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DIRECT AND RESIDUAL EFFECTS OF PHOSPHORUS ON RICE AND WHEAT CROP IN LONG TERM TRIAL UNDER IRRIGATED CONDITIONS OF SARGODHA (PUNJAB)

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Three year trial on direct and residual effects of phosphorus on rice-wheat crop sequence was carried out during 1984-88 under irrigated condition at Adaptive Research Farm, Sargodha. Five levels of P (0, 15, 30, 45, 60 kg P/ha) were applied only to rice crop in 1984-85 growing season and subsequent crops were raised on residual phosphorus. The results indicated that significant crop response to applied phosphorus could be obtained only when initial status of phosphorus in available form is not very high. The grain yields of first three crops (rice-wheat-rice) during 1984-85 and 1985-86 season harvested from direct and residual fertilization were not statistically significant when soil contained more than 7.19 ppm available phosphorus. The grain yields of successive crops i.e. wheat (1985-86), rice and wheat (1986-87) and rice (1987-88) differed significantly, when soil phosphorus dropped below 7.19 ppm and ranged between 4.15-7.19 ppm.

Key words: Residual phosphorus, *Triticum aestivum, Oryza sativa.*

INTRODUCTION

Potential for crop production under irrigation in Punjab is high because of its favourable physical environment based on solar radiation and temperature. At the same time, increase crop yields under irrigation through double cropping will require large amount of plant nutrients from soil [1]. To maintain a high yield level under such circumstances will require adequate supply of plant nutrients which will compensate for crop removal and other losses.

In general, intensive cropping with short or no following has drastically reduced the native soil fertility to such an extent that addition of fertilizers has become necessary to increase and maintain crop yield. Long term fertility studies with continuous cropping has also shown on one hand as to how high production can be achieved under different conditions, and on the other hand how far soils are able to withstand depletion [2].

The maximum initial application of a nutrient is considered a resources investment which can be amortized over a period of several years [3-5].

The main objective of this approach is that the fixed phosphorus is gradually released over a period of several years sufficient to support adequate crop growth. The knowledge of the exact duration of the residual effect is of major practical importance [6-9].

The present experiment was designed to investigate the direct and residual effect of applied phosphorus under double cropping of rice and wheat under the irrigated conditions of Sargodha (Punjab).

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MATERIALS AND METHODS

The experiment was conducted during 1984-87 at Adaptive Research Farm, Sargodha (Punjab). The composite soil samples from top 20 cm were collected at the time of initiation of the experiment to determine nutrients status at planting. The physico-chemical characteristics of the investigated site were determined according to [11] methods. The results are presented in Table 1.

Table 1. The physico chemical characteristics of the investigated experimental site at the initiation of the experiment (top-20 cm soil layer).

pH	8.4
E Ce dsm^{-1}	2.8
$CaCO_3$%	10.7
Organic matter %	0.67
Total nitrogen %	0.03
Available - P (Olsen method)	12.6
Available - K (NH_4 OAC method)	257
Available P (ppm)	
at planting of Wheat 1985-86	7.2
Rice 1986-87	6.6
Wheat 1986-87	5.1
Rice 1987-88	4.2
Textural class	Clay loam (Sand 40% silt 28% and clay 32%)
Soil series	Rustam series
Soil taxonomic Classification	Typic ustifluvents

The rice crop (cv. basmati-370) was sown during second week of July and harvested during first fortnight of November. Wheat crop (cv. koh-e-noor-83) were sown during first week of December and harvested during first week of May in each season. The proper crop husbandry practices were adopted to raise these crops. Five levels of phosphorus (0, 15, 30, 45, 60 kg per hectare) through single super phosphate were arranged in randomized complete block design with four replications. The potassium fertilizer at the rate of 42 kg K/ha through sulphate of potash was applied only to rice crop sown during (1984-85) season. The phosphorus and potassium fertilizers were broadcast and mixed well in the top 15 cm soil at the time of seed-bed preparation. A blanket dose @ 100 kg N/ha through urea was applied to each crop in every year in two splits, i.e., one half at planting and the second half one month after planting.

Rice crop was raised during 1984-85. (July-November) to monitor the direct effects of applied phosphorus. During successive seasons of 1984-87, three crops each of wheat and rice were raised to monitor the residual effects of applied phosphorus on these crops.

The data on grain yield and its attributes were recorded at maturity of each crop. The collected data were statistically analyzed described by [12].

RESULTS AND DISCUSSION

Data presented in Table 2, 3 and 4 indicate that grain yield data on direct effect of phosphorus on rise during 1984-85 and residual effects of phosphorus on wheat and rice in the cropping year 1984-85 and 1985-86 were not statistically significant. It is mainly due to adequate supply of phosphorus through soils as it can be seen from the data of available phosphorus content (Table 1).

Significant residual effect of phosphorus (Table 5-8) was obtained on wheat (1985-86), rice and wheat (1986-87) and rice (1987-88). Soil test values indicated that before planting 1985-86 wheat crop, the available phosphorus status of PO (non-fertilized treatment) plot was 7.19 ppm, which is considered to be low for wheat crop growth [13-15] and hence responded well to residual effect of various levels of phosphorus applied in 1984-85 season. During the year 1986-87 and 1987-88, both wheat and rice crops responded significantly to the residual P (Tables 5-8), since available soil phosphorus was as low as 4.15 ppm in the control plots. It clearly indicated that significant yield difference in rice and wheat are depended on the phosphorus status of the soil. The response to phosphorus by rice and wheat also indicate that optimal level of phosphorus to each crop is dependent on initial phosphorus status of the soil [2-4, 7, 8, 13-15]. The grain yield data of rice (1984-85), wheat (1984-85) and rice (1985-86) were not statistically significant due to different applied phosphorus levels. The absence of response on rice and wheat crops might be due to additional application of fertilizer, when initial available phosphorus ranging from 7.19-12.61 ppm was sufficient to

Table 2. Direct response of rice to phosphorus during the season 1984-85.

Treatment P (kg/ha)	Grain yield (kg/ha)	No. of effective panicle per hill	No. of filled grain per panicle	1000 husked grain weight (g)	Panicle length (cm)
PO	2800	8	60	20	30
P15	2880	9	60	21	30
P30	2900	9	60	21	31
P45	3000	10	60	21	31
P60	3080	10	70	21	32
LSD (P=0.05)	N. Sign	N. Sign.	4.0	1.1	1.0

Table 3. Residual response of wheat to phosphorus during the season 1984-85.

Treatment P (ka/ha)	Grain yield (kg/ha)	No. of tillers per m^2	No. of spiletets per spike	No. of grain per spike	1000 grain weight (g)
P_0	2595	250	15	36	29
P_{15}	2686	252	17	47	30
P_{30}	2790	257	18	50	32
P_{45}	2886	263	20	52	35
P_{60}	2942	263	20	53	35
LSD (P=0.05	N.Sign.	N.Sign.	1.1	3.3	1.1

Table 4. Residual response of rice to phosphorus during the season 1985-86.

Treatment P (kg/ha)	Grain yield (kg/ha)	No. of effective panicle per hill	No. of filled grain per panicle	1000 husked grain weight (g)	Panicle length (cm)
P_0	2740	6	70	20	28
P_{15}	2880	8	80	20	29
P_{30}	2989	8	80	20	30
P_{45}	3080	8	80	22	30
P_{60}	3100	8	90	22	30
LSD (P=0.05)	N. Sign.	N. Sign.	3.2	1.4	1.3

Table 5. Residual response of wheat to phosphorus during the season 1985-86.

Treatment P (kg/ha)	Grain yield (kg/ha)	No. of tillers per m^2	No. of spikelets per spike	No. of grain per spike	1000 grain weight (g)
P_0	2604	235	15	36	29
P_{15}	2880	237	18	42	30
P_{30}	3037	247	19	45	32
P_{45}	3340	258	21	49	34
P_{60}	3677	267	24	54	36
LSD (P=0.05)	79.0	5.5	1.0	2.8	1.0

Table 6. Residual response of rice to phosphorus during the season 1986-87.

Treatment P (kg/ha)	Grain yield (kg/ha)	No. of effective panicle per hill	No. of filled grain per penicle	1000 husked grain weight (g)	Panicle length (cm)
P_0	2640	10	70	24.3	30.30
P_{15}	2970	12	70	26.4	31.40
P_{30}	3150	12	87	26.4	31.00
P_{45}	3360	14	120	28.7	32.25
P_{60}	3075	13	90	26.7	30.40
LSD (P=0.05)	104.36	2.05	3.57	1.62	1.01

Table 7. Residual response of wheat to phosphorus during the season 1986-87.

Treatment P (kg/ha)	Grain yield (kg/ha)	No. of tillers per m^2	No. of spikelets per spike	No. of grain/ spike (g)	1000 grain weight (g)
P_0	2570	236	15	38	28.70
P_{15}	3735	242	18	40	30.10
P_{30}	2940	252	19	43	32.70
P_{45}	3270	262	22	48	34.80
P_{60}	2973	257	20	44	32.90
LSD (P=0.05)	88.17	4.57	2.03	1.91	0.56

meet the requirements of crops. However, there were significant responses to residual effects of different phosphorus levels on grain yields of wheat (1985-86), rice and wheat (1986-87) and rice (1987-88), when initial value of

Table 8. Residual response of rice to phosphorus during the season 1987-88.

Treatment P (kg/ha)	Grain yield (kg/ha)	No. of effective penicle per hill	No. of filled grain per penicle	1000 husked grain weight (g)	Panicle length (cm)
P_0	2800	13	70	18.4	28.13
P_{15}	3080	14	72	20.4	29.63
P_{30}	3300	15	89	23.2	30.90
P_{45}	3520	18	102	25.2	32.80
P_{60}	3301	15	82	23.4	30.50
LSD (P=0.05)	66.03	1.49	7.05	1.38	1.40

available phosphorus dropped down from 12.61 to 4.15 ppm in 1987. These results substantiate with those of [2, 3, 13-15].

The data illustrated in Fig. 1 on the response to phosphorus by rice and wheat also indicate, that optimal level of P to each crop is dependent on the initial P status of the soil. In the year 1986-87, the optimum level of P to rice was found to be 56.88 kg P/ha, but in 1987-88 it was 54.44 kg P/ha. It is mainly due to changes in available P status of the soil. Similar for wheat, the optimum value of P was found to be 84.54 kg P/ha in the year 1986-87.

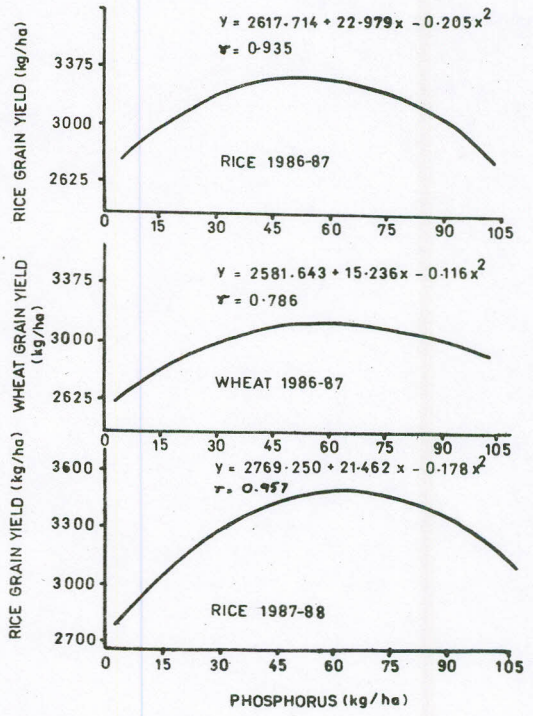

Fig. 1. Relationship between phosphorus doses and grain yield.

Optimum level of P was worked out using the equation:

$$XOpt = b - q / \frac{P}{2C}$$

Where X Opt is level of p kg/ha, b and c are the regression co-efficient, q is the price of fertilizer per unit (here is Rs. 10.00 per kg P), p is the price of wheat or rice per kg (here it is Rs. 2.00 and Rs. 3.00 per kg of wheat and rice respectively).

It could be concluded from the present investigation that optimum yield of wheat and rice could be harvested when the soil test values before planting these crops are higher than 7.19 ppm and 6.59 ppm for wheat and rice respectively under irrigated conditions of Sargodha area.

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