

Note

Effects of the Timing and the Number of Sprays on Cotton Yields in Sind: An Exploratory Analysis

SAJJAD AKHTAR*

I. INTRODUCTION

Plant protection measures for a weather-sensitive crop like cotton can make a difference between its actual and normal yields. Since in the cotton-growing areas of Pakistan, small variations are observed in the use of complementary inputs like fertilizer, seeds, irrigation and cultural practices, the timing of application and the quality and amount of pesticides assume crucial importance in determining cotton yields.¹

In Pakistan, quality data relating to pesticide use are almost non-existent because of the absence of organized and coordinated research on pest management. As a result, it is very difficult, if not impossible, to test models of pest-crop environment and to derive optimal pesticide dosage response, incorporating pest damage and pest kill functions. Furthermore, a survey of literature available in Pakistan reveals that whereas studies under controlled experiments on the biological aspects of the use of pesticide have been frequent [1; 2; 3; 4], few studies exist on the economics of pesticide applications as observed from the farmer's land. This paper, therefore, adopts an exploratory method for assessing the usefulness of the application of pesticide to cotton crop in Sind. By applying simple statistical techniques to farm-level data, we try to answer some key questions. Is the timing or number of sprays more important in explaining the variation in yields? Is the interaction of these two factors a significant source of explained variation? Are there any observed

*The author is a Research Economist at the Applied Economics Research Centre, University of Karachi. He is indebted to Professor Mahmood Hasan Khan, whose guidance made this study possible, and to Dr. Aly Ercelawn for his useful comments. Thanks are also due to Professor S. A. Sarwar Rizvi for the supply of the relevant data. The anonymous referees of this *Review* are also thanked for their comments. Messrs. Sharique Ayubi and Joseph Cyprian are thanked for their typing assistance. The author alone is responsible for all the remaining errors.

¹In 1983, pest attack destroyed nearly 40 percent of cotton in Pakistan, leading to a negative agriculture growth rate for the year, import of cotton and loss of foreign-exchange earnings.

patterns of spray timing and number of sprays leading to high yields? Are low pest damage and higher yields correlated with the same timing of sprays? It is hoped that even tentative answers to these questions would increase our understanding of these relationships and help the agricultural extension service in educating farmers in the efficient use of pesticides.

II. DATA SOURCES

Realizing the importance of the extension service for improving cotton yields, the Pakistan Central Cotton Committee (PCCC) initiated the Cotton Maximization Project in Tharparkar district of Sind in 1980-81. The Applied Economics Research Centre of the University of Karachi was asked to evaluate the impact of the extension service provided specifically to that project. This study is based on a sample of 114 respondents in 1983. Information was gathered on the number of sprays, the timing of sprays, the farmer's assessment of pest damage, and the yield per acre.² Among these variables, the timing of the pesticide spray needs some elaboration.

Since rains and high humidity encourage pest breeding, the likelihood of damage by insects and pests is highest during the rainy season, which extends from July to September. The rainy season is thus a period of extensive spraying activity in the province.³ Depending on a host of factors, e.g. past experience, pest infestation, advice of the extension agent, and ability to pay for expensive pesticide, spraying farmers spray their crop 1-2 times, and, in some cases, five times during the season.⁴ To capture the timing of spray as closely as possible, the three-month spraying season was divided into 12 weeks, and farmers were asked to identify the week of the spray and the number of the successive sprays, i.e. whether it was the first, second or third one during the season.

During the survey, farmers and extension agents revealed that pest attacks were most severe during the period from the second fortnight of August to the first fortnight of September.⁵ On the basis of this information, spray timing was split into four periods. The pre-pest attack period was split into two sub-periods: D1, which covered the entire month of July, and D2, which covered the first fortnight of August. The pest-attack period was denoted by D3, and the last fortnight of the spraying season by D4. This procedure of aggregation, it was hoped, would partially overcome problems of recall errors commonly associated with field surveys.

²Information on the timing of spray was systematically gathered under this study for the first time in this year.

³It is equally possible that pest attacks are independent of actual rain fall, as was the case in this year.

⁴Spraying is usually undertaken to control Cotton Jassid, Whiteflies, Spotted Bollworm, Armyworm and Cotton Leaf Roller, commonly found in this region of the country.

⁵In 1983, Armyworm and Cotton Leaf Roller severely damaged the cotton crop at the maturity stage.

III. RESULTS

Among the three important variables – yield per acre, percentage of damage from pests, and number of sprays – the last variable revealed the least amount of variation. Forty-seven percent of the sampled farmers sprayed twice during the season.⁶ Seventy-five percent of the sample farmers sprayed early during the season.⁷ The practice of “preventive” spraying by farmers may be a reason for a high concentration in the early part of the season.

A correlation matrix of all major variables is given in Table 1. On an *a priori* basis, yield (YLD83) is expected to be positively related with number of sprays (NSPRA) and negatively related with percentage of damage by pest attack (PESTDAM). An inverse relationship is hypothesized between pest damage and number of sprays. The correlations among the three variables are weak but confirm the *a priori* expectations. Low negative correlations among the spray periods may be interpreted as indicative of some degree of interval between spray periods. For example, those who sprayed early in the season are less likely to spray just before the

Table 1
Correlation Matrix

	YLD 83	PESTDAM	NSPRA	EARLY	BEFORE	DURING	AFTER
YLD 83	1.0000	-0.3011	0.2482	-0.0531	0.1252	0.2048	0.0327
PESTDAM		1.0000	-0.1324	-0.0254	0.0051	-0.2581	0.0930
NSPRA			1.0000	0.2805	0.2598	0.5712	0.1196
EARLY				1.0000	-0.1559	-0.0207	-0.1333
BEFORE					1.0000	-0.1765	0.0436
DURING						1.0000	-0.1369
AFTER							1.0000

PASTDAM = Percentage of damage by pests.

NSPRA = Number of sprays.

⁶Twenty-two percent sprayed once and 21 percent sprayed thrice. Only 3.5 percent did not spray at all.

⁷The percentages of the farmers reporting sprays during other periods are: 44 percent during D2; 45 percent during the pest attack and 11 percent after the pest attack (D4).

pest attack. This observed pattern in spraying practice may be guided either by biological consideration, i.e. the necessity to maintain some minimum time interval between successive sprays, or by purely economic reasons, i.e. the limited capacity of the farmers to pay for pesticides.

We use regression analysis to explore the relationship of spray period and number of sprays with yield as well as percentage of pest damage. The regression results are reported in Appendix (Tables A and B). For equations with yield per acre as the dependent variable, we can make three major observations:

- (1) Among the four interaction variables corresponding to spray periods, only D3 has a significant impact on yields. The highest yields seem to have resulted from higher number of sprays and from spraying in the pest-attack period.
- (2) Results do not improve by including the spray periods and the number of sprays as independent variables in a single equation. However, it may be noted that the impact of the timing of sprays on yields is highest for D3, i.e. those who sprayed during the pest-attack period had the highest yields.
- (3) If only the number of sprays are regressed, they have a significant and positive impact on yields. But if the spray periods are regressed on yields, the coefficient of D3 is significant. In other words, spraying during the pest-attack period led to higher yields.

In equations with the percentage of pest damage as the dependent variable, it is observed that spraying during the pest-attack period (D3), either independently or jointly with the number of sprays, consistently appears as a significant determinant of lower pest damage.

Since the yield level and degree of pest damage seem to vary with the combination of the number and the timing of sprays, cross-classified matrices with yield levels and pest damage are given in Tables 2 and 3. In Table 2, yields are higher on farms with larger numbers of sprays and those on which spraying was done before and during the pest attack.⁸ In Table 3, the combination of the timing and the number of sprays, showing a lower percentage of damage by the pests, are the same, as shown in the yield matrix.

All farmers who sprayed before and during the pest attack and three times during the season were selected. Though the farmers who sprayed four times show higher yields, it was felt that the mean of a small number of observations would be less reliable. The average yields of those who sprayed twice and before and during the pest attack were significantly lower than those of the rest of the sample. A two-sample t-test was applied to establish whether the average yield and the percentage of pest damage of this select group were significantly different from the means

⁸Excluding those cells which had just one observation.

Table 2
Yields by Timing and Number of Sprays

Number of Sprays	Yield when Spraying is Done			
	Early (in D1 period)	Before (in D2 period)	During (in D3 period)	After (in D4 period)
1	6.05 (14)	6.70 (5)	7.00 (4)	10.00 (1)
2	8.17 (45)	7.87 (28)	7.68 (18)	8.74 (7)
3	8.91 (19)	11.59 (12)	10.99 (21)	5.25 (4)
4	12.15 (6)	12.22 (4)	12.15 (6)	23.00 (1)
5	3.12 (1)	20.00 (1)	11.56 (2)	—

Note: Figures in parentheses represent the numbers of the farmers involved.

Table 3
Percentage of Damage by Timing and Number of Sprays

Number of Sprays	Percentage of Damage when the Spraying is Done			
	Early (in D1 period)	Before (in D2 period)	During (in D3 period)	After (in D4 period)
1	17.85 (14)	23.00 (5)	12.50 (4)	25.00 (1)
2	19.93 (44)	22.48 (27)	13.53 (17)	33.33 (6)
3	15.42 (19)	12.08 (12)	11.09 (21)	15.00 (5)
4	4.17 (6)	0 (4)	4.17 (6)	0 (1)
5	20.00 (1)	10.00 (1)	15.00 (2)	—

Note: Figures in parentheses represent the numbers of the farmers involved.

obtained for the rest of the sample. The results are reported in Table 4. The mean yields of the selected farmers are significantly different from those of the rest of the sample. However, the t-value for the differences in average pest damage is low and statistically insignificant.

Table 4
Average Yield and Pest Damage for the Selected Group
and for the Rest of the Farmers

Category	Yield			Pest Damage		
	Average	Standard Deviation	N	Average	Standard Deviation	N
Rest of the Farmers	7.95	5.66	104	18.38	22.84	102
Selected Group	12.71	6.88	10	11.50	16.67	10
	t-Value: 6.99			t-Value: 0.85		

IV. POLICY IMPLICATIONS

There are two major findings of this study:

- (1) The number of sprays and spraying during the pest attack are significant in explaining variation in yields, while only the latter variable contributes to a lower damage by pests. Specifically, the study indicates that a combination of three sprays and spraying during the last fortnight of August and the first fortnight of September result in significantly higher yields.
- (2) A more disaggregated look at the data reveals that the yields obtained by farmers using the above combination were sixty percent higher than the yields obtained by farmers employing other combinations.

A word of caution is necessary before any policy conclusions are drawn. The above preliminary findings are specific to location, timing, pest density, and type of pest and relate to a single year. Similar analysis is needed of data over a number of years and from other cotton-growing areas of Pakistan. This would not only verify the results obtained from the Tharparkar region of Sind, but would also ensure a wider and robust generalization of the results for the benefit of agricultural extension services. Moreover, policy-oriented research on the economics of pesticide use should focus on the following aspects: (a) information on pesticide use with respect to the brand and generic names, quantities, cost, and timing; (b) data collection on a weekly basis by pest-scouting teams on pest characteristics and intensity of pest attack; and (c) monitoring of the extent of boll formation in each week during the

Appendix

Table A

Dependent Variable = Yield per Acre (YLD 83)
Independent Variable = Timing (D); (Number of Sprays (X));
Early = D1; Before = D2; During = D3; After = D4

Eq. 1.	YLD 83	=	6.9517 -	0.5277D1X +	0.7993D2X +	1.1187D3X +	0.3882D4X	
			(1.05)	(1.87)	(2.66)**	(0.56)		
							R ² = 0.1115	SEE = 5.70 F = 3.36
Eq. 2.	YLD 83	=	5.85105 -	1.2106D1 +	0.9833D2 +	1.3419D3 +	0.2010D4 +	1.1291X
			(0.78)	(0.70)	(0.78)	(0.10)	(1.19)	(1.19)
							R ² = 0.0846	SEE = 5.81 F = 1.96
Eq. 3.	YLD 83	=	5.247 +	1.5042X				
			(2.70)**					
							R ² = 0.0612	SEE = 5.74 F = 7.29
Eq. 4.	YLD 83	=	6.2077 -	0.1052D1 +	2.0483D2 +	2.7800D3 +	0.9059D4	
			(0.08)	(1.82)	(2.48)**	(0.52)		
							R ² = 0.0708	SEE = 5.78 F = 2.07

Table B

Dependent Variable = Percentage of Pest Damage (PESTDAM)

Independent Variable = Timing (D); No. of Sprays (X)

Early = D1; Before = D2; During = D3; After = D4

$$\text{Eq. 1. PESTDAM} = 21.5764 + 0.7319D1X - 0.4648D2X - 4.0351D3X - 1.1899D4X$$

$$(0.37) \quad (0.28) \quad (2.48)** \quad (0.44)$$

$$R^2 = 0.0687 \quad \text{SEE} = 22.01 \quad F = 1.97$$

$$\text{Eq. 2. PESTDAM} = 23.97 - 3.3455D1 - 3.8285D2 - 14.3103D3 + 2.4519D4 + 1.9734X$$

$$(0.57) \quad (0.72) \quad (2.20)** \quad (0.33) \quad (0.55)$$

$$R^2 = 0.0753 \quad \text{SEE} = 22.03 \quad F = 1.72$$

$$\text{Eq. 3. PESTDAM} = 24.07 - 3.0290X$$

$$(1.40)$$

$$R^2 = 0.0175 \quad \text{SEE} = 22.29 \quad F = 1.96$$

$$\text{Eq. 4. PESTDAM} = 24.67 - 1.5910D1 - 2.1532D2 - 11.6435D3 + 3.9922D4$$

$$(0.32) \quad (0.50) \quad (2.71)** \quad (0.58)$$

$$R^2 = 0.0727 \quad \text{SEE} = 21.96 \quad F = 2.09$$

REFERENCES

1. Ahmed, Z., M. R. Atique, and Abdul Khaliq. "Preliminary Observations on the Efficiency of Various Pyrethroids and Organophosphates as Cotton Insecticides". *Pakistan Cotton*. Vol. 27, No. 2. April 1983.
2. Ali, Mahbub. "Preliminary Observations on the Most Effective Period of Spraying for the Control of Pink/Spotted Bollworms". *Pakistan Cotton*. Vol. 21, No. 2. January 1977.
3. Naqvi, K. M., A. S. Buriro, and N. A. Rizvi. "Effect of Pyrethroids Spray on Cotton Insect Pest Complex and Side Effects on Cotton Maturity and Mite Resurgence". *Pakistan Cotton*. Vol. 25, No. 2. April 1981.
4. Waheed, Tajammal. "Comparative Effect of Synthetic Pyrethroids and Endosulfan on Cotton Pests and Cotton Crop in Pakistan". *Pakistan Cotton*. Vol. 23. April/July 1979.