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Resource use efficiency in cotton production in Palwal district of Haryana

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ABSTRACT

This paper examines productivity, profitability and resource use efficiency of cotton production in Palwal district of Haryana (India). The study is based on primary data collected from a total of 120 farmers selected randomly using two-stage sampling and data related to agricultural year 2017–18. Analytical tools like farm business analysis and production function approach is applied to summarise data. Results have revealed that large farms were more productive and earned higher profit from cotton production than small and medium farms. The regression results have shown that factors like human labour, phosphatic fertilizer, farm machinery and zinc had positive and significant impacts on cotton yield. The MVP of human labour, and phosphatic fertilizer were greater than unity indicating underutilization. However, other resources were applied in excess and suggested to utilize optimally to improve the yield of cotton.

Keywords: Cotton, Resource productivity, Resource use efficiency

Cotton is the key fibre producing cash crop and contributes 5.6% (₹70581 crore) to total value of output produced from crop sector (₹1258053 crore) at 2011-12 prices in India during the period triennium ending (TE) 2017-18 (MoSPI 2019). India ranks first in both area and production of cotton in the world and contributed 37.2% (12 million ha, Mha), and 23.3% (31.9 million bales, 170 kg each), respectively, during TE 2017-18. The scenario of cotton production changed with adoption of Bt varieties. Though the cultivation of Bt cotton started in 1996 on about 0.8 Mha in developed countries (James 2002), its cultivation in India was approved from the year 2002-03. Presently more than 95% cotton area in India is under Bt varieties. The adoption of Bt varieties has helped in increasing yield and stabilizing the supply of cotton both for domestic use and export (Qaim and Zilberman 2003). Moreover, the yield of cotton in India is low by 42.8% (457 kg/ha) as compared to global average (799 kg/ha) during TE 2017-18. The key reasons attributed to low yields are poor irrigation facilities, high temperature, and incidence of pests and diseases (Pattanayak 2016). Other factors limiting yield include lack of access to information, inadequate agricultural credit, high prices of inputs (seeds, fertilizers, pesticides, etc.), lack of knowledge about good agricultural practices, and adulteration in pesticides, fertilizers and seeds (Goud *et al.* 2018, Gohil *et al.* 2016, Agarwal *et al.* 2015, Gopalkrishnan *et al.* 2007).

High operational cost is other issue in cotton cultivation, and it was ₹44036.4/ha during TE 2017-18 in Haryana. The expenditure on human labour, seed and machinery are the primary reasons for high operational cost, accounting for about two-third to three-fourth of total operational expenses (Kumar *et al.* 2020). Because of high operational costs, cotton growers seek production systems that use inputs efficiently to achieve higher profitability. This study examines resource use efficiency of cotton farms that could be helpful in taking proper decision to increase cotton production and its yield in Haryana.

MATERIALS AND METHODS

The present study was carried out in Palwal district of Haryana. Climate of the district is semiarid and hot. Annual average rainfall of district is 521 mm during the rainy season (July to mid-September). Farmers of the area grow cash crops like cotton, sugarcane, and food crops like wheat, rice, etc. Besides, farmers' rear milch animals (mostly buffalo) mainly for domestic consumption. The two-stage sampling technique was adopted to collect primary data from cotton growers. In the first stage of sampling, four villages, viz. Jor Khera, Rakhota and Nagli Pachanki (in Palwal block) and Khokiyaka (in Hathin block) were selected. In second and final stage, 30 farmers (covering small, medium and large) from each village were selected randomly. Hence, a total number of 120 sample farmers covering 50 small (< 2

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ha), 40 medium (2-4 ha), and 30 large (> 4 ha) were selected for the study.

The type of data collected from sample farmers include inputs used in cultivation of cotton like seed (kg), fertilizers (kg), pesticides, and labour (person-days) and pertains to agricultural year 2017–18. The other socioeconomic variables of farm households include age, education, farming experience, family size, family labour, holding size, etc.

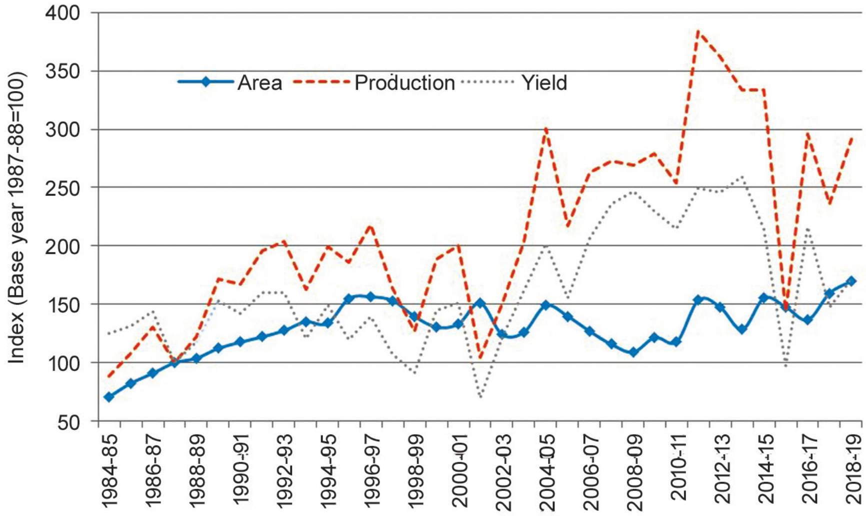

Fig 1 Progress in area, production and yield of cotton in Haryana, 1984-85 to 2018-19.

Efficiency measurement: Since limited resources have competing demand, efficiency measurement is crucial because it leads to substantial resource savings (Bravo *et al.* 1991). One of the strategies for increasing yield and total output is to make efficient use of available farm resources. Technical inefficiency arises when less than maximum output is obtained from a given bundle of resources, while allocative inefficiency arises when factors are not used in desired proportions, and lead to underutilization of resources and yield lesser benefits. Efficient use and allocation of resources requires redistribution of resources to achieve optimal level of production.

The farm business analysis and functional analysis is used to summarize data. A number of studies (Manjunath *et al.* 2013, Shrey and Kamble 2014, Shelke *et al.* 2016) have used Cobb Douglas (C-D) production function to measure resource use efficiency. The C-D production function is able to handle multiple inputs along with problems of autocorrelation, heteroscedasticity and multicollinearity (Bhanumurthy 2002). Economists prefer C-D production function over Constant Elasticity of Substitution (CES), because when the function involves more than two inputs, it is difficult to use CES (Smith 1982). Overall, C-D production function has several advantages and most importantly its ease in estimation or use, good empirical fit across many data sets and extreme flexibility are discussed (Miller 2008). The functional form of CD model for deriving production function, returns to scale and resource use efficiency can be referred from Karthick *et al.* (2013).

RESULTS AND DISCUSSION

Trends in production and productivity of cotton in Haryana: Cotton is grown mainly in rainfed condition (above 60% of total area) and contributes to about 50% of total production in India. Maharashtra, Gujarat, Telangana, Andhra Pradesh, Karnataka, Haryana, Madhya Pradesh, Rajasthan and Punjab are the nine major cotton growing states which together accounted for about 97% share (each) in both area and production of cotton during TE 2018-19. Under irrigated condition, cotton is grown in Gujarat, Haryana, Madhya Pradesh, Rajasthan, and Punjab accounting for about 38.8% area (4.66 Mha) and 49.1% of production (15.4 million bales, 170 kg each) during TE 2018-19. Among the irrigated states, Haryana ranks second after Gujarat in production of cotton and contributed to 13.9% area and 12.3% production during TE 2018-19. After launch of Bt varieties in 2002-03, the scenario of cotton production has changed significantly. The progress in cotton output over past three and a half-decade (1984-85 to 2018-19) in Haryana is presented in Fig 1.

After adoption of Bt varieties, cotton production increased significantly, which otherwise have seen ups and downs before adoption of Bt varieties. To better understand the role of Bt varieties, the total period is divided into period I (1984-85 to 2001-02), period II (2002-03 to 2018-19), and overall period (1984-85 to 2018-19). The compound annual growth rate of area, production and yield of cotton was analysed. During the overall period, cotton output grew at the rate of over 5% annually and was driven by growth in yield (3.2%) and area (1.8%). Analysis showed that during the period I, output increased at 2.4% annually and was contributed mainly by increase in area (1.7%), while during the period II, output grew by 6.6%, and was backed by both growths in area (3.3%) and yield (3.2%).

General characteristics of the households: The knowledge of farm household characteristics is important to contextualize farmers' behaviour of cotton cultivation. Analysis has shown that sample households were in middle aged group across farm size, varying from 44 years in small category farms to 50 years in large category farms and the average age was 46 years. The average farmers had education up to 9th standard. The average family had 7 members, varying 6 in small category to 9 in large category. Data showed that more than three members of a family were involved in farming as full-time workers. The average farm household had farming experience of 26 years, varying 24 years in medium category to 29 years in large category. The average farm size was above 2 ha, varying from about 1 ha on small farms to above 6 ha on large farms. Though the share cropping was prevalent in the study area, but farmers' owned cultivated lands accounted for over 72% of

Table 1 Average input use in cotton cultivation on sample farms in Haryana (Per ha)

Items of Inputs	Unit	Small	Medium	Large	Overall
Seed	kg	2.21	2.23	2.06	2.13
Manures and fertilizers					
Farmyard manure	q	30.72	27.11	23.77	25.87
Nitrogen (nutrient)	kg	72.85	77.79	85.23	81.05
Phosphorus (nutrient)	kg	32.49	36.87	45.59	40.92
Potash (nutrient)	kg	5.86	5.24	15.37	10.90
Chemical fertilizers (total)	kg	111.22	119.90	146.24	132.87
Zinc and micro-nutrients	kg	4.99	8.55	10.82	9.19
Human labour					
Family labour	days	54.04	54.63	56.56	57.45
Hired labour	days	45.22	50.51	39.88	45.15
Total human labour	days	99.29	105.14	96.45	102.60

Source: Authors' estimate

total cultivated area, and varied from 90% on small farms to 57% on large size farms.

Cropping pattern: The major crops grown by average farm households included cotton, jowar, and bajra in *kharif*, and wheat and rapeseed & mustard in *rabi*. During *kharif*, an average farmer allocated about two-third (64%) of the net sown area in cotton, followed by jowar (12.2%), sugarcane (6.1%), and bajra (3.8%), while in *rabi*, an average farmer allocated about 88% area to wheat crop. Almost similar trend in allocation of area was noted across size groups during both *kharif* and *rabi*. The yield level of several crops was above the state average obtained during 2017-18. The average cropping intensity was observed as 179%, varying 177% at large farms to 191% at small farms. This extent of cropping intensity was at par with state average 184% during TE 2016-17. The higher cropping intensity on sample farms over country's average (142%) denotes large parts of net sown area under irrigation. Farmers of the study area use mostly groundwater for irrigation, despite its poor quality (saline). Some resourceful farmers also bring water from far places through underground channel which add cost to farmers.

Input use pattern: Field survey revealed that all farmers had grown Bt hybrids of cotton on their farms. Data show that an average farm applied seed of 2.13 kg/ha, ranging between 2.1 kg at large farm and 2.2 kg at medium and small farms (Table 1). Application of farmyard manure on average farm was 25.9 q/ha, ranging between 23.8 q/ha in large farm and 30.7 q/ ha in small farms.

Data show that an average cotton farmer applied chemical fertilizers of about 133 kg/ha, ranging from 111 kg/ha at small farms to 146 kg/ha at large farms. Farmers applied about 90% of fertilizers through basal dose and 10% through foliar spray (only urea) at the boll formation stage to obtain higher yields. Human labour is one of the main inputs and 103 labour days/ha was used on average farm, ranging from 99 labour days/ha at small farms to 105 labour days/ha at medium farms. Family labour accounted for more than half of total labour used (57%) in cultivation and is attributed to its availability.

Cost of cultivation: The average cost of variable inputs for overall farm was estimated to be ₹54195/ha, ranging from ₹52272/ha at small farms to ₹55864/ha at medium farms. Among inputs, human labour was the main item of cultivation cost and accounted for 56% (₹30153/ ha) of total operational cost. This share of labour cost is similar to labour cost share (57%) in operational cost of cotton cultivation in Haryana during TE 2017-18. Irrigation has emerged as second major item of cultivation cost and contributed 11.6% of the operational cost. Expenditure on land preparation (tractor ploughing) was other key item of operational cost for growing cotton and contributed to about 9%. Although study villages are electrified, farmers use both tractor and diesel pump set for irrigation, and rising prices of diesel is one of the key reasons for increasing cost. Cost on seeds contributed above 7% of total cultivation cost. Expenditure on manures and fertilizers accounted above 8%, while pesticides cost varied between 3-4% of total cost.

Value of output and returns: Average gross return obtained from cotton production was ₹78702/ha, ranging from ₹68798/ ha at small farms to ₹ 83952/ha at large farms. The gross return included both the value of main products and value from by-products. The cotton production generated an average net returns of ₹24507/ha, and it varied from ₹16527/ha at small farms to ₹30016/ha at large farms. The higher net returns at large farms is attributed to higher yield and farmers' ability to hold produce for longer time which helped in fetching better price and increased returns per quintal. Yield of cotton varied between 16.5 q/ha at small farms and 18.8 q/ha at large farms.

Resource use efficiency: The estimated coefficient of C-D production function for sample cotton farmers is given in Table 2. The observed value of R^2 (0.575) indicates that 57% of the variations in Bt cotton yield is being explained by the explanatory variables included in the model. The coefficient for human labour (0.641) is positive and significant at less than 1%. This implies that 1% increase in human labour use will increase cotton yield by 0.64% (Table 2). The similar results for labour use in yield increase in cotton have been reported by Shelke *et al.* (2016) from Maharashtra, Manjunath *et al.* (2013) from Karnataka and Chatterjee *et al.* (2012) from Haryana.

The cotton yield is affected largely by use of plant nutrients. The coefficient for use of phosphatic fertilizers is estimated as 0.206 and significant at 1% level. This implies that 10% increase in phosphatic fertilizers would lead to 2.1% increase in cotton yield. Chatterjee *et al*. (2012) reported significant impact of fertilizers on cotton yield in all major cotton growing states. However, coefficient for nitrogenous fertilizer was found to be negative (-0.142) and significant at 10% level, and infers that farmers are using excess dose of nitrogenous fertilizers in cotton fields. Shelke *et al.* (2016) have observed excess use of nitrogen impacting negatively on yield of cotton. This excess dose of nitrogen is interpreted in terms of imbalance use of fertilizers. Application of macro fertilizers like nitrogen, phosphorus and potash is recommended in the ratio of 3:2:1 (N_2, P_2O_5, K_2O), respectively. Data show that selected farms households have used macro nutrients in the ratio of 7.4:3.8:1, respectively. With balanced fertilization, the efficiency of resources could be improved.

Like macro fertilizer, micro nutrients like zinc sulphate also help in increasing yield by improving efficiency of fertilizers and other inputs. The coefficient of zinc (cost) is positive and significant, though weak. During survey farmers reported the problem of yellowishness in cotton crop. Application of both macro and micro nutrients in right quantity and method could help in reducing the problem. Timely completion of production activities helps in achieving better crop yield. The machine labour coefficient (tractor for ploughing) was observed 0.110. This implies that 10% increase in use of machine labour will lead to 1.1% increase in cotton yield. Nagraj *et al.* (1994) for Tungabhadra command area also reported positive impact of machinery in improving cotton yield.

The coefficient for pesticide (insecticides) was found negative and significant (-0.028). This implies excessive use of pesticides and infers that 1% increase in insecticides will reduce yield by 0.028%. Kiresur and Ichangi (2011) and Manjunath *et al.* (2013) from Karnataka and Shrey and Kamble (2014) from Maharashtra have also reported negative impact of insecticide in cotton yield. Also, irrigation coefficient was negative (-0.001), and infers that farmers were applying more irrigation water but coefficient was non-significant. Hence, more use of irrigation water in cotton crop cannot be confirmed. The resultant proportionate change in output due to the proportionate change in the level of all inputs used is referred as returns to scale. It also infers economies of scale because of duality in production theory (Jehle and Reny 2001). The returns to scale in production is of great interest, given its implications for potential changes to the targeted size of future production units (Kurbis 2000). Production function on overall basis depict returns to scale of 0.701, which indicate that if all inputs are increased by 1%, yield of cotton will increase by 0.70% and hence decreasing returns to scale.

The resource use efficiency was examined for those variables which had significant effect on cotton yield. The ratio of Marginal Physical Product and Marginal Factor Cost determines the efficiency of employed resources, i.e. r =MVP/MFC. If r = 1 resource being efficiently utilized, if r > 1 resource is underutilized and if r < 1 resource is over utilized. Results show that ratios of MVP to MFC were greater than unity for human labour and phosphorus, and imply that inputs were underutilized (Table 2). Hence, there is a need for adjustment in use of inputs. This further indicate that there is a need to increase the use of human labour, phospahtic fertilizer, machine labour and zinc to increase the cotton yield, and reduce the use of nitrogen and pesticides to optimum level to improve the profitability of cotton farmers.

This study has examined the productivity, profitability and resource use efficiency of farm households growing cotton in Palwal district of Haryana. The results have indicated that cotton-wheat crop rotation was prevalent in the area and farmers allocated about two-third of area to cotton crop in *kharif* and nearly 90% to wheat crop in *rabi*. Overall farm household received an average yield of 18 q/ha, and received output price ₹4148/ q. The per ha average operational cost of cultivation and net return from cotton were ₹54195.2, and ₹24506.5, respectively. Among the

Table 2 Estimated regression coefficient and resource use efficiency for Bt cotton farmers in Haryana

Variable	Coefficients (βi)	MVP	MFC#	Efficiency ratio (r)
Constant	- 1.126**			
Human labour (number days)	0.641***	453.41	292.52	1.5492
Phosphorus (nutrient in kg)	0.206***	1294.73	23.91	54.1431
Machine labour cost (in ₹)	0.110**	1.58	2017.10	0.0008
Zinc cost (in ₹)	0.003*	1.81	257.24	0.0070
Nitrogen (nutrient in kg)	-0.150*	139.68	6.52	-21.4185
Pesticides cost (in ₹)	-0.028*	1.92	420.69	-0.0045
Irrigation cost (in ₹)	-0.001			
Return to scale	0.781			
F-statistics	df (7112) 21.647 (Sig 0.000)			
R^2	0.575			

***, ** and * indicate significance level at < 1% level; <5% level and <10% level, respectively. # = farm area is taken for a single cycle of production. *Source*: Authors' estimate inputs, expenditure on human labour, irrigation, machinery, seed, fertilizers and insecticides accounted for about 93% of operational cost of cotton. The coefficients of estimated production function show that factors like human labour, phosphatic fertilizer, machinery and zinc had positive and significant impacts on determining yield and there is further scope to increase cotton yield. Water is a scarce resource globally, and its sensible use is a management issue. About reducing pesticides cost, farmers should be educated about economic injury level using threshold limit of insects and other pests.

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