,452.47 and ₹ 33,231.24 per hectare followed by Nagarkurnool with ₹ 1,28,254.13 and ₹ 31,982.02 and Warangal with ₹ 1,27,452.45 and ₹ 32,252.21 per hectare, respectively.

Human labour occupied the highest share among all the components of variable cost in case of both HDPS and non HDPS cotton cultivation, *i.e.,* 17.65 per cent and

17.15 per cent, respectively. The cost of seed and fertilizers was estimated high for HDPS cotton at ₹ 7,125.56 (7.25%) and ₹ 10,356.16 (10.54%) as compared to non HDPS cotton at ₹ 4,580.28 (4.91%) and ₹ 8,693.12 (9.32%) respectively as the requirement of seed and fertilizer is usually high for HDPS compared to normal cotton cultivation. The average cost of bullock labour and machinery labour spent in HDPS cotton was found to be low at ₹ 6,029.43 (6.14%) and ₹ 3,392.33 (3.45%) as compared to non HDPS cotton at ₹ 5,980.96 (6.41%) and ₹ 3,532.83 (3.79%) respectively. Most of the adopter farmers were using growth regulators for early maturity of cotton plant and as a result the cost of growth regulators has increased in HDPS cotton at ₹ 666.45 (0.68%) as compared to non HDPS cotton at ₹ 147.61 (0.16%) respectively.

The farm business income for HDPS cotton farms was found to be ₹ 75,857.40 per hectare which is higher than non HDPS farms *i.e.,* ₹ 61,241.23 per hectare. The family labour income of the HDPS farmer was also found to be more for HDPS cotton *i.e.,* ₹ 45,784.11 per hectare compared to the non HDPS cotton farms *i.e.,* ₹ 31,502.68 per hectare. Because of high farm business income, the family investment income was more for HDPS cotton *i.e.,* ₹ 65,665.92 per hectare as compared to the non HDPS cotton *i.e.,* ₹ 53,225.01 per hectare respectively.

The average gross returns of HDPS cotton across the State on selected marginal, small and large farms were ₹ 1,17,750.00, ₹ 1,28,587.50 and₹ 1,38,125.12 per hectare, respectively. Similarly, the net profits for HDPS cotton over cost C_2 basis on marginal, small and large farms in the state were ₹ 21,373.26, ₹ 29,979.80 and ₹ 37,769.35 per hectare respectively. The gross returns and net returns for pooled HDPS cotton were higher by ₹ 1,29,131.41 and ₹ 30,891.92 per hectare compared to the non HDPS cotton farms by ₹ 1,12,621.17 and ₹ 19,355.10 per hectare respectively.

Average yield obtained in HDPS cotton farms was 20.25 quintal per hectare and for non HDPS cotton farms it was 17.95 quintal per hectare.

Key words:Cotton, Economic impact, High density planting system, cost of cultivation.

Introduction

Cotton is known for its versatility, performance and natural comfort.The most often used elements of the cotton plant arecotton lint and cotton seeds. Cotton lint, itsstrength and absorbency make it an ideal fabric to make clothes and homewares and industrial products like tarpaulins, tents, hotel sheets, army uniforms and even astronauts' clothing choices when inside a space shuttle. Mainly linters which are short fibres remains on the seed are used to produce the goods such as bandages, swabs, bank notes, cotton buds and x- rays *etc.* Cotton seed, that makeup around half the weight of the picked cotton, is used as feed for cattles and seeds are crushed to make oil which are of cholesterol free.One tonne of cotton seed yields approximately 200kg of oil, 500kg of cotton seed meal and 300kg of hulls (Prashanth *et al*. 2013). Globally, cotton seed production can potentially provide protein requirements for hundreds of millions of people and animals.

Globally, cotton was sown on 32.94 million hectares in the 2021-22 growing season, producing 120.2 million bales with a productivity of 778 kg per hectare. Cotton production in India in 2021-22 was 362.18 lakh bales farmed on 120.69 lakh hectares with a yield of 510 kg per hectare (Cotton Corporation of India, 2022). In the world, the largest cottonproducing countries are India (12.96 million hectares),the United States of America (3.52 million hectares), China (3.17 million hectares), Pakistan (2.19 million hectares), Brazil (1.52 million hectares) and Uzbekistan (1.03 million hectares).

According to current cotton scenario report of the Cotton Corporation of India (2022), Maharashtra had the most cotton area with 42.86 lakh ha, followed by Telangana, which had 24.51 lakh ha. and then by Gujarat, Rajasthan and Karnataka. Gujarat had the largest production with 90 lakh bales, followed by Maharashtra (84 lakh bales) and Telangana (51 lakh bales). Rajasthan (673 kg per ha) and Maharashtra (333 kg per ha) had the greatest and lowest yields respectively (Cotton Corporation of India, 2022).

Telangana is the third-largest cotton producer and has the second-largest cotton acreage in India. It is expected that the production will be around 51 lakh bales from a land area of 24.72 lakh hectares during 2020-2021 (https://www.agri.telangana.gov.in). Telangana's key cotton farming districts, according to the Planning Department, Government of Telangana's state statistics summary (2019) include Nalgonda, Adilabad, Nagarkunool, Sangareddy, Kumuram Bheem, Siddipet, Rangareddy, Vikarabad, Warangal, Khammam, Medak and Mahbubnagar. Adilabad had the best output of 26.09 quintals per hectare and produced 6.65 lakh bales from an area of 1.40 lakh hectares. Nalgonda had the largest production and area of 7.16 lakh bales and 2.74 lakh hectares respectively with productivity of 14.38 quintals per hectare.

But India's seed cotton production per unit area is still significantly lower than that of several other cotton-growing countries throughout the world. Two of the most prominent factors leading to the country's low cotton crop productivity are a lack of plant population and the use of low-potential cultivars (Pradeep *et al.* 2017).Several researches are conducted, including maintaining a sufficient plant density, employing the right number of fertilizers, applying growth regulators and so on and released some varieties which are suitable for high density planting system.

The High Density Planting System (HDPS) is a method where planting is done very closely per unit area.It is one of the new systems of cultivation of cotton,

popularly known as **'Ultra Narrow Row'** cottondeveloped in India by the Central Institute of Cotton Research, Nagpur in 2010. The system is now being conceived as an alternate production system having a potential for improving productivity and profitability, increasing efficiency, reducing input costs and minimizing risks associated with India's cotton production system. A highdensity planting system (HDPS) leading to more rapid canopy closure and decreased soil water evaporation is becoming popular to address water scarcity challenges.

In HDPS, the optimum level of plant population mainly depends upon not only spacing but also on the plant type. Because, presentday cotton genotypes have a long duration of 180 to 200 days they are late maturing, tall growing and spreading types leading to bushy appearance, posing problems in taking up plant protection measures, machine picking, inefficient in trapping of solar energy, physiological efficiency and harvest index (Pariah *et al*. 2018). Because of longer duration, these varieties require a greater number of pickings as a result leading to manifold increase in cost of cotton cultivation especially manual picking and the margin of profit is low and fluctuating in an erratic manner. These problems are expected to be reduced by using the genotype suitable for HDPS.

To minimize the risk, recently in Telangana, Professor Jayashankar Telangana State Agricultural University, Rajendranagar developed to verities, ADB-39 and NCS-2778 with a technology *i.e.*, High Density Planting System (HDPS) with the unique spacing of 60 x 20 cm and 80 x 20 cm, in two cotton varieties. One is ADB-39 with the spacing of 60 x 20 cm and another Bt variety NCS-2778 with 80 x 20 cm. HDPS is more relevantly developed by the University that reduces the spacing, increases the number of plants per ha (nearly 1 lakh plants per ha), so that the farmers will get the higher yields. It reduces the cost of cultivation and improve effective surveillance against pests and disease.The present research study on "Economic impact of High Density Planting System in cotton – A case study in Telangana state" was focused to know about economic impact on the HDPS cotton adopted farmers by comparing with non-HDPS cotton adopted farmers.

MATERIALS AND METHODS

1) SAMPLING PROCEDURE

Multiple sampling technique and purposive sampling were adopted for the selection of sample at various stages namely districts, mandals, villages and farmers.

Selection of the sample districts

One district each from NTZ and STZ; and two districts from CTZ were selected *viz.*,Adilabad district from Northern Telangana Zone, Nagarkurnool district from Southern Telangana Zone and Warangal Urban and Warangal Rural districts from Central Telangana Zone were selected, respectively.

Selection of the mandals

From each selected district, mandals which have more proportion to the adoption of HDPS Cotton were selected. In NTZ and STZ from each selected district, two mandals were selected and then from each mandal 15 Adopters and 15 Non adopters were fixed and selected. For fulling the sample requirement, the flexible selection of number of villages were adopted. A total sample of 30 farmers from each mandal making a sample of 30 Adopter and 30 Non adopter farmers from each district. In CTZ, from the selected district four mandals were selected as HDPS adopters were not available. A total of 30 Adopters and 30 Non adopters were selected from the district.

Selection of villages

Considering the extent of adoption of HDPS cotton, minimum of one village from each of the selected two mandals, four and eight villages were selected purposively making a suitable sample of villages without restriction. This has resulted in selection of two villages in Adilabad district, eight villages in Warangal district and four villages in Nagarkurnool district. The total villages included in the sample to fulfil the sample size of farmers (30 Adopters and 30 Non adopters per district).

Selection of farmers

As most offarmers have not adopted HDPS from the village where HDPS is practiced, depending on the number of farmers adopted HDPS, proportionate sample size for adopters and non adopters of HDPS is fixed accordingly. Therefore, the sample size will varied in each village.

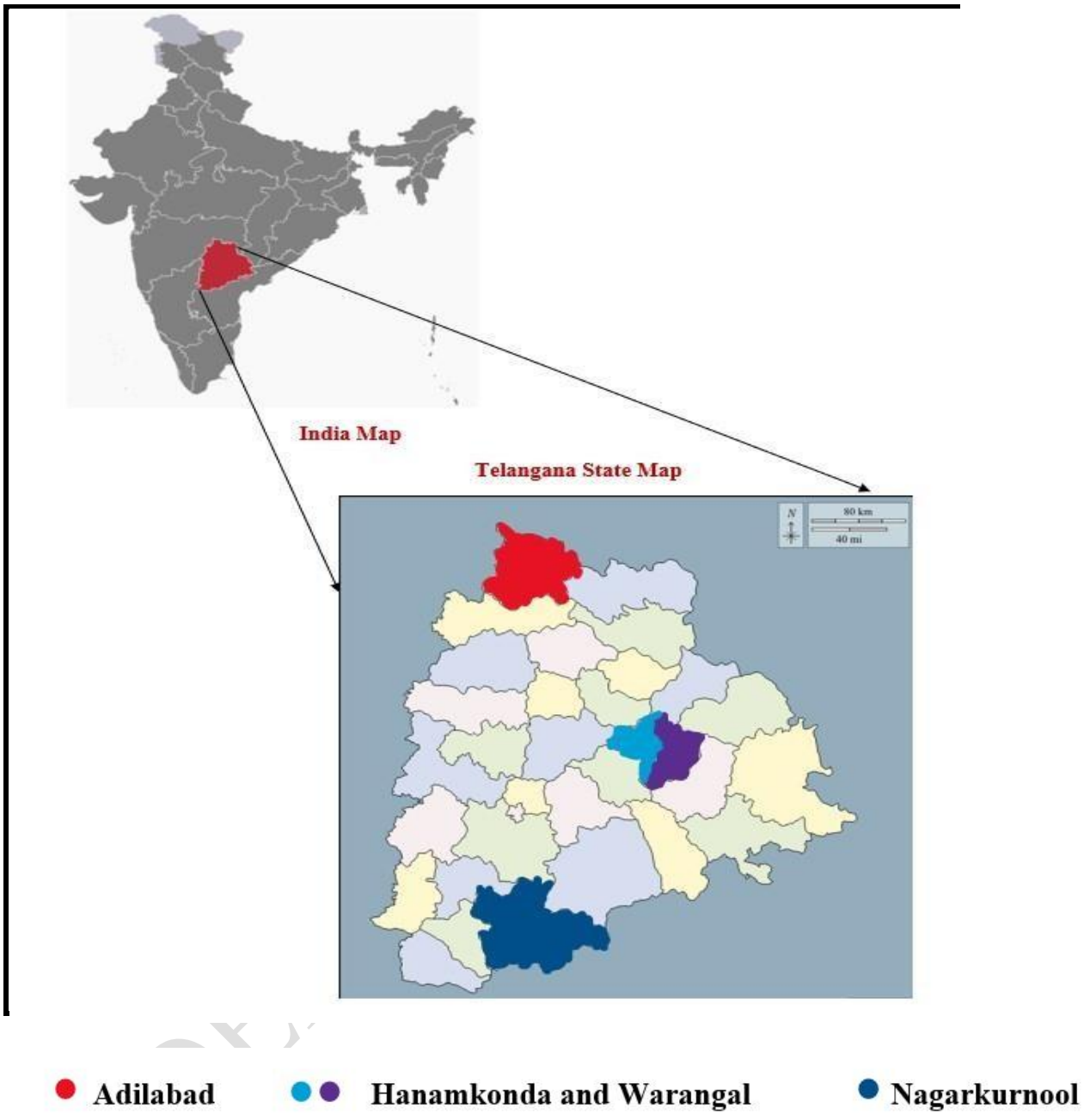


Fig 1 Pictographical representation of study area

Sample size

From the selected fourteen sample villages from eight mandals of three zones of Telangana were selected as the study area, from each zone of Telangana 60 samples were selected (Thirty adopter farmers of HDPS Cotton and thirty non adopter farmers of HDPS Cotton). A total sample of 180 cotton farmers were selected for the present study.

2) TOOLS OF ANALYSIS

i) Cost concepts

Farm management techniques were utilised to determine cost of cultivation of adopter and non adopter farmers by using Cost A_1, Cost A_2, Cost B_1, Cost B_2, Cost C_1, Cost C_2 and Cost C_3. The details of these concepts are given below

Cost A_1: It contains all actual cash and kind expenditures spent by the farmer in the course of cultivation.

a) Value of human labour
b) Value of bullock labour (hired and owned)
c) Value of machine power (hired and owned)
d) Value of seeds
e) Value of fertilizers
f) Value of farm yard manure
g) Value of plant protection chemicals
h) Value of depreciation for implements and farm buildings
i) Value of land revenue, cess and others taxes
j) Irrigation charges
k) Miscellaneous expenses (like electricity charges *etc.*)
l) Interest on working capital

Cost A_2: Cost A_1 + Rent paid for leased in land

Cost B_1: Cost A_1 or A_2 + Interest on owned fixed capital assets

Cost B_2: Cost A_1+ Rental value of owned land + Rent paid for leased-in land

Cost C_1: Cost B_1 + Imputed value of family labour

Cost C_2: Cost B_2 + Imputed value of family labour

Cost C_3: Cost C_2 + 10 per cent of cost C_2 to account for managerial input of farmer.

ii) FarmIncome Measures

1) **GrossReturns:**The value of the main product plus the value of the by-product. The primary products and by-products must be imputed using the current market price or the village level pricing in effect at the time of inquiry.

2)Net Returns: Gross income – Total cost of cultivation

3)Farm Business Income: This is the return on the farm operator's and his family'slabourand investment on owned land and fixed capital.

$$\text{Farmbusinessincome} = \text{Grossincome} - \text{Cost}A_1$$

4) Family Labour Income: It is the measure of returns of family labour involved in crop cultivation. It was obtained by removing cost B_2 (Cost A_1+ Rental value of owned land + Rent paid for leasedin land) from gross returns.

$$\text{Family labour income} = \text{Gross income} - \text{Cost } B_2$$

5) Farm Investment Income: It is the measure of the income that reflects as the returns oncapital invested in the farm. It was obtained by deducting imputed family labour from farm business income.

Farm investment income = Farm business income – The imputed value of family labour.

6) Return Per Rupee Spent: It is the profit made per rupee invested on agriculture production.

$$\text{Return per rupee spent} = \text{Gross return} \div \text{Total cost (or) Cost } C_2$$

RESULTS AND DISCUSSIONS

Cost of cultivation of HDPS and Non HDPS cotton

The cost of cultivation of cotton under HDPS and non HDPS were calculated by taking the percentage of each item, the contribution of this item to the overall cost of cultivation, the crop's cost structure was examined during *Kharif*season of 2021 in Telangana state. Additionally, the production cost per hectare was also calculated. To compare the cost differences, the cost of cultivation for the two categories, HDPS and non HDPS methodsof cotton crop was calculated separately.

From Table1. and Table.2 it could be observed that the pooled per hectare cost of cultivation of HDPS and non HDPS cotton was in order of ₹ 98,239.49 and ₹ 93,266.07 per hectare, respectively. The cost of cultivation of HDPS cotton was higher by ₹ 4,973.42. The variable cost of HDPS cotton cultivation was found to be slightly higher *i.e.*,63.37 per cent, when compared to the variable cost of non HDPS, which was 62.28 per cent. Among all the components of variable cost, human labour occupied the highest share in both, HDPS and non HDPS cotton cultivation *i.e.,* 17.65 per cent and

17.15 per centrespectively. The results were inline with the results of Reddy *et al*. (2010).

In the HDPS cotton method, due to more number of plants per hectare, the requirement of seed and fertilizer is usually more compared to normal cotton cultivation obviously the cost of seed and fertilizers were found to be more for HDPS cotton *i.e.,*at ₹ 7,125.56 (7.25%) and ₹ 10,356.16 (10.54%) as compared to non HDPS cotton at ₹ 4,580.28 (4.91%) and ₹ 8,693.12 (9.32%) respectively. Most of the farmers were using human labourfor frequent weeding instead of bullocks and machinery, as a result, the cost of bullock labour and machinery labour was low in HDPS cotton at ₹ 6,029.43 (6.14%) and ₹ 3,392.33 (3.45%) as compared to non HDPS cotton at ₹ 5,980.96 (6.41%) and 3,532.83 (3.79%), respectively. Most of the adopter farmers were using growth regulators for early maturity of cotton plant, as the result, the cost of growth regulators was more in HDPS cotton at ₹ 666.45 (0.68%) as compared to non HDPS cotton at ₹ 147.61 (0.16 %) respectively. As the varieties of the HDPS cotton were morepest resistant and short duration in nature, the attack of pink boll worm and other pests was expected to be low compared to the non HDPS cotton.

As a result, low amount of plant protection chemicals were needed for HDPS cottoncompared to non HDPS cotton which cost at ₹ 4,242.66 (4.32%)and ₹ 8,134.08 (8.72%) for HDPS and non HDPS cotton, respectively.

The proportion of fixed costs was marginally higher in total cost of HDPS cotton cultivation at ₹ 35,987.23 per hectare as compared to non HDPS cotton cultivation*i.e*at ₹ 35,179.54 per hectare. Almost similar proportional differences were observed between HDPS and non HDPS marginal, small and large category farmers also.

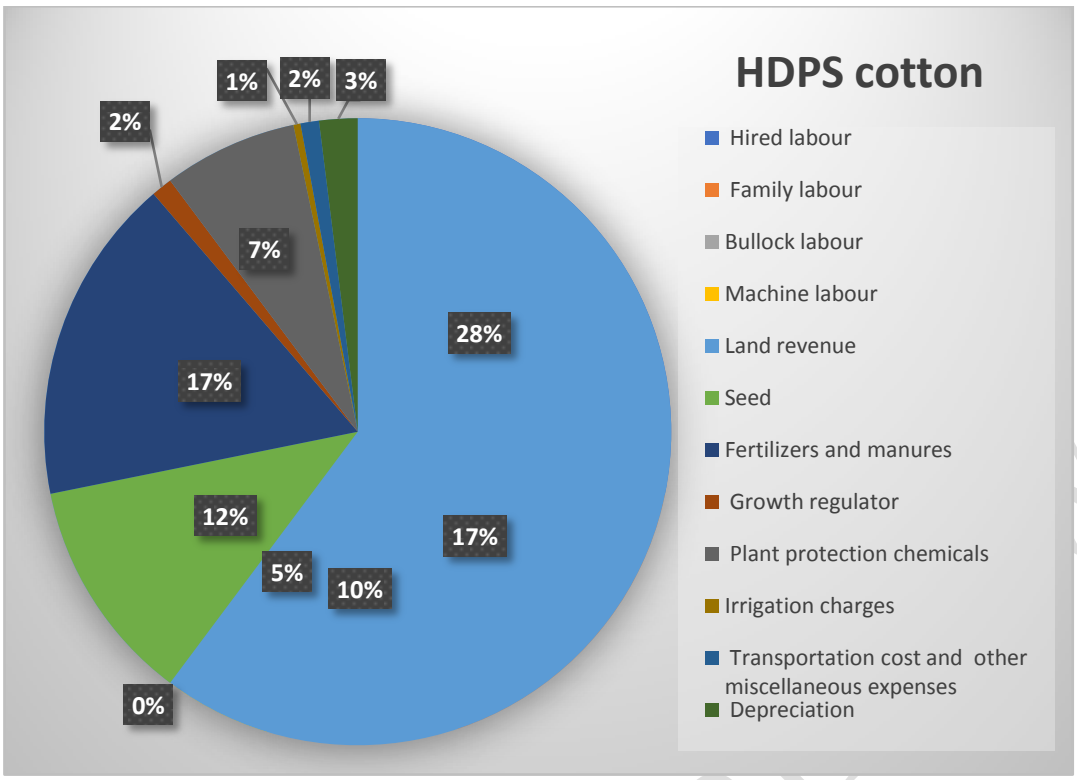


Fig.2 Composition of cost of cultivation of pooled HDPS cotton farms

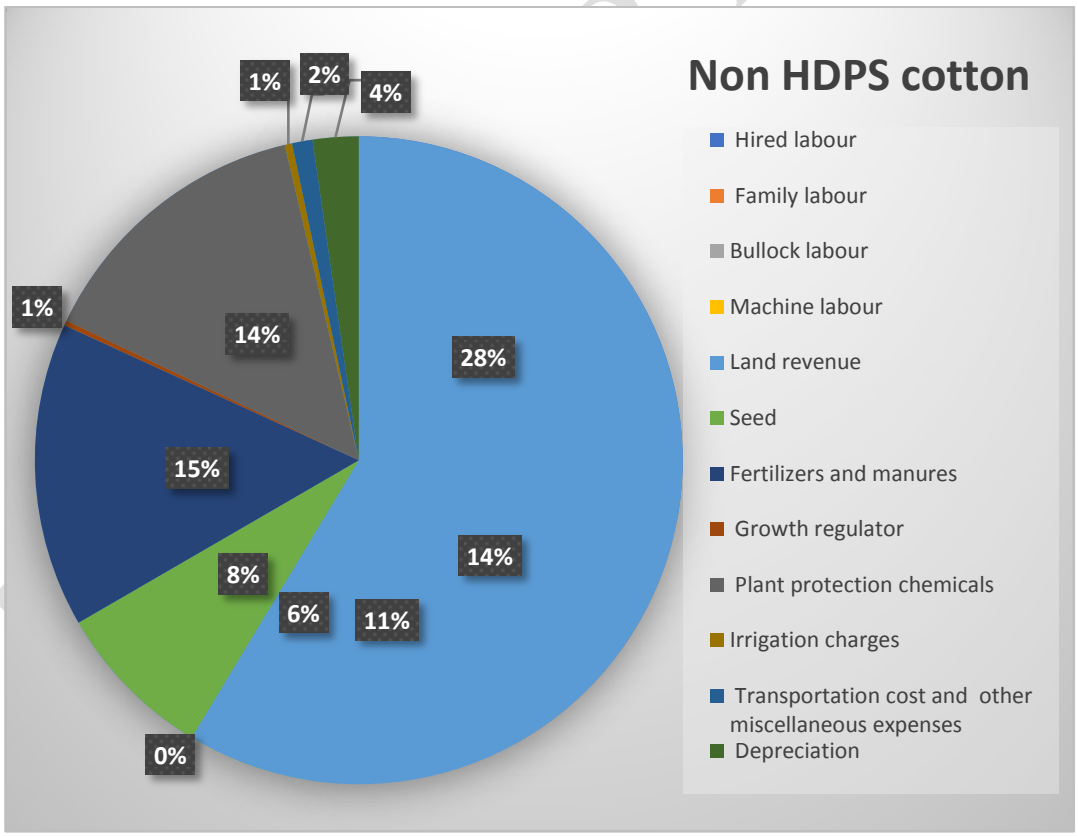


Fig.3 Composition of cost of cultivation of pooled non HDPS cotton farms

Cost concepts

To calculate farm efficiency indicators in the cultivation of HDPS cotton and non HDPS cotton across farms, cost concepts are crucial. Costs A_1, A_2, B_1, B_2, C_1, C_2per hectarewere calculated for this purpose and were shown in Table 3 and in Fig. 1.Among the different costs, cost C_2includes both fixed and variable costs. It provides a basis for comparison between various size of operational holdings. As a result, cost C_2 has been considered as the basis for calculating cost of cultivation.

The cost A_1 ranged from ₹ 51,840.83 on marginal to ₹ 54,607.98 on large farms for HDPS cotton and ₹ 50,856.31 on marginal to ₹ 51,901.52 on large farmers for non HDPS cotton. On an average, cost A_1on pooled farm of HDPS cotton (₹ 53,274.01) was more compared to non HDPS (₹ 51,379.94). In HDPS cotton production, the cost A_1 for marginal farmers was low because they have limited resources at their disposal to invest on the inputs for cultivation.

Cost B_1 ranged from ₹ 54,983.72 on marginal farms to ₹ 58,046.79 on large farms for HDPS cotton and ₹ 53,967.43 on marginal farms to ₹ 55,192.32 on large farms for non HDPS cotton and for pooled farm of HDPS cotton it was more (₹ 56,354.19 per hectare) than non HDPS(₹ 54,578.08 per hectare).

Cost B_2 also showed a positive relationship with farm size. It is observed to be ₹ 85,576.38 on marginal farms, ₹ 88,393.19 for small farms and ₹ 90,796.13 for large farms of HDPS cotton and ₹ 84,027.21 for marginal farms, ₹ 85411.05 for small farms, ₹ 86,549.66 for large farms of non HDPS cotton. On an overall, cost B_2 for HDPS cotton (₹ 88,048.01 per hectare) was more compared to non HDPS cotton (₹ 85,249.85 per hectare).

Cost C_1 was estimated by adding B_1 to the imputed value of family labour. Cost C_1 ranged from ₹ 65,784.02 per hectare on marginal to ₹ 67,606.41 per hectare on large farms for HDPS cotton and ₹ 61,168.78 per hectare on marginal farm to ₹ 64,238.57 per hectare on large farm for non HDPS cotton. Overall, cost C_1 of HDPS cotton (₹ 66,545.67 per hectare) was more compared to the non HDPS cotton (₹ 62,594.32 per hectare).

From the Table 4 it could be observed that imputed value of family labour was more for marginal farmers *i.e.,* ₹ 10,800.31 per hectare, but the cost C_1 was more for large farms *i.e.,* ₹ 67,606.41 per hectare due to more intensive use of hired labour, fertilizers, manure, seeds and plant protection chemicals.

Same as the cost C_1, Cost C_2 was calculated by addingB_2 with imputed value of family labour. The cost C_2ranged from ₹ 96,376.74 per hectare on marginal to ₹ 1,00,355.77 per hectare on large farms of HDPS and ₹ 91,229.89 per hectare of marginal farm to ₹ 95,346.71 per hectare of large farm of non HDPS cotton. Overall, cost C_2 of HDPS cotton was ₹ 98,239.49 per hectare which was more compared to non HDPS cotton *i.e.,* ₹ 93,266.07 per hectare. The findings of this study have in close conformity with the findings reported by Reddy *et al.* (2020).

It is clearly evident from the above discussion that various cost concepts indicated a direct and positive relationship with the farm size.

Farm income measures of HDPS and Non HDPS cotton

The outcomes of various farm income measures were shown in Table 1. and illustrated in the figure.5 and.6.

Farm business income

Farm business income is an estimate of the farmreturns on family labour, investments and fixed capital.It was acquired through subtracting cost A_1 from gross income. It is an indicator of decision-making about the maintenance of a specific enterprise.

As the farm size increases the farm business income also increased. Farm business income for HDPS cotton was more on large farms (₹ 83,517.14 per hectare) followed by small (₹ 75,222.75 per hectare) and marginal farm (₹ 65,909.18 per hectare) and in case of non HDPS cotton ₹ 66,973.51 for large farms followed by small farms (₹ 62,075.76) and marginal farms (₹ 50,706.21 per hectare). Overall, farm business income for HDPS and Non HDPS cotton was ₹ 75,857.40 and ₹ 61,241.23 per hectare respectively. Higher farm business income was obtained by large farms in both HDPS and Non HDPS due to their productivity and high net returns compared to small and marginal farms. Further, in all sizes of farms, HDPS farmers income was found to be higher than non HDPS farmers.

Family labour income

The farmer family returns were evaluated by the family labour income. It was obtained by subtracting cost B_2 from gross income. The family labour income increases with farm size usually due to the economies of scale. Family labour income obtained for HDPS cotton was more for large farms (₹ 52,225.56 per hectare) compared to small

(₹ 44,927.02 per hectare) and marginal farms (₹ 36,600.98 per hectare) whereas ₹ 21,418.93 for marginal farms, ₹ 32,488.84 for small farms and ₹ 36,632.78 large farms of non HDPS cotton. Overall, family labour income for HDPS and non HDPS cotton was ₹ 45,784.11 and ₹ 31,502.68 per hectare. It shows clear evidence of superiority of HDPS over non HDPS in terms of returns for the family labour involvement in cotton farming.

Family investment income

It was obtained by subtracting the imputed value of family labour from the farm business income. As the farm size increases, family investment income will also increase. Family investment income obtained was more for large farms (₹ 73,957.52 per hectare) followed by small (₹ 65,008.72 per hectare) and marginal farm (₹ 55,108.87 per hectare) whereas ₹ 57,927.26 per hectare for large farms followed by small (₹ 54,275.21 per hectare) and marginal farm (₹ 43,504.86 per hectare) of non HDPS cotton respectively. Overall, family investment income for HDPS and Non HDPS cotton was ₹ 65,665.92 and ₹ 53,225.01 per hectare, respectively. Here also superiority of HDPS over non HDPS is clearly seen in terms of the performance of the capital invested in farm.

Net returns

Large farms of HDPS cotton realized more net returns of ₹ 37,769.35 per hectare followed by small farms ₹ 29,979.80 per hectare and marginal farms ₹ 21,373.26 per hectare whereas ₹ 23,528.31 for large farms followed by small (₹ 20,485.51) and marginal(₹ 10,262.62 per hectare) for non HDPS cotton respectively. On an average, the net returns for the HDPS and non HDPS cotton ranged between ₹ 30,891.92 and ₹ 19,355.10 per hectare respectively for different farm sizes.

Return per rupee spent

Return per rupee spent was calculated in order to assess the level of production for every rupee spent on inputs. It is obtained by dividing gross returns with Cost C_2 (total cost of cultivation) and presented in Table 1.

Return per rupee spent for HDPS adopters was more, 1.22 on marginal farms, 1.30 on small farms, 1.37 on large farms and 1.31 for pooled farms whereasfor non HDPS adopters, it was1.11 on marginal farm, 1.22 on small farm, 1.24 on large farm and 1.20 on pooled farm. It shows that HDPS cotton cultivation was profitable across all farm sizes. The results are in accordance with Reddy *et al.* (2020).

From the above discussion of farm income measures for HDPS cotton and non HDPS cotton, it canbe concluded thatgrossreturns for HDPS farmers*i.e.,* ₹ 1,29,131.41 per hectare was more compared to non HDPS *i.e.,* ₹ 1,12,621.17 per hectare.Farm business income for HDPS cotton was more (₹ 75,857.40 per hectare) compared to the non HDPS (₹ 61,241.23 per hectare). Due to high yields in the HDPS cotton, the family labour income increases with farm size. Family labour income obtained for HDPS cotton was more (₹ 45,784.11 per hectare) compared to the non-HDPS (₹ 31,502.68 per hectare). Because of high farm business income in HDPS cotton, the family investment income was more for HDPS cotton *i.e.,*₹ 65,665.92 per hectare as compared to the non HDPS cotton *i.e.,* ₹ 53,225.01 per hectare, respectively. On an average, returns per rupee spent in HDPS cotton was more (1.31) compared to non HDPS cotton (1.20). The results are in the line with the results of Venugopalan *et al*. (2019).

As per the results, the HDPS adopter farmers selected from three districts of three zones of Telangana were benefited more (on an average ₹ 16,530.23 per hectare in gross returns and ₹ 11,231.15 per hectare in net returns) as compared to non adopters of HDPS cotton.

Table 1. Variable costs in HDPSand non HDPS cotton cultivation (₹ /ha)

Particulars	HDPS adopters				HDPS non adopters			
	Marginal farms	Small farms	Large farms	Pooled farms	Marginal farms	Small farms	Large farms	Pooled farms
Variable costs								
a) Labour cost								
1. Hired labours	16050.24 (16.65)	17301.35 (17.55)	18651.75 (18.59)	17334.67 (17.65)	15150.91 (16.61)	15780.88 (16.93)	17058.53 (17.89)	15996.92 (17.15)
2. Family labours	10800.31 (11.20)	10214.23 (10.36)	9559.62 (9.53)	10191.48 (10.37)	7201.35 (7.89)	7800.55 (8.37)	9046.25 (9.49)	8016.22 (8.60)
3. Bullock labours	6085.75 (6.31)	6052.03 (6.14)	5950.12 (5.93)	6029.43 (6.14)	6180.55 (6.77)	6080.82 (6.52)	5681.23 (5.96)	5980.96 (6.41)
4. Machinery labours	3350.57 (3.47)	3450.82 (3.50)	3375.14 (3.36)	3392.33 (3.45)	3376.31 (3.70)	3639.19 (3.90)	3580.55 (3.76)	3532.83 (3.79)
b) Material cost								
1. Seed	7200.22 (7.47)	7150.32 (7.25)	7025.45 (7.00)	7125.56 (7.25)	4688.54 (5.14)	4551.25 (4.88)	4500.35 (4.72)	4580.28 (4.91)
2. Fertilizer and manure	10376.11 (10.76)	10550.45 (10.70)	10140.25 (10.10)	10356.16 (10.54)	8801.75 (9.56)	8950.75 (9.60)	8325.62 (8.73)	8693.12 (9.32)
3. Growth regulators	656.82 (0.68)	678.45 (0.69)	663.56 (0.66)	666.45 (0.68)	133.23 (0.15)	160.34 (0.17)	148.68 (0.16)	147.61 (0.16)
4. Plant protection chemicals	4375.32 (4.54)	4100.23 (4.16)	4250.45 (4.24)	4242.66 (4.32)	8300.75 (9.10)	8150.53 (8.74)	7950.42 (8.34)	8134.08 (8.72)
5. Irrigation charges	208.32 (0.21)	223.22 (0.23)	247.77 (0.25)	226.64 (0.23)	198.24 (0.22)	210.57 (0.23)	233.07 (0.24)	214.10 (0.23)
6. Miscellaneous cost	611.25 (0.63)	583.25 (0.59)	550.27 (0.55)	581.73 (0.59)	625.32 (0.69)	583.25 (0.63)	525.60 (0.55)	578.25 (0.62)
Total working capital	59714.91 (61.95)	60304.35 (61.15)	60414.38 (60.20)	60147.11 (61.22)	54656.95 (59.91)	55908.13 (59.48)	57050.31 (59.83)	55874.37 (59.91)
7. Interest on working capital @7%	2,090.02 (2.16)	2110.65 (2.14)	2114.50 (2.11)	2105.14 (2.14)	2350.62 (2.58)	2,188.12 (2.35)	2097.61 (2.20)	2212.16 (2.37)
Total variable cost (I)	**61,804.93 (64.13)**	**62,415.00 (63.30)**	**62,528.88 (62.31)**	**62252.25 (63.37)**	**57,007.57 (62.49)**	**58,096.25 (62.33)**	**59147.84 (62.03)**	**58086.53 (62.28)**

*****Figures in parenthesis indicates percentage to the total

Table.2Fixed costs in HDPS and non HDPS cotton cultivation (₹ /ha)

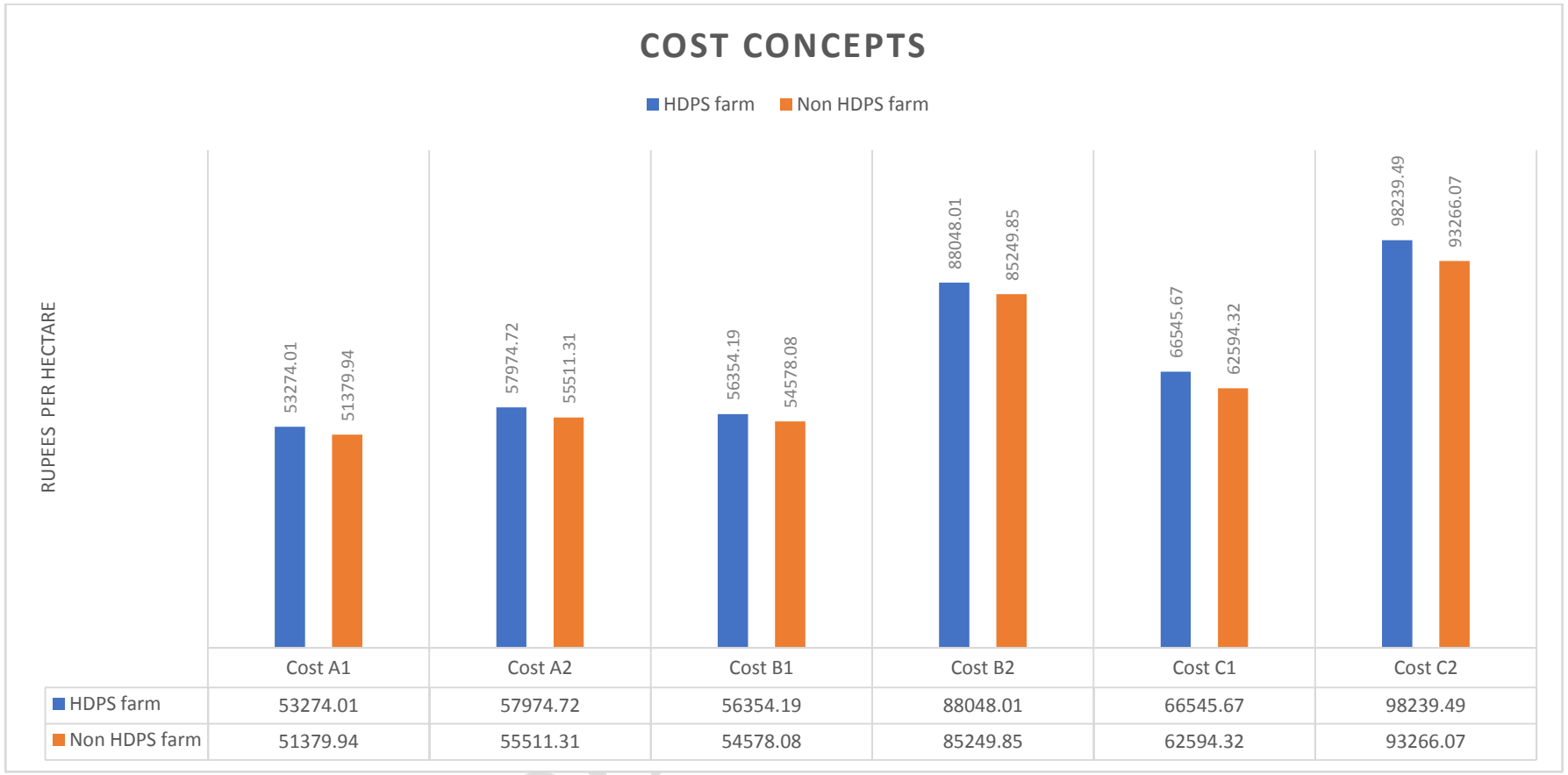
Particulars	**HDPS adopters**					**HDPS adopters**			
Fixed cost	**Marginal farms**	**Small farms**	**Large farms**	**Pooled farms**		**Marginal farms**	**Small farms**	**Large farms**	**Pooled farms**
1. Rent value of own land	26165.31 (27.14)	27,005.53 (27.39)	27,852.77 (27.75)	26993.11 (27.48)		26176.15 (28.69)	26,394.58 (28.32)	27049.92 (28.37)	26540.41 (28.46)
2. Rent paid for leased in land	4427.35 (4.59)	4732.69 (4.80)	4896.57 (4.88)	4700.71 (4.78)		3883.63 (4.26)	4202.39 (4.51)	4307.42 (4.52)	4131.36 (4.43)
3. Land revenue	0	0	0	0		0	0	0	0
4. Depreciation on implements and farm buildings	836.25 (0.86)	1164.21 (1.18)	1638.75 (1.63)	1213.23 (1.23)		1051.42 (1.15)	1326.43 (1.42)	1550.73 (1.63)	1309.63 (1.40)
5. Interest on fixed capital@ 10%	3142.89 (3.26)	3,290.21 (3.34)	3438.81 (3.43)	3080.18 (3.14)		3111.12 (3.41)	3192.34 (3.42)	3290.80 (3.45)	3198.14 (3.43)
Total fixed costs (II)	**34,571.81 (35.87)**	**36,192.64 (36.70)**	**37,826.89 (37.69)**	**35,987.23 (36.63)**		**34,222.32 (37.51)**	**35,115.74 (37.67)**	**36,198.87 (37.97)**	**35,179.54 (37.72)**
Total cost (I+II)	**96,376.74 (100)**	**98,607.71 (100)**	**1,00,355.77 (100)**	**98,239.49 (100)**		**91,229.89 (100)**	**93,211.99 (100)**	**95,346.71 (100)**	**93,266.07 (100)**

*Figures in parenthesis indicates percentage to the total

Cost concepts	HDPS of cotton					Non HDPS of cotton			
	Marginal farms	Small farms	Large farms	Pooled farms		Marginal farms	Small farms	Large farms	Pooled farms
Cost A_1	51,840.83	53,364.76	54,607.98	53,274.01		50,856.31	51,621.74	51,901.52	51,379.94
Cost A_2	56,268.18	58,097.45	59,504.53	57,974.72		54,739.94	55,824.13	56,208.94	55,511.31
Cost B_1	54,983.72	56,654.97	58,046.79	56,354.19		53,967.43	54,814.08	55192.32	54578.08
Cost B_2	85,576.38	88,393.19	90,796.13	88,048.01		84,027.21	85,411.05	86,549.66	85,249.85
Cost C_1	65,784.02	66,869.12	67,606.41	66,545.67		61,168.78	62,614.63	64,238.57	62,594.32

Cost C_2	96,376.74	98,607.71	1,00,355.77	98,239.49		91,229.89	93,211.99	95,346.71	93,266.07
Gross returns	**1,17,750.00**	**1,28,587.50**	**1,38,125.12**	**1,29,131.41**		**1,01,562.51**	**1,13,697.50**	**1,18,875.02**	**1,12,621.17**

Table.3 Cost concepts estimated for HDPS cotton adopters and non adopters (₹ /ha)



	Cost A1	Cost A2	Cost B1	Cost B2	Cost C1	Cost C2
HDPS farm	53274.01	57974.72	56354.19	88048.01	66545.67	98239.49
Non HDPS farm	51379.94	55511.31	54578.08	85249.85	62594.32	93266.07

Figure:.4 Cost of cultivation of pooled HDPS cotton adopter farms andnon adopter farms as per cost concepts

Table 4 Yield and income fromHDPS and non HDPS cotton cultivation

S. No.	Yield and Income	HDPS of cotton					Non HDPS of cotton			
		Marginal farms	Small farms	Large farms	Pooled farms		Marginal farms	Small farms	Large farms	Pooled farms
1.	Cost of cultivation (₹ /ha)	96,376.74	98,607.71	1,00,355.77	98,239.49		91,229.89	93,211.99	95,346.71	93,266.07
2.	Yield (q/ha)	18.75	20.25	21.25	20.25		16.25	18.25	18.75	17.95
3.	Price (₹ /q)	6,280.00	6,350.00	6,500.10	6,376.86		6,250.00	6,230.00	6,340.00	6,274.16
4.	Gross returns (₹ /ha)	1,17,750.00	1,28,587.50	1,38,125.12	1,29,131.41		1,01,562.51	1,13,697.50	1,18,875.02	1,12,621.17
5.	Farm business income (₹ /ha)	65,909.18	75,222.75	83,517.14	75,857.40		50,706.21	62,075.76	66,973.51	61,241.23
6.	Family labour income (₹ /ha)	36,600.98	44,927.02	52,225.56	45,784.11		21,418.93	32,488.84	36,632.78	31,502.68
7.	Farm investment income (₹ /ha)	55,108.87	65,008.72	73,957.52	65,665.92		43,504.86	54,275.21	57,927.26	53,225.01
8.	Net returns (₹ /ha)	21,373.26	29,979.80	37,769.35	30,891.92		10,262.62	20,485.51	23,528.31	19,355.10
9.	Returns per rupee spent	1.22	1.30	1.37	1.31		1.11	1.22	1.24	1.20

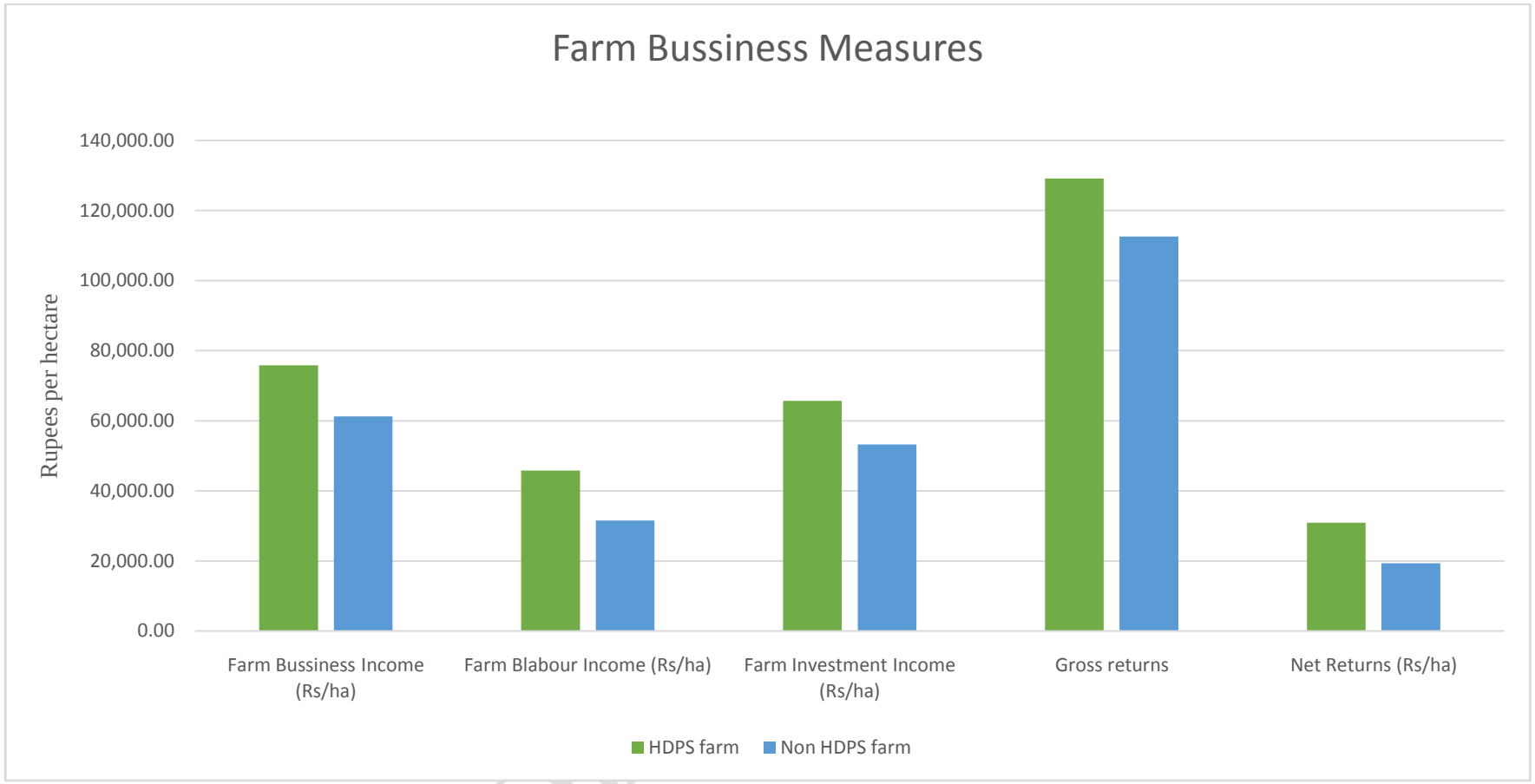


Figure: 5 Farm income measures of HDPS and non HDPS cotton respondents

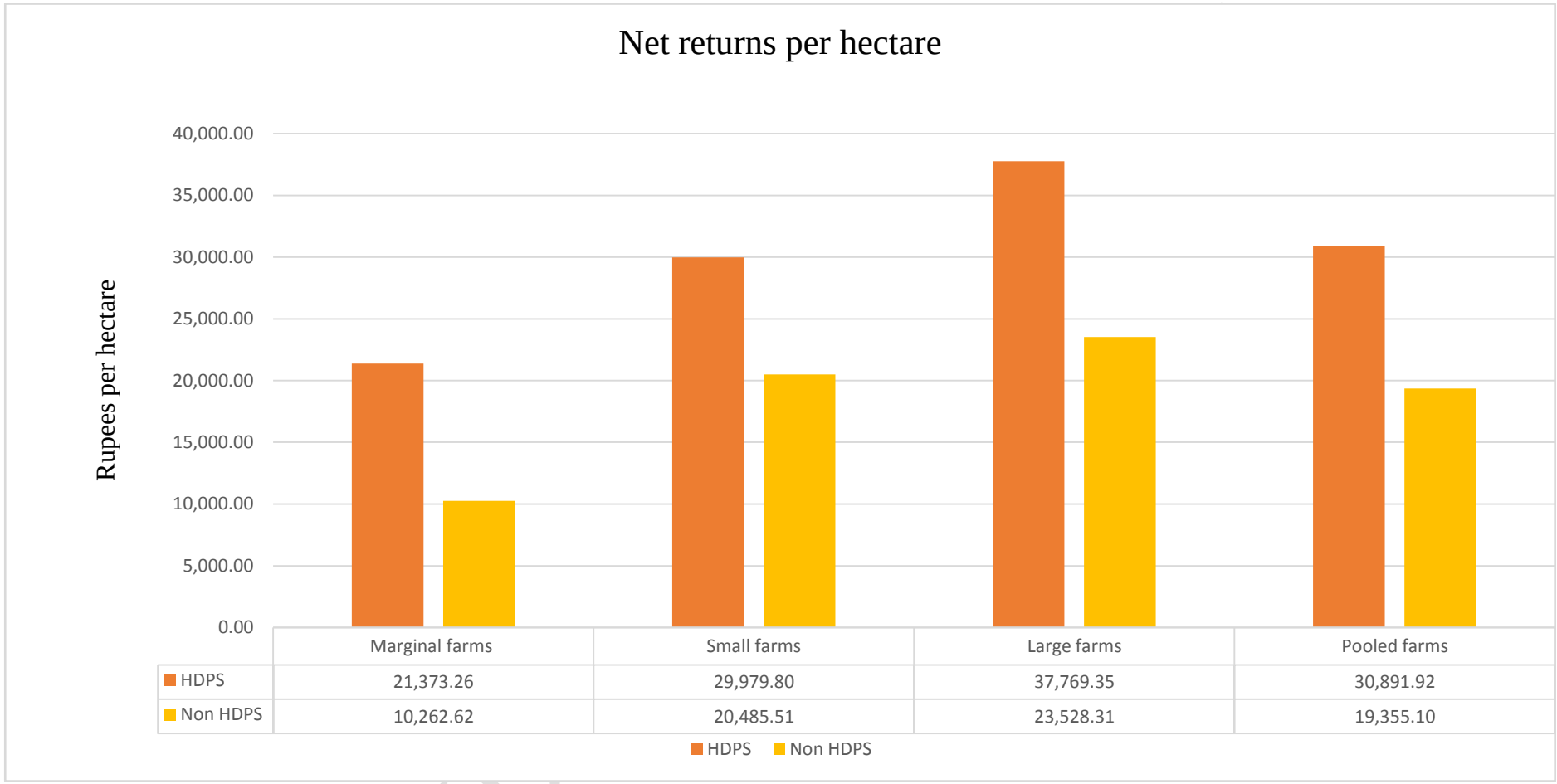


Figure:.6 Farm size wise net returnsof HDPS and Non HDPS cotton growers

Conclusions

- The total cost of cultivation has shown a positive relationship with farm size due to increase in input usage on large farms.
- The comprehensive analysis of the costs associated with cultivation of HDPS cotton revealed that labour costs account for the largest share of the total expenditures followed by costs on seed and fertilizers The need for seeds and fertilizers increases with increase innumber of plants per hectare.
- The value of family labour contribution declines as the farm size increases in case of HDPS as well as non HDPS adopters; large farms were engaging more hired labour than small and marginal farms do.
- Usage of plant protection chemicals was low in HDPS cotton when compared to non HDPS cotton as the cultivars chosen for HDPS cotton cultivation were more resistant to pest attack such as sucking pests and boll worms.
- HDPS cotton cultivation has recorded higher gross and net returns. The gross and net returns for HDPS cotton increase with the increase in farm size; they were higher on large farms than on small and marginal farms.
- In both HDPS and non HDPS cotton, the farm income measures*viz.*, farm business income, family labour income and farm investment income have shown a positive and direct relationship with farm size.
- Net profits were more in HDPS cotton than in non HDPS cotton as high gross returns in HDPS cotton were recorded when compared to non HDPS cotton.

Environmental Impacts of Cotton

Though it is a natural fiber, cotton is not as environmentally beneficial as you might believe. Genetically modified organisms (GMOs), a lot of water, and a lot of toxic chemicals are used in the manufacturing of inorganic cotton.

In particular, genetically modified seeds and fertilizers are used in over 99% of cotton production. Additionally, around 10% of pesticides and 25% of insecticides used globally are used on cotton. The use of chemical fertilizers and pesticides generally has a detrimental effect on the ecosystem, according to the World Wildlife Fund (WWF). They might cause pollution and harm the water.

Considering the fact that cotton is typically biodegradable, cotton goods shouldn't be disposed of in landfills. When biodegradable objects, such as cotton clothing, personal care

items, or other throwaway items, are dumped in landfills, they must go through anaerobic biodegradation, which results in the release of the dangerous greenhouse gas methane.

When you consider all of these elements, it becomes clear how cotton production and deterioration can have a negative effect on the ecosystem and contribute to global warming.

So, despite being a natural fiber, cotton isn't always sustainable. To ensure that the cotton items you buy have a minimal impact on the environment, it's crucial to read the labels and choose organic cotton while making your purchases.

Therefore, organic cotton more eco-friendly than regular cotton. It is, specifically, greener. It makes use of nature and does not require a lot of water or inorganic methods, such as artificial pesticides and fertilizers.

The Soil Association estimates that growing cotton organically consumes 91% less water than growing cotton conventionally. This is so that the soil can absorb water and release it during dry spells thanks to a mechanism used by organic cotton that improves soil fertility. Additionally, organic soils created without the use of harsh chemicals are more climate resilient, allowing them to survive the effects of our changing climate.

The Soil Association also discovered that growing organic cotton reduces water pollution by 26% and greenhouse gas emissions by 46%. Neither harsh pesticides nor genetically engineered seeds are used in the production of organic cotton.

Additionally, when conventional cotton farming's unsustainable practices are eliminated, organic cotton farming has less effect on the environment, wildlife, and people. As it doesn't expose farmers to dangerous chemicals, its production is also safer for them.

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