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EFFECT OF DIFFERENT DEPTHS OF IRRIGATION AND FERTILIZER COMBINATIONS ON WHEAT YIELD ~A FIELD STUDY

Buland Akhtar, Amjad Hussain, Naeem Mahmood, Muhammad Saleem, Azraf-uL-Haq Ahmad & Muhammad Aslam'

Directorate of Crop Production and Water Management &
'Department of Agricultural Economics, University of Agriculture. Faisalabad

The study was conducted to measure the effect of three depths of irrigation Le. 50, 75 and 100 mm with three levels of fertilizer application @ 89 N, 84 P and 0 K; 128 N, 111 P and 25 K; 158 N, 111 P and 62 K kg/ha on wheat crop. The analysis of data revealed that wheat grain yield was affected more with the dose of fertilizer 128 N, 111 P and 25 K kg/ha with 100 mm depth of irrigation water than that of other combinations of fertilizer and irrigation depth. This combination yielded 6223 kg/ha of wheat grain. This yield level promised the marginal rate of return of 819.20% to added expenditure on fertilizer and water.

Key words: depths of irrigation, fertilizer combinations, wheat yield

INTRODUCTION

Pakistan is a country with enormous potential to produce agricultural crops. It has rich soils, good water, favourable climate and energetic people. Despite highly conducive environment, Pakistan is yet to achieve the targets of production of which it is capable. A breakthrough in cotton production has been achieved but on the other hand, the production of wheat and rice has increased rather slowly with even much wider use of improved seed and greater use of fertilizers and ground water.

It is indeed a matter of great concern that Pakistan has to import wheat now, in which it was almost self-sufficient a few years ago. This gap is likely to increase unless we take immediate steps, not only to bridge it but also to keep a matching pace with our future requirements. High yields of wheat obtained at research stations are not common at the farm level. Research recommendations and extension efforts have emphasized a "package approach", where as many as six to seven different technological components may be extended to farmers. However, farmers do not adopt packages rather make improvements in a stepwise fashion (Byerlee and Hesse de Polanco, 1986).

Water and fertilizer nutrients are two inputs which have important interrelationships. Considerable research has been done on the response 'of various crops to fertilizer and irrigation in Pakistan. Finkner and Fuehring (1972) studied the effect of 45, 90 and 130 kg N per acre and 300, 450, 600, 750, 900 and 1050 mm of irrigation water applied in various combinations. They concluded that the maximum benefits of applied nitrogen were gained only if enough water was available. High levels of nitrogen and irrigation caused lodging. Raghu et al. (1974)' reported higher yield of wheat with 5 irrigations of 75 mm than that of with three irrigations. Reducing the amount of irrigation to 50 mm decreased the yield by 14. 16%. Chaudhry and Bhatnagar (1977) reported that 55 mm irrigation depth' resulted in higher yields by 17% and 27 % over those obtained with 75 mm and 100 mm water depth. Singh et al. (1976) concluded that application of 890 mm water with 150,40 kg NP per hectare gave a maximum yield of 6.3 t/ha and application of 750 mm water with 132, 40 NP/ha gave the highest economic return. Yet the water variable in these experiments has seldom been quantified. In view of the above deficiency in most of the experimental trials, the present study was designed to estimate the effects of different depths of irrigation and fertilizer combinations on the yields that will permit derivation of economically optimum input combination, gross and net benefits of wheat production by using the well known partial budgeting technique.

MATERIALS AND METHODS

This experiment was started in Rabi 1994-95 at the Research Area of the Directorate of Crop Production and Water Management, University of Agriculture, Faisalabad. The soil was classified as loamy. The sowing of wheat (cv. Inqalab-91) was done with the help of single row hand drill and a uniform seed rate of 100 kg per hectare was used. The split-plot design was adopted for laying out the trial. The effect of the following three irrigation application depths (treatments) i.e. I_1(50 mm), I_2 (75 mm) and I_3(100 mm) and their fertilizer levels, F_1 (89 N, 84 P, 0 K), F_2 (128 N, 111 P, 25 K) and F_3 (158 N, 111 P, 62 K) kg/ha was studied. These fertilizer levels were randomized in main-plots and irrigation levels in sub-plots, respectively. The plot size was 4.5 m x 12 m. There were 20 rows (23 cm apart) in each sub-plot. The irrigation levels 50 mm, 75 mm and 100 mm were applied with the help of siphon tubes. Six irrigations were applied at the same intervals to all treatments. Experimental data thus generated were subjected to rigorous analysis using discrete economic analysis technique as described by CIMMYT (1988).

RESULTS AND DISCUSSION

A major assumption of this analysis is that farmers think in terms of net benefits as they make any crop production decision. The fanners while considering a choice among the alternative package of fertilizers and depths of irrigation application, would naturally weigh the expected benefits in the form of added income gains, the costs of inputs and cash given to apply the package. The net result of this consideration in the farmers' mind is referred to as the net benefit from a decision.

Calculation of Average Net Field Benefits: The first step towards calculating the average net field benefits was to record the observed average experimental yield of the wheat crop. A perusal of the data revealed that wheat grain yield was affected more with the dose of fertilizer 128 N, 111 P and 25 K nutrient kg/ha and 100 mm depth of irrigation application which yielded 6223 kg/ha. Downward adjustments were proposed and made in the observed average experimental yield to arrive at adjusted farm level yield. Observed and adjusted average yields of wheat crop are given in Table 1.

The gross field benefits for each experimental treatment were calculated by multiplying the field price with the adjusted yield. The gross field benefits, thus, calculated appeared in the partial budget (Table 2) for each experimental treatment. It was found that the fertilizer application of 128 kg N, 111 kg P and 25 kg K per hectare with the irrigation application at the depth of 100 mm yielded the highest gross field benefits. Costs of purchased inputs for labour, machinery and equipment vary between experimental treatments. Estimation of these costs is essentially needed, since farmers will want to evaluate all the changes that are involved in adopting a new practice. It is, therefore, important to take into consideration all inputs that are affected in any way in changing from one treatment to another. In the partial budget analysis, the costs that vary include only the cash" expenses on fertilizers applied and the opportunity costs of labour, fertilizer application and water charges (Table 2).

The field price of input (fertilizer) is the total value which must be given up to bring an extra unit of input into the field. For the calculation of field price of fertilizer, price per nutrient kg of nitrogen, phosphorus and potassium were determined. The opportunity costs of labour required for fertilizer application and water charges were also determined. Finally by multiplying the price of fertilizer by the quantity in each treatment and summing along with cost of application, total costs that vary for each treatment were obtained (Table 2). The net benefits have been calculated by subtracting the total costs that vary from the gross field benefits from each treatment. Treatment -6 with 128 kg N, 111 kg P, 25 kg K and 100 mm of water is relatively better than all the other treatments.

Marginal Analysis of Net Benefits: The marginal analysis is the method of calculating marginal rates of return between alternate treatments. It proceeds in steps from a lower cost treatment and compares these rates of return to the minimum acceptable rate of return. It should be stressed that the marginal rate of return (MRR) measures the returns that correspond to the change from less expensive to more expensive treatment. The marginal rates of return of" the undominated treatments have been calculated in Table 3. The question remains, what level of expenditure would the average farmers choose if they had all the information? As a general rule, an average farmer will not make investment unless the average rate of return is at least 50 % per crop season, which approximates to 100% per annum assuming two crops season in a year. From the above calculations 'it would appear that an average farmer would opt for the alternative which provides the highest rate of return (MRR 819.20%) i.e.

Tahle I. Observed and adjusted average yield of wheat (grain and straw) from different combinations of fertilizer application and depth of applied water

Particulars	Treatments								
	T1	T2	T3	T4	T5	T6	T7	T8	T9
Fertilizer applied (kg/ha)									
N	89	89	89	128	128	128	158	158	158
P	84	84	84	III	III	III	III	III	III
K	-	-	-	25	25	25	62	62	62
Depth of water applied (mm)	50	75	100	50	75	100	50	75	100
Observed Av. grain yield (kg/ha)	4997	4926	4783	4645	4935	6223	5119	4920	6192
Observed Av. straw yield (kg/ha)	6256	6624	6256	6931	6808	6501	6685	5704	5336
Calculated Av. grain yield "	4248	4188	4065	3984	4195	5289	4351	4182	5263
Calculated Av. straw yield "	5318	5630	5318	5891	5787	5526	5683	4848	4536

Table 2. Partial budget of average wheat yield data from different combinations of fertilizer application and depth of applied water

Particulars	Treatments								
	T1	T2	T3	T4	T5	T6	1'7	T8	T9
Gross Field Benefits (kg/ha)									
Observed Av. yield of wheat grain	4997	4926	4783	4645	4935	6223	5119	4920	6192
Adjusted Av. yield of wheat grain	4284	4188	4065	3984	4195	5289	4351	4182	5263
Observed Av. yield of wheat straw	6256	6624	6256	6931	6808	6501	6685	5704	5336
Adjusted Av. yield of wheat straw	5318	5630	5318	'5891	5787	5526	5683	4848	4536
Gross field benefits (Rs./ha)	16039	15975	15446	15305	16064	19511	16529	15627	19010
Costs That Vary									
a) Cash costs									
Fertilizer costs (Rs./ha)	1989	1989	1989	861	861	861	3277	3277	3277
b) Opportunity costs (Rs./ha)									
Fertilizer application	238	238	238	70	70	70	322	322	322
Water charges	750	1125	1500	750	1125	1500	750	1125	1500
Total costs that vary	2977	3352	3727	1681	2056	2431	4349	4724	5099
Net field benefits	13062	12623	11719	13624	14008	17080	12180	10903	13911

Table 3. Dominance and marginal analysis

Treatments	Total variable cost (Rs./ha)	Net field benefits (Rs./ha)	Incremental cost (Rs./ha)	Incremental benefits (Rs./ha)	Marginal rate of return (%)
T4	1681	13524	-	-	-
T5	2056	14008	375	384	102.40
T6	2431	17080	375	3072	819.20
T1	2977	130620	-	-	-
T2	3352	126230	-	-	-
T3	3727	11719D	-	-	-
T7	4349	12180D	-	-	-
T8	4724	10903D	-	-	-
T9	5099	139180	-	-	-

D = Dominated treatments.

Table 4. Sensitivity analysis

Treatments	Total variable cost (Rs./ha)	Net field benefits (Rs./ha)	Incremental cost (Rs./ha)	Incremental benefits (Rs./ha)	Marginal rate of return (%)
Cost over-run option					
T4	2017	13317	-	-	-
T5	2467	14221	450	904	200.88
T6	2917	16267	450	2046	454.66
T1	3571	12493 D	-	-	-
T2	4021	11981 D	-	-	-
T3	4471	11000 D	-	-	-
T7	5219	11339 D	-	-	-
T8	5669	9982 D	-	-	-
T9	6119	12911 D	-	-	-
Benefit reduction option					
T4	1681/	10586	-	-	-
T5	2056	10818	375	232	61.86
T6	2431	12916	375	2098	559.47
T1	2976	9875 D	-	-	-
T2	3351	9450 D	-	-	-
T3	3726	8651 D	-	-	-
T7	4349	8898 D	-	-	-
T8	4724	7796 D	-	-	-
T9	5099	10125 D	-	-	-

fertilizer levels of 128 N, 111 P and 25 K kg/ha with a water depth of 100 mm.

Sensitivity Analysis: Sensitivity analysis is used to examine the impact of any possible variability in prices of both inputs and output on returns to investment. For this purpose, economic analysis was done by (i) Cost over-run option, and (ii) Benefit reduction option.

Cost over-run option: Assuming that the process of inputs (fertilizer price, labour charges for fertilizer application and water charges) go up by as much as 20 %. Accordingly, the total costs that vary went up by 20%. Although the gross field benefits were the same, a reduction in net field benefits across the treatments was visible. The marginal rate of return was also affected, but the level of return was still attractive enough. The respective priorities as determined in the original analysis also remained the same (Table 4).

Benefit reduction option: Here, the costs that vary were assumed to remain the same and the output prices of both the wheat grain and straw, were reduced by 20%. Accordingly, the gross field benefits fell and so did the net field benefits. Marginal rate of return of the midominated treatments were then reworked. The results of this analysis also did not change the original ranking of the alternatives under consideration (Table 4).

Based on the sensitivity analysis, it can safely be concluded that the treatment with 100 mm irrigation water depth and fertilizer level of 128 N, 111 P, 25 K kg/ha should be an appropriate recommendation for farmer's field.

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