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Economic assessment of pesticides use in cotton cultivation

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Abstract: The present study was undertaken in three tehsils of Nagpur district *i.e.* Savner, Narkhed and Hingna with a view to socio economic characteristics of cotton growers, examine input used, cost structure, returns and frequency and extent of pesticide use, pesticide allocative efficiency in production of cotton and handling practices and safety measures. Data pertains to the year 2018-2019.The standard cost concepts were used for working out/ha. cost and returns. Regression model used to study the technical efficiency and allocative efficiency. Simple tabular analysis was worked out for examine the handling practices of pesticide use and safety measure. The study was based on total 90 cotton growers. It states that, 51.12 per cent farmer has small (upto 4 members) size of family. However, 51.11 per cent farmer were young age (upto 40) group. In the study, 71.12 per cent farmer family type was nuclear and remaining 28.88 per cent farmer as a joint family. The cropping intensity was 127.07 per cent for overall. The highest cropping intensity observed in large type of land holding *i.e.* 132.84 per cent. The study revealed that cropping intensity increases as the size of holding increases. Whereas, cost C3 was 99089.63 Rs/ha. The major share of cost of cultivation goes towards plant protection chemical *i.e.* 8.70 per cent. The rate of return obtained from pesticides use was Rs 2.15. The Input-output ratio at Cost A2 and C3 were 1.65 and 1.05, respectively. The optimum quantity of pesticide required for cotton cultivation was 5.27 l/ha.on the other hand the farmers in the study area were used 6.21 l/ha *i.e.* about one liter excess application. This implies that 1176.97 Rs/ha can be saved. This is not only uneconomical but also would lead to other ill effects of pesticide use. Therefore, there is an urgent need to create awareness among the farmers about the balanced use of pesticides.

The resource use efficiency analysis clearly indicated that the resources were not optimally used as guided by the economic principles. The MVP/MFC ratio was negative for seed. Most of the farmers (62.22 %) does not consider direction of wind during PPCs application. 94.44 per cent farmers used knapsack sprayer, 93.75 per cent farmers eating after spraying, 64.44 per cent farmers used measuring cap of bottle for mixing pesticides. The farmers are under the misconception that higher returns could be obtained through higher doses of plant protection chemical. However this has resulted in pest resistance, pest resurgence and secondary pest outbreak in the region over the past few years. Hence, Government awareness programmeorganised for farmers regarding the optimal pesticide use and handling practices of pesticides. It is also urgent need to provide compulsorily safety kit at free of cost along with the plant protection chemicals to restrict the health losses in the region.

Key words: Chemicals, cost and return, cotton, pesticides

Cotton is one of the most important fiber cash crop in India and plays a dominant role in the industrial and agricultural economy of the country. Cotton is the most important crop not only in India but also in entire world. It provides basic raw material to textile industry. The total estimated cotton production in India is 324.8 lakh bales in which Gujrat state having highest production of 88.3 lakh bales, followed by Maharashtra having production of 78.3 lakh bales (Anonymous, 2018). Cotton and paddy are the major crops where pesticides consumption is 50 per cent and 18 per cent, respectively. Cotton covers only 5 per cent of the cropped area, but accounts for 50 per cent of pesticide use (Devi *et al.*, 2017).

The use of pesticides to prevent pre harvest and post harvest losses has assumed a great significance during the last two decades, in an attempt to provide sufficient nutritive food for the ever growing world population. The use of synthetic pesticides in agriculture has increased rapidly and has over shadowed the traditional methods used to protect crop damages due to

insect, pest, diseases and weeds. Though pesticide use is said to have contributed significantly to the food security by the way of reduction of crop production and post harvest losses, there is a growing concern over the ill effect of pesticides on human and animal health, environment, natural resources and sustainability of agriculture production However, out of all inputs, pesticides play key role in increasing agricultural production by controlling agriculture pests and diseases. It has been observed that about one third of reliable global output is estimated to be lost due to insect pests, disease and weeds.

The farmers in the district are under the misconception that higher returns could be obtained through higher doses of plant protection chemical. However this has resulted in pest resistance, pest resurgence and secondary pest out break in the region over the past few years. In this regard, the study provides insight into economics of pesticides use. The results of the study would be useful to both policy maker and farmers of the region in understanding the nature and economic consequence of pesticide use.

LIMITATION OF STUDY

The study pertains to agriculture year 2018-2019 and is based on information obtained by 90 randomly selected farmers. Hence, various conclusion drawn and explanation of various problems have been on behaviour of the sampled farmers and availability of data during reference period. The respondents were not in the habit of maintaining records of their income and expenditure. The entire information was by recollecting past events by the farmers.

The main objective of any scientific investigation is to draw useful conclusion in light of objective of study. In order to get the meaningful conclusion, it is essential for investigator to adopt appropriate method and procedure, keeping this in view, to explain the methodology adopted, and to fulfill the objective of study. It also deals with source of data, type of data, selection of area, selection of farmers, collection of data, and analytical tools used.

A. Nature and source of data:

The present study was undertaken in Nagpur district of Vidarbha region. The villages and the number of farmers selected are as fallows.

The present study is based on the primary data obtained from sample farmers of Nagpur district. The three predominantly growing tehsils were selected *viz.*, Savner, Narkhed, Hingna. Two villages were selected from each tehsil and fifteen cotton growers were randomly chosen from each village for getting the required information on cotton cultivation. Thus the study was based on 90 randomly selected cotton growing farmers spread in Nagpur district for the year 2018-2019.

B. Method of analysis

Tabular analysis:- The data was summarized in the form of appropriate tables. The budgeting technique was used to asses the

Table1. Tehsil wise distribution of farmers

Sr. No.	Name of tehasil	Name of villages	Farmers selected
1	Savner	Khangao	15
		Kodegao	15
2	Narkhed	Bishnur	15
		Sahjapur	15
3	Hingna	Kinhidhanoli	15
		Mondha	15
	Total		90

cost, returns and profits from cotton cultivation in the study area. The percentage and averages were computed and compared to draw meaningful inferences.

Production function analysis:

The Cobb-Douglas production function was estimated to study the resource use efficiency and influence of inputs on cotton yield.

$Y = A X_1^{b1} X_2^{b2} X_3^{b3} X_4^{b4}$

Where,

Y – Gross Income from cotton (Rs. ha^{-1})

X_1 – Expenditure on seed (Rs. ha^{-1})

X_2 – Expenditure on Fertilizer and manures (Rs. ha^{-1})

X_3 – Quantity of pesticides used (Kg. ha^{-1})

X4 – Expenditure on labour (Rs. ha^{-1})

A- Constant

bi – production elasticities

One of the objective of the study was to estimate optimum quantity of pesticide use. Hence, PPC input was measured in physical quantity while other inputs measured in monetary value. The above function was converted into the linear form through logarithmic transformation of all variables and is written as

$\log Y = \log A + b_1 \log X_1 + b_2 \log X_2 + b_3 \log X_3 + b_4 \log X_4$

The marginal value product for each input were calculated by using following formula

Marginal value product of Xi = bi (Y/X)

Where,

Y = geometric mean of gross income

Xi = geometric mean of i resource

b = production elasticity of i^{th}

The marginal value product was equated the marginal factor cost to determine optimal use of resources. To determine the optimum quantity of pesticide use, under the assumption of profit maximization behaviour, the following relationship was estimated. The marginal Physical product (MPP) of pesticides was equated to the price ratio of the pesticide and cotton.

MPP= (dy\dx) = Pp/Py

i.e. b_3 (Y\X) = Pp/Py

$X^* = (b_3 . Y . Py)/Pp$

Where,

X* = Optimum quantity of pesticides

b_3 = Production elasticity of pesticides

MPP = Marginal physical product of pesticides

Pp = Unit price of pesticides (Rs/a.i)

Py = Out put Price of the cotton (Rs/Qtls)

The rate of return from pesticide use in the cotton was computed by using formula as suggested by Nguyen and Tran Thi, 2003. The rate of return was estimated as the ratio of (Return – Total cost other than pesticides)/ total pesticide cost.

Plant protection chemical expenditure function

The following log linear regression function was used for estimating the plant protection chemical elasticity coefficient.

$\log Y = \log A + b1 \log X_1 + b_2 \log X_2 + b_3 \log X_3 + b_4 \log X_4$

Where;

Y= Expenditure on plant protection chemicals (Rs. ha^{-1})

X^1 = Total family income (Rs. ha^{-1})

X^2 = Expenditure on fertilizer and manures (Rs. ha^{-1})

X^3 = Intensity of pesticide application (no of times ha^{-1})

X^4 = Area under cotton (ha.)

Keeping in view the objectives of the study, the data were analysed using suitable techniques. The results obtained from this study have been presented and discuss critically.

A) Profile of sample farm:

A total of six (6) villages spread across three tehsil of Nagpur district of Vidarbha region were surveyed for the study. The demographic characteristics of the sample farm's families are profiled in Table 2.

Age and education play vital role in farmers disposition towards technology and their comprehension and adoption. Hence, it is

Table 2. Family Profile of the sample farm household

Sr. No.	Particular	Frequency (N = 90)	Percentage (%)
A	**Age groups**		
1	Young (<40)	45	50.00
2	Middle(41 - 64)	39	43.33
3	Old (>64)	06	06.67
B	**Education status**		
1	Illiterate	01	01.12
2	Primary level	07	07.78
3	Secondary level	11	12.22
4	High School level	29	32.22
5	Higher secondary	31	34.44
6	Graduate and above	11	12.22
C	**Family size (member)**		
1	Small (<5)	65	72.22
2	Medium(5-10)	07	07.78
3	Large (>10)	18	20.00
D	**Average size of holding**		
1	Small (0.01 - 2. 0 ha.)	65	72.23
2	Medium (2.01- 4. 00 ha.)	18	20.00
3	Large (Above 4 ha.)	07	07.77

observed from the table that, only 6.67 per cent of the respondents fell under old age category while 43.33 per cent belonged to middle age category and rest 50 percent to young category. The educational profile showed that 34.44 per cent higher secondary level, followed by 32.22 per cent high school level, 12.22 per cent graduate and above level and 7.78 per cent farmers had primary school level. However, only1.12 per cent farmers were illiterate in the sample.

Family size is a major factor in determining the economic well being of the farmers. The family size distribution showed that 72.22 and 20 per cent had small family and 7.78 per cent had medium size of family. Whereas on an average 72.23 per cent farmers had small size of holding 21.67per cent farmers had medium size of holding and 7.77 per cent farmers had small large size of holding was observed in the sample.

B) Cost and returns from cotton cultivation with reference to pesticide use

The cost incurred and returns realized from cotton cultivation were calculated and presented in Table3. It is revealed from the Table 3 that average cost of cultivation in cotton worked out to Rs. 90081.50/ha. The net returns/ha obtained by farmers was Rs. 13992.20/ha. The share of variable costwas 69.61 per cent and that of fixed cost was 21.72 per cent. Labour expense was the major component of variable cost while rental value of land was major in fixed cost. The pesticide share intotal cost was estimated 3.55 per cent. The average yield of cotton was 19.73q/ha. Further, It revealed that the expenditure on pesticides worked out to be Rs. 7834.56/ha. The rate of return from pesticide use was computed by using formula as suggested by theNguyen and Tran Thi (2003). The result also indicated that the rate of return obtained from pesticides use was Rs. 2.15. Though the rate of return on pesticides was more than two, it should notbe based on inferred that the farmers should spent more on PPCs. The decision to spend on PPC must be economic threshold of pest infestation. The farmers need to be educated with respect to various issues of pesticides.

C) Resource use efficiency in cotton

The Cobb-Douglass production function

Table 3. Cost and returns of cotton cultivation

Sr. No.	Items		Units	Units required	Price/unit	Cost Rs.	(Rs./ha) Per cent
1	Hired human labour	Male	Days	10.98	245.91	2700.12	3.00
		Female	Days	97.53	148.96	14528.39	16.13
		Total	Days	108.51		17228.39	19.13
2	Bullock labour	Hired	Days	00.00	00.00	00.00	00.00
		Owned	Days	07.14	847.93	6054.20	6.72
		Total	Days	07.14	847.93	6854.20	6.72
3	Machine	Hired	Hrs.	10.23	673.98	6894.81	7.65
		Owned	Hrs.	00.00	00.00	00.00	00.00
		Total	Hrs.	10.23	673.98	6894.81	7.65
4	Seed		Kg.	2.49	1479.76	3684.60	4.09
5	Manure		Qtl.	31.21	210.41	6566.78	7.29
		N	Kg.	116.94	20.78	2429.76	2.70
6	Fertilizer	P	Kg.	109.34	35.51	3882.86	4.31
		K	Kg.	66.58	26.99	1796.85	1.99
		Total		292.86		8109.47	9.00
7	Irrigation	Rs.			162.05	0.18	
8	Incidental	Rs.			2215.28	2.46	
9	Plant protection	Rs.			7834.56	8.70	
10	Repairs	Rs.			656.61	0.73	
11	Depriciation	Rs.			1072.66	1.19	
12	Land revenue	Rs.			39.79	0.04	
13	Int. on wor. cap.	Rs.			2503.99	2.78	
14	Cost A1	Rs.			63023.31	69.96	
15	Cost A2	Rs.			63023.31	69.96	
16	Int. on fixed capital	Rs.			1841.83	2.04	
17	Cost B1	Rs.			64865.14	72.01	
18	Rental value of land	Rs.			17305.82	19.21	
19	Cost B2	Rs.			82170.96	91.22	
20	Cost C2	Rs.			90081.48	100.00	
21	Yield main	-	19.73	5274.89	104073.68		
22	Cost of production/Rs/qtl	-			5022.28		
23	Rate of return to pesticide				2.15		

Note: rate of return to pesticide = (Return – all cost other than pesticides)/ total pesticide cost

was estimated to analyse the relationship between resources and productivity of cotton using survey data from sample farmers. The gross realized income expressed in rupees from cotton output was taken as dependent variable while expenditure made on seeds (Rs), fertilizers and manures (Rs), labours (Rs) and quantity of pesticide used (l) were taken as independent variables. The dependent and independent variables in production function were defined on per ha basis. The estimated production functions are presented in Table 4.

The inputs included in model explained 83 per cent of variation in cotton output as revealed by the coefficient of multiple determination (R2). The summation of production elasticities indicated that the regression coefficient of area under cotton cultivation was significant at one per cent level.

The estimated parameters of area under cotton cultivation was positively significant at one per cent of probability level for selected farmers indicating that every one per cent increase in area would result in increase of gross return by 1.01 per cent. The coefficients of seed was negative for farmers and non significant. One per cent increase in seed would result in decrease of gross income by 0.24 per cent.

Table 4. Estimated Cobb-Douglass production function in cotton production

Sr. No.	Explanatory Variable	Coefficient
1	Intercept	5.05
2	Expenditure on seed (Rs./ha)	-0.24
3	Expenditure on Fertilizers and manures (Rs./ha)	0.05
4	Quantity of Pesticide (l/ha)	0.06
5	Expenditure on Labour (Rs./ha)	0.12
6	Area under cotton cultivation (ha)	1.01**
7	Coefficient of multiple determination (R2)	0.83

Note ;* * - denotes significance at 1%

Table. 5 Ratio of Marginal value product to the marginal factor cost in cotton production

Sr. No	Resources	MFC	MVP	MVP / MFC
1	Seed	1	- 0.33	-0.33
2	Fertilizer and manures	1	0.06	0.06
3	Pesticides	1	0.36	0.36
4	Labour	1	0.14	0.14

Table 6. Distribution of sample farmers according to number of pesticide application

Sr. No.	No. of application	Frequency	Percentage
1	3	12	13.33
2	4	26	28.89
3	5	28	31.11
4	6	17	18.89
5	7	6	06.67
6	8	1	01.11
Average application per farm		5.5	

Table 7. Quantity of pesticide used in cotton cultivation (a.i /ha)

Sr. No.	Pesticides	Quantity	Percentage
1	Insecticides	05.54	89.21
2	Fungicides	00.61	09.82
3	Weedicides	00.16	02.57
	Total	06.21	100.00

D) Marginal value product to marginal factor cost

The Cobb-Douglas function estimates and geometric levels of inputs and outputs were used to estimate the marginal value products of the inputs. The knowledge of the marginal value products of resources facilitates comparison of marginal value product with marginal factor cost of the resources to arrive at optimal use of resources.

It was evident from Table 5 that the ratio of MVP to MFC were less than unity in all most the resources except seed which means they are over utilised. The ratio of MVP to MFC was negative in case of seed (-0.24) revealed that every rupee of an additional income on seed will lead to reduction of income. It clearly shows that seeds are extensively and indiscriminately used negative extradites i.e. decreased in the use of other inputs would enhance over returns.

E) Frequency distribution of pesticide use intensity

Frequency distribution of farmers by pesticide use intensity was presented in Table 6. The farmers in the study area were found that use ofpesticides frequently in cotton cultivation. More than 6.67per cent farmers treated the crop by application of pesticides, five times during its

production cycle. However, 18.89 per cent farmers applied pesticides four times. The maximum numbers of application of pesticides were observed to be three times.

F) Type of pesticides used by cotton growers

Pesticide use in cotton cultivation has become a regular and inevitable feature in the study area even though most of the farmers discount the complexity involved in and consequence of indiscriminate use of pesticides. On an average one hectare of cotton area received 6.21a.i of technical grade pesticides in the study area. Insecticides were the most frequently used pesticides which accounted for bulk of the share (89.21 per cent) in total pesticides used and followed by Fungicides (9.82 per cent) and Weedicides (2.57 per cent).

G) Optimum quantity of pesticide requirement

The optimum quantity of pesticide requirement for cotton production was presented in Table 8. The optimum quantity of pesticide required for cotton was estimated to be 5.27 a.i./ha. The requirement of pesticide as estimated through production function. The actual quantity of pesticide use was high in the sample farmers. As such farmers were found to over uses ofpesticides by 0.93 active ingredients/ha. In other words the farmers spent Rs. 1176.97/ha extra because of an uneconomical use of pesticides in cotton farming. This is because of the risk aversive nature farmers to avoid crop loss due to pest infestation. Therefore, any increase in pesticides higher than the optimal level is really not a rational expenditure. Moreover, in the process of overusing of pesticides, environmental problems are inevitably generated.

H) Expenditure elasticity co-efficient of pesticides use in cotton

A log linear regression model was estimated considering the cost of pesticides as dependent variable. Total family income (Rs.), expenditure on fertilizer and manures (Rs.), number of pesticide applications and area under cotton (ha) were taken as independent variable. The independent variables included in model explained 26 per cent of total variation in expenditure on PPCs (Table 9)

The estimated parameter of expenditure on fertilizer and manure was positively significant at five per cent probability level for farmers, indicating that five per cent increase in total family income would result in increase expenditure on plant protection chemicals by 0.25 per cent. The regression coefficient of area under cotton was 0.52. This indicated that five per cent increase in area under cotton crop would

Table 8. Optimum quantity of pesticide requirement in cotton cultivation

Particulars	a. i./ha	Cost (Rs./ha)
Optimal Use	5.27	6657.57
Actual used	6.21	7834.53
Saving	0.93	1176.97

Table 9. Expenditure elasticity of pesticide use in cotton

Sr. No.	Explanatory variable	Co-efficient
1	Intercept	3.95
2	Total family income (Rs)	-0.02
3	Expenditure on fertilizer and manure (Rs)	0.25*
4	No. of pesticide application (No.)	-0.48
5	Area under cotton (ha)	0.52*
6	R2	0.26

Note:, *denotes significance at 5%

bring about 0.52 per cent increase in expenditure on plant protection chemicals. This as the area under cotton increases the chance of applying more pesticides would also increase in order to secure higher returns by controlling the insect pest. Similarly the intensity of pesticide application was found to contribute positively to the expenditure on PPCs which clearly indicated that the farmers in the study area were spending more on pesticides. It was noticed that as the family income decreased, the farmers tend to spend more on pesticides to control the pest which is not only uneconomical but also would lead to emergence of pest as resistance.

I) Safety practices followed by sample farmers

i) Farmers response towards pesticide use

It could be seen that from the table 10 about 36.66 per cent farmers felt that the use of PPC was adequate. Among the sample farmers only 7.77 percent farmer were aware of the recommended dose of pesticides. This is the reason for farmers using pesticides indiscriminately. Nearly 17.77 per cent of the sample farmers were observed to look at the labels on the pesticide container. The farmers who had education up to secondary, college and above were aware of colour symbols on PPC container and toxicity level (11.11 %). Further only 11.11 per cent farmers were aware of the prices of all pesticides.

ii) Pesticide handling practices

The pesticide handling practices followed by sample farmer were presented in Table 11. 62.22 per cent of the farmer did not consider the direction of wind as important. Table also revealed that most of the farmers (37.77%) applied PPC's along the wind direction. The application of PPC's along the wind direction reduces farmer's exposure to chemicals. This is the correct method of applying PPCs and reduces the probability of poisonous effect, through inhalation of chemicals. But most of the applicators (47.77 %) did not use any protective covering like hand gloves, shoes and facemasks. This increased the probability of exposure to poisoning by contact and health hazards. Particles of PPCs, which adhered body and hands of the applicator were washed with soap and mud through bathing, after spraying, thus, reducing the risk of health hazards.

Majority of the applicators (88.88%) mixed the chemical by using wooden stick. This was the practice of farmers while few farmers also used pouring water by mug/jar. Nearly 35.55 per cent of the respondents used measuring jar for measuring pesticide which is correct method. While 64.44 per cent of the farmers used pesticide bottle cap or matchbox (if powder) for measuring pesticides and also in the process of diluting the PPCs with water.

Attitudinal response of PPC applicators are presented in Table 12. It reveals that about 80 per cent of the respondents eat / drunk prior to spraying activity to avoid the possible consumption of pesticide residue due to human negligence in washing the hand after spraying activity. And the other reason was to get the energy for spray. 5.55 per cent of the farmers reported working in field after spraying activity.

Table 10. Farmers awareness towards pesticide use.

Sr. No.	Particular	No. of farmer	Percentage
1	Adequacy of pesticide use	33	36.66
2	Aware of recommended dose	07	07.77
3	Look at the labels	16	17.77
4	Aware of importance of colour symbols on PPC containers	14	15.55
5	Aware of toxicity level	10	11.11
6	Aware of prices of all pesticides	10	11.11

Table 11. Pesticide handling practices followed by sample farmers

Sr. No.	Particular	No. of farmers (n=90)	Percentage
1	**Direction of PPCs application**		
	a) Along with wind	34	37.77
	b) Across the wind	00	00.00
	c) Do not consider	56	62.22
2	**Protective coverings covers**		
	a) No protective covers	43	47.77
	b) Use of shoes	14	16.20
	c) Use of gloves	00	00.00
	d) Use of facemask/cover the face	28	31.11
	e) Use of plastic polythene bags as shoes	00	00.00
3	**Hand washing practices**		
	a) With soap	80	88.88
	b) With mud/soil	06	06.66
	c) With soap/mud	04	04.44
4	**Take the bath after spraying**	90	100.00
5	**Pesticide and water mixing practices**		
	a) Use of wooden stick	80	88.88
	b) Use sprayer lancer	00	00.00
	c) Pouring the water by mug/jar	10	11.11
6	**Measurement of pesticides**		
	a) Measuring the jar	32	35.55
	b) Pesticides bottles/cap	58	64.44
	c) Weighing balance	00	00.00

Table 12. Attitudinal response of PPC applicators

Sr. No.	Activities	No. of Farmer	Percentage
1	Eat / drunk before spraying	72	80.00
2	Work in the field after spraying	05	5.55
3	Rest after spraying	86	95.55

V. CONCLUSION

The study concluded that that MVP/MFC ratio was positive for plant protection chemicals *i.e.*, PPCs were properly used as guided by economic principles. But, the actual use of PPCs is slightly more than the optimal use of PPCs. Thus the withdrawal of these resources would maximize the returns from cotton production. The farmer need to be educated and advised about the proper use of resources particularly plant protection chemicals. The farmers in the study area were using more amount of pesticide. This is not only uneconomical but also leads to other ill effects of pesticide use. Therefore, there is need to create awareness among the farmers related to balance use of pesticides. They also need to be advised about the method of applying and identifying the spurious chemicals. Awareness needs to be created and use of personal protective measures among farmers whole handling pesticides. Farmers need to be encouraged to reduce, if not eliminated the use of pesticides, with the introduction of incentives to the farmers to help them shift from synthetic pesticide to biopesticides, organic farming and adoption of integrated pest management (IPM) practices.

Government awareness programs need to be organised for the farmers regarding the optimal pesticide use and handling practices of pesticides, also compulsorily toprovidesafety kit free of cost along with the plant protection chemicals to restrict the health losses faced by farmers by application of those chemicals.

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