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Efficiency in Cotton Production Across the States in India

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ABSTRACT

Background: Cotton is one of the oldest crops in the world. About 60 million people are directly engaged in cotton textiles and processing works. Cotton is an important cash crop. In some places, it is called "white gold" because it brings in foreign exchange. India is one of the top cotton producers and exporters in the world. 85% of the world's cotton is cultivated in ten major countries, including India, which is the second-largest producer. India has a competitive advantage in the production of cotton. The study's objective is to find out the relative yield efficiency between the states of India in cotton farming.

Methods: The Secondary data of cotton production is collected from the website of INDIASTAT. The ANOVA is used to calculate the relative yield efficiency of cotton.

Result: The paper's result is calculated using SPSS V22 (Statistical Package for Social Sciences). The result shows that Punjab, Haryana, Gujarat and Orissa have the highest efficiency in cotton yield, while Maharashtra, Karnataka and Andhra Pradesh have the lowest efficiency in cotton yield and the rest states have the average yield. In Maharashtra and Karnataka, rainfall was uneven and soil fertility was not good. The dryland of Karnataka played an important role in less productivity of cotton. Punjab, Haryana and Gujrat had better soil fertility which makes it better for cotton yield. Government should take the necessary steps to increase the average yield of cotton by shifting cotton farming from the low-yield region to the high-yield region. The government should promote cotton production where the yield is higher and demote cotton farming where the yield is lower. Government should also promote "better cotton" farming because it is more sustainable and has a higher yield with a lower cost of cultivation.

Key words: Agriculture, ANOVA, Cotton efficiency, Cotton production, Yield.

INTRODUCTION

Agriculture has a long history in India, dating back to the Indus Valley Civilization and it was discovered in some places of Southern India even before the Harappans. Today, India is one of the leading countries regarding farm output. Along with fisheries and forestry, agriculture is among the greatest contributors to the gross domestic product (GDP). Statista shows that in 2019, 42.6% of India's workforce was devoted to farming; the rest worked in the industrial and service sectors. Cotton is one of the oldest crops in India, which has been growing since 3000 BCE (Santhanam and Sundaram, 1997). Cotton is an important cash crop. It is called "white gold" in some places because it brings in foreign exchange (Khan *et al*., 2020). India is one of the top cotton producers and exporters in the world. More than 60 million people are working in the cotton textile and processing sector directly and indirectly (Blaise and Kranthi, 2019). India has a competitive advantage in producing cotton (Sharma and Bugalya, 2014) (Maqbool *et al*., 2020). 85% of the world's cotton is cultivated in ten major countries, including India, the second-largest producer (Samuel *et al*., 2015). In 2000, the cotton production area in India was 8709.5 thousand hectares, which increased to 13286 thousand hectares in 2020, while cotton productivity in 2000 was 225 kg per hectare, which increased to 455 kg per hectare in 2020.

Cotton is one of the oldest crops in the world. About 60 million people are directly engaged in cotton textiles and processing works (Blaise and Kranthi, 2019). The cotton yield could have been better than the Bt cotton production started in 2002 in India. It was a gene revolution. Farmers have quickly adopted Bt cotton in India, which is grown on almost 90% of cotton fields (Kalamkar, 2013). Bt cotton implementation made a change in cotton production. It accounted for the rapid growth in cotton production in India (Bennett *et al*., 2004) (Ashok *et al*., 2012) (Stone, 2012) (Subramanian and Qaim, 2010). India has a competitive advantage in cotton production (Sharma and Bugalya, 2014) (Maqbool *et al*., 2020). The cost of cotton production in India is 5 to 6 times lesser than USA (Sharma and Bugalya, 2014). Because Bt cotton has resulted in significant pesticide savings (Ali and Abdulai, 2010) (Bennett *et al*., 2005) (Qaim *et al*., 2006). Despite the competitive advantage, India has a significantly lower yield than the global average yield. It is lower than 500 kg lint per hectare, while the global average yield of cotton production is 792 kg lint per hectare (Blaise and Kranthi, 2019). Changing the planting date, High-density planting can increase cotton production yield (Hebbar *et al*., 2013)

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(Blaise and Kranthi, 2019). There is another way to increase yield and reduce costs with sustainable development. It is better cotton. Better cotton is more input and output-efficient (Zulfiqar and Thapa, 2016). Better cotton (BC) should be promoted to help the farmers increase the yield, reduce the cost and conserve natural resources and social benefits (Zulfiqar and Thapa, 2018). This article aims to find out the relative yield efficiency across the Indian states in cotton production.

MATERIALS AND METHODS

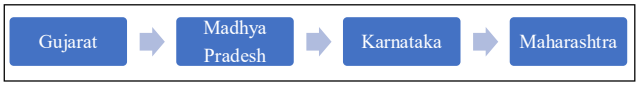
In this article, we have found out whether there is any significant difference in the yield of cotton farming across states or not? For this research article, data on cotton production and yield in each state from 2000 to 2020 is taken from the INDIASTAT website (https://www.indiastat.com/). Data on Andhra Pradesh and Tamil Nadu were separated since 2011, so it has been merged for the consistency of the study. The ANOVA technique was used to analyse the relative efficiency of the cotton yield of the states. The ANOVA was calculated with the help of the SPSS V22 (Statistical Package of Social Science). This work is carried out in 2022 in the Department of Agricultural Economics and Business Management of Aligarh Muslim University.

RESULTS AND DISCUSSION

The F-Value is 11.569 which is statistically significant at 5% ($p<0.05$) (Table 1). The value of ANOVA shows that there is a significant difference in mean yield across the states.

Comparison: Gujarat v/s other states

The result of the analysis shows that there is a significant differences (Appendix Table 3) in the yield of Gujarat with respect to the yield of Karnataka, Maharashtra and Madhya Pradesh only. Other than these three states, Gujrat has differences in yield but these differences are insignificant. The comparison shows that the Gujrat has a significantly higher yield than Karnataka, Maharashtra and Madhya Pradesh.



The above picture shows the efficiency of the states in terms of yield in decreasing (Higher to lower) order.

Comparison: Haryana v/s other states

The result of the analysis shows that there is a significant difference (Appendix Table 4) in the yield of Haryana with respect to the yield of Karnataka, Maharashtra and Madhya Pradesh only. Other than these three states, Haryana has differences in yield but these differences are insignificant. The comparison shows that Haryana has a significantly higher yield than Karnataka, Maharashtra and Madhya Pradesh.



The above picture shows the efficiency of the states in terms of yield in decreasing (Higher to lower) order.

Comparison: Karnataka v/s other states

The result of the analysis shows that there is a significant difference (Appendix Table 5) in the yield of Karnataka with respect to the yield of Gujrat, Haryana and Punjab only. Other than these three states, Karnataka has differences in yield but these differences are insignificant. The comparison shows that Karnataka has a significantly lesser yield than the Gujrat, Haryana and Punjab.



The above picture shows the efficiency of states in terms of yield in increasing order (Lower to Higher).

Comparison: Maharashtra v/s other states

The analysis shows a significant difference (Appendix Table 6) in the yield of Maharashtra and Gujrat, Haryana, Orissa, Punjab, Rajasthan and Andhra Pradesh only. Other than these six states other states have differences in yield but these differences are insignificant. The comparison shows that Maharashtra yields significantly less than Gujarat, Haryana, Orissa, Punjab, Rajasthan and Andhra Pradesh.

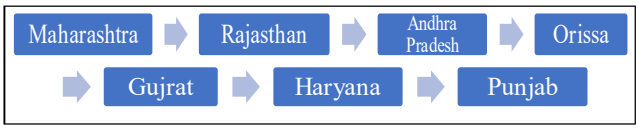


Table 1: Mean value calculated by ANOVA for significant differences across states yield.

States	Mean	F-value	p-value	Decision	Significant difference
Gujrat	500.095	11.569	0.000	Rejected	Yes
Haryana	529.095				
Karnataka	334.905				
Maharashtra	259.048				
Madhya Pradesh	351.048				
Orissa	427.905				
Punjab	627.048				
Rajasthan	404.143				
Tamil Nadu	390.905				
Andhra Pradesh	411.705				

Appendix Table 3: Gujarat.

(I) States	(J) States	Mean difference (I-J)	Sig. (P-value)	Decision	Significant difference
Gujrat	Haryana	-29.00000	1.000	Accepted	No
	Karnataka	165.19048*	.008	Rejected	Yes
	Maharashtra	241.04762*	.000	Rejected	Yes
	Madhya Pradesh	149.04762*	.028	Rejected	Yes
	Orissa	72.19048	.824	Accepted	No
	Punjab	-126.95238	.114	Accepted	No
	Rajasthan	95.95238	.469	Accepted	No
	Tamil Nadu	109.19048	.281	Accepted	No
	Andhra Pradesh	88.39048	.590	Accepted	No

Appendix Table 4: Haryana.

(I) States	(J) States	Mean difference (I-J)	Sig. (P-value)	Decision	Significant difference
Haryana	Gujarat	29.0000	1.000	Accepted	No
	Karnataka	194.1905*	.001	Rejected	Yes
	Maharashtra	270.0476*	.000	Rejected	Yes
	Madhya Pradesh	178.0476*	.003	Rejected	Yes
	Orissa	101.1905	.389	Accepted	No
	Punjab	-97.9524	.438	Accepted	No
	Rajasthan	124.9524	.128	Accepted	No
	Tamil Nadu	138.1905	.058	Accepted	No
	Andhra Pradesh	117.3905	.191	Accepted	No

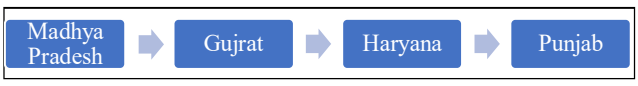
Appendix Table 5: Karnataka.

(I) States	(J) States	Mean difference (I-J)	Sig. (P-value)	Decision	Significant difference
Karnataka	Gujarat	-165.19048*	.008	Rejected	Yes
	Haryana	-194.19048*	.001	Rejected	Yes
	Maharashtra	75.85714	.778	Accepted	No
	Madhya Pradesh	-16.14286	1.000	Accepted	No
	Orissa	-93.00000	.516	Accepted	No
	Punjab	-292.14286*	.000	Rejected	Yes
	Rajasthan	-69.23810	.857	Accepted	No
	Tamil Nadu	-56.00000	.958	Accepted	No
	Andhra Pradesh	-76.80000	.765	Accepted	No

The above picture shows the efficiency of the states in terms of yield in increasing order (lower to higher).

Comparison: Madhya Pradesh v/s other states

The result of the analysis shows that there is a significant difference (Appendix Table 7) in the yield of Madhya Pradesh with respect to Gujrat, Haryana and Punjab only. Other than these three states, Madhya Pradesh has differences in yield but these differences are insignificant. The comparison shows that Madhya Pradesh has a significantly lesser yield than the Gujrat, Haryana and Punjab.



The above picture shows the efficiency of the states in terms of yield in increasing order (lower to higher).

Comparison: Orissa v/s other states

The result of the analysis shows that there is a significant difference (Appendix Table 8) in the yield of Orissa with respect to the yield of Maharashtra and Punjab only. Other than these two states, Orissa has differences in yield but these differences are insignificant. The comparison shows that Orissa has a significantly higher yield than Maharashtra and the lesser yield than Punjab.



Appendix Table 6: Maharashtra.

(I) States	(J) States	Mean difference (I-J)	Sig. (P-value)	Decision	Significant difference
Maharashtra	Gujarat	-241.04762*	.000	Rejected	Yes
	Haryana	-270.04762*	.000	Rejected	Yes
	Karnataka	-75.85714	.778	Accepted	No
	Madhya Pradesh	-92.00000	.532	Accepted	No
	Orissa	-168.85714*	.006	Rejected	Yes
	Punjab	-368.00000*	.000	Rejected	Yes
	Rajasthan	-145.09524*	.036	Rejected	Yes
	Tamil Nadu	-131.85714	.086	Accepted	No
	Andhra Pradesh	-152.65714*	.021	Rejected	Yes

Appendix Table 7: Madhya Pradesh.

(I) States	(J) States	Mean difference (I-J)	Sig. (P-value)	Decision	Significant difference
Madhya Pradesh	Gujarat	-149.04762*	.028	Rejected	Yes
	Haryana	-178.04762*	.003	Rejected	Yes
	Karnataka	16.14286	1.000	Accepted	No
	Maharashtra	92.00000	.532	Accepted	No
	Orissa	-76.85714	.764	Accepted	No
	Punjab	-276.00000*	.000	Rejected	Yes
	Rajasthan	-53.09524	.970	Accepted	No
	Tamil Nadu	-39.85714	.996	Accepted	No
	Andhra Pradesh	-60.65714	.931	Accepted	No

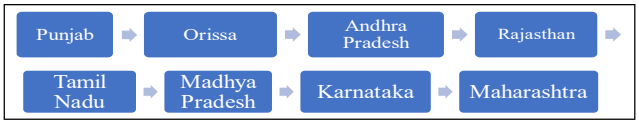
Appendix Table 8: Orissa.

(I) States	(J) States	Mean difference (I-J)	Sig. (P-value)	Decision	Significant difference
Orissa	Gujarat	-72.1905	.824	Accepted	No
	Haryana	-101.1905	.389	Accepted	No
	Karnataka	93.0000	.516	Accepted	No
	Maharashtra	168.8571*	.006	Rejected	Yes
	Madhya Pradesh	76.8571	.764	Accepted	No
	Punjab	-199.1429*	.000	Rejected	Yes
	Rajasthan	23.7619	1.000	Accepted	No
	Tamil Nadu	37.0000	.998	Accepted	No
	Andhra Pradesh	16.2000	1.000	Accepted	No

The above picture shows the efficiency of the states in terms of yield in decreasing order (higher to lower).

Comparison: Punjab v/s other states

The result of the analysis shows that there is a significant difference (Appendix Table 9) in the yield of Punjab with respect to the yield of Karnataka, Maharashtra, Madhya Pradesh, Orissa, Rajasthan, Tamil Nadu and Andhra Pradesh only. Other than these Seven States, Punjab has differences in yield but these differences are insignificant. The comparison shows that Punjab has a significantly higher yield than Karnataka, Maharashtra, Madhya Pradesh, Orissa, Rajasthan, Tamil Nadu and Andhra Pradesh.



The above picture shows the efficiency of the states in terms of yield in decreasing order (higher to lower).

Comparison: Rajasthan v/s other states

The analysis result shows a significant difference (Appendix Table 10) in the yield of Rajasthan with respect to the yield of Maharashtra and Punjab only. Other than these two states, Rajasthan has differences in yield, but these differences are insignificant. The comparison shows that Rajasthan has a significantly higher yield than Maharashtra and the lesser yield than Punjab.



The above picture shows the efficiency of the states in terms of yield in decreasing order (higher to lower).

Appendix Table 9: Punjab.

(I) States	(J) States	Mean difference (I-J)	Sig. (P-value)	Decision	Significant difference
Punjab	Gujarat	126.9524	.114	Accepted	No
	Haryana	97.9524	.438	Accepted	No
	Karnataka	292.1429*	.000	Rejected	Yes
	Maharashtra	368.0000*	.000	Rejected	Yes
	Madhya Pradesh	276.0000*	.000	Rejected	Yes
	Orissa	199.1429*	.000	Rejected	Yes
	Rajasthan	222.9048*	.000	Rejected	Yes
	Tamil Nadu	236.1429*	.000	Rejected	Yes
	Andhra Pradesh	215.3429*	.000	Rejected	Yes

Appendix Table 10: Rajasthan.

(I) States	(J) States	Mean difference (I-J)	Sig. (P-value)	Decision	Significant difference
Rajasthan	Gujarat	-95.95238	.469	Accepted	No
	Haryana	-124.95238	.128	Accepted	No
	Karnataka	69.23810	.857	Accepted	No
	Maharashtra	145.09524*	.036	Rejected	Yes
	Madhya Pradesh	53.09524	.970	Accepted	No
	Orissa	-23.76190	1.000	Accepted	No
	Punjab	-222.90476*	.000	Rejected	Yes
	Tamil Nadu	13.23810	1.000	Accepted	No
	Andhra Pradesh	-7.56190	1.000	Accepted	No

Appendix Table 11: Tamil Nadu.

(I) States	(J) States	Mean difference (I-J)	Sig. (P-value)	Decision	Significant difference
Tamil Nadu	Gujarat	-109.19048	.281	Accepted	No
	Haryana	-138.19048	.058	Accepted	No
	Karnataka	56.00000	.958	Accepted	No
	Maharashtra	131.85714	.086	Accepted	No
	Madhya Pradesh	39.85714	.996	Accepted	No
	Orissa	-37.00000	.998	Accepted	No
	Punjab	-236.14286*	.000	Rejected	Yes
	Rajasthan	-13.23810	1.000	Accepted	No
	Andhra Pradesh	-20.80000	1.000	Accepted	No

Comparison: Tamil Nadu v/s other states

The result of the analysis shows a significant difference (Appendix Table 11) in the yield of Tamil Nadu with respect to the yield of Punjab only. Other than Punjab, Tamil Nadu has differences in yield with other states but these differences are insignificant. The comparison shows that Tamil Nadu has a significantly lesser yield than Punjab.



The above picture shows the efficiency of the states in terms of yield in decreasing order (higher to lower).

Comparison: Tamil Nadu V/s Other States

The result of the analysis shows that there is a significant difference (Appendix Table 12) in the yield of Andhra Pradesh with respect to the yield of Maharashtra and Punjab only. Other than these two states andhra Pradesh has differences in yield with other states but these differences are insignificant.

The comparison shows that Andhra Pradesh has a significantly higher yield than Maharashtra and a lesser yield than Punjab.

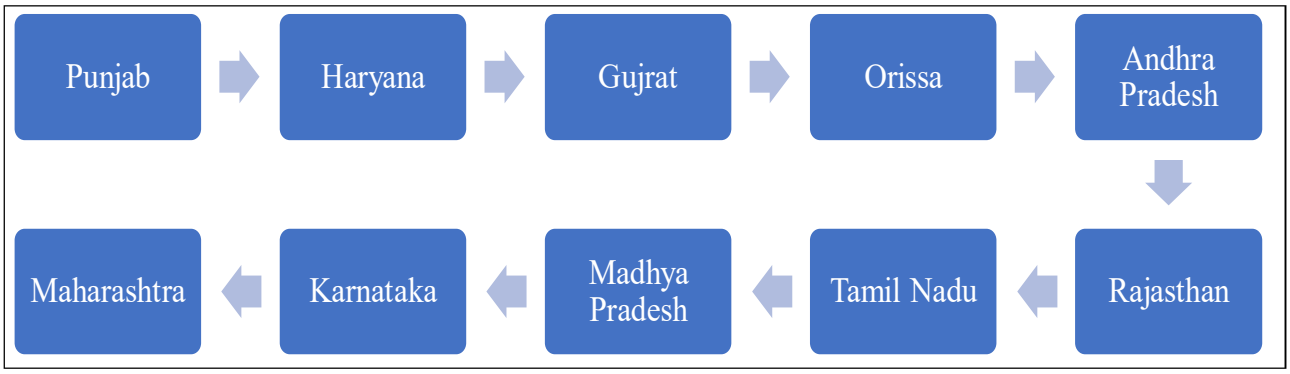


The above picture shows the efficiency of the states in terms of yield in decreasing order (higher to lower).

After analysing the efficiency of the yield of the states by using ANOVA. It is found that there is a statistically significant difference in the yield of the states. It is also found that Punjab, Haryana and Gujarat have the highest yield, while Maharashtra, Karnataka, Madhya Pradesh and Tamil Nadu have the lowest yield. Other states have the average Yield.

Virtual water efficiency state wise in decreasing order

Cotton is the crop which had a large requirement for water. Maharashtra and Karnataka were the states where rainfall was uneven and Maharashtra had poor soil fertility too.



Appendix Table 12: Andhra Pradesh.

(I) States	(J) States	Mean difference (I-J)	Sig. (P-value)	Decision	Significant difference
Andhra Pradesh	Gujarat	-88.39048	.590	Accepted	No
	Haryana	-117.39048	.191	Accepted	No
	Karnataka	76.80000	.765	Accepted	No
	Maharashtra	152.65714*	.021	Rejected	Yes
	Madhya Pradesh	60.65714	.931	Accepted	No
	Orissa	-16.20000	1.000	Accepted	No
	Punjab	-215.34286*	.000	Rejected	Yes
	Rajasthan	7.56190	1.000	Accepted	No
	Tamil Nadu	20.80000	1.000	Accepted	No

Table 2: State wise yield potenstial yield gap.

State	Representative genotypes	Potential yield	Yield gapacross the districts
	F414/F1054	1200	700-800
Punjab	J34/F846		
	Bengal desi	1000	
Haryana	H777,J34/F846	1000	600-650
	Bengal desi	800	
Rajasthan	J34/RST-9	1000	700-775
	Bengal desi	800	
Gujarat	H6	1000	150-750
	V797/Digvijay	300	
Madhya Pradesh	H6/JKHy-1 1007/	600	300-500
	LRA5166/K2	500	
	Desi	400	
Maharashtra	NHH44 LRA 5166	500	225-350
	AKH-4/AKA	400	
	8401	300	
Andhra Pradesh	MCU5, JKHy-I/H4MECH	800	400-650
	1 and 11, LK8611L389	600	
	LRA 5166	500	
Karnataka	DCH32 NHH44	1200	200-1000
	Jayadhar/Suvodhar	800	
		300	
Tamil Nadu	DCH32, TCHB2	1200	150-900
	MCU5, LRA5166	1000	

Source: (Ramasundaram and Gajbhiye, 2001).

The dryland of Karnataka made the worst situation for producing cotton (Gopalakrishnan *et al*., 2007). Farmers grew cotton because the government provided many incentives, which made cotton production cheaper. Cheaper production made cotton yield inefficient (Mohanty *et al*., 2002). Table 2 shows that, the potential cotton yield in Punjab Haryana and Gujrat was also more than in the other states (Ramasundaram and Gajbhiye, 2001). That's why these states had an actual high yield of cotton.

Table 2 shows that, all the Indian states have prominent potential yield which is not achieved by the Indian farmers. There is huge gap in the potential cotton yield and actual cotton yield of the Indian states. Increasing actual yield up to the level of the potential yield level will decrease per unit cost of cotton production and the farmers' income will also increase.

CONCLUSION

This paper analysed the country's relative cotton production efficiency across India's states. The study results show that Punjab, Haryana, Gujrat and Orissa are the most efficient states in cotton production. At the same time, Maharashtra, Karnataka and Andhra Pradesh are the least efficient or inefficient states in cotton production. The rest of the States, Madhya Pradesh, Tamil Nadu and Rajasthan, are average in cotton yield. Government should take the necessary steps to increase the average yield of cotton by shifting cotton farming from low-yield to high-yield regions. The government should promote cotton production where the yield is higher.

Conflict of interest: None.

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