

## Management strategy for increasing the productivity of rice (*Oryza sativa*) – wheat (*Triticum aestivum*) system under late-sown conditions

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### ABSTRACT

A 3-year study at 9 locations with rice (*Oryza sativa* L.) – wheat (*Triticum aestivum* L. emend. Fiori & Paol.) system showed that use of appropriate varieties can partly offset the yield loss under late-sown conditions at a few locations. With increase in plant density by 25%, the productivity of late-sown rice and wheat increased by almost 4 and 6% respectively at recommended level of fertilizer application. There was also improvement in productivity owing to 25% increase in fertilizer application above the recommended level. However, with 25% increase in both plant population and fertilizer application, the additive effect on yield was not noticed except at Sabour and Rewa in the case of wheat. Increased fertilizer application was beneficial both in rice and wheat at most of the locations. However, under fertilizer constraints, it was better to reduce its application to rice than to wheat.

Rice (*Oryza sativa* L.) – wheat (*Triticum aestivum* L. emend. Fiori & Paol.) system is the most important double-cropping sequence practised mostly in northern, central and eastern parts of India. In canal-irrigated areas, very often rice planting gets delayed due to inadequate canal water. It also becomes difficult to plant wheat in time either due to late planting of rice or long duration of rice cultivars. Quite often, though rice crop vacates land in time, excess soil-moisture conditions do not permit field preparation and planting of wheat in time. Thus, the productivity of rice-wheat system gets affected adversely due to late-sown conditions (Soni and Bhatia, 1989; Hegde, 1990). Among the strategies one can think of to increase the productivity under late-sown conditions, use of a suitable variety, change

in plant population and fertilizer levels are important ones.

### MATERIALS AND METHODS

The data for this study pertained to experiment on resources constraints conducted on rice-wheat sequence during 1986-89 at 9 cropping systems research centres under the All India Co-ordinated Agronomic Research Project. The treatments comprised selected combinations of 2 varieties ( $V_1$  and  $V_2$ — suited for normal and delayed date), 3 fertilizer levels ( $F_1$ ,  $F_2$  and  $F_3$ — 75, 100 and 125% of the recommended level) and 2 plant population levels ( $P_1$  and  $P_2$ — optimum and 25% higher than optimum). The recommended cultivars, sowing dates and fertilizer levels for different centres were adopted. Only

selected treatment combinations were tested to suit the requirements of the objectives of the experiment.

Four sets each consisting of a main plot with 6 treatment combinations within each set as subplots were formed during the rainy season. Each of these sets was repeated 4 times in completely randomized arrangement in compact-family block design. During the winter season, corresponding sets of treatments were superimposed over the rainy-season treatments. The experiment was conducted on the same layout and site in all the years. The soil type, fertility status, general climate conditions of different locations are given in Table 1. The grain yield data of 1986-89 were analysed after pooling separately for rice and wheat.

Economic analysis was carried out to identify fertilizer-management options.

The gain or loss in value of rice and wheat yields per rupee increase or decrease in fertilizer nutrient over the recommended

level was worked out at recommended and 25% higher plant population levels — to decide a proper strategy for fertilizer application under late-sown conditions in the present investigation.

## RESULTS AND DISCUSSION

### *Effect of delayed sowing*

Productivity of both rice and wheat was reduced significantly due to delayed sowing at most of the centres (Table 2). Wheat yields at R. S. Pura (Jammu and Kashmir) and Jabalpur (Madhya Pradesh) increased probably because the dates selected for late sowing were within the optimum range of dates for wheat planting. Maximum reduction in productivity of both the crops was noted at Faizabad (Uttar Pradesh). In general, the reduction in yield was of higher magnitude in wheat than in rice. This is because of exposure of wheat to adverse atmospheric temperature at different stages of growth and shorter growing period under late-sown conditions. However, delayed

Table 1. Soil type, climate and fertility status of different locations

| Location   | Soil type                                                   | Climate  | pH  | Organic carbon (%) | Available nutrients (kg/ha) |      |     |
|------------|-------------------------------------------------------------|----------|-----|--------------------|-----------------------------|------|-----|
|            |                                                             |          |     |                    | N                           | P    | K   |
| R. S. Pura | Eutrochrepts, lowland clayey                                | Subhumid | 7.1 | 0.67               | 271                         | 12.6 | 131 |
| Faizabad   | Udic Fluvents-Fluvaquents association, lowland clayey       | Subhumid | 7.7 | 0.45               | 108                         | 24.2 | 136 |
| Kanpur     | Udic Ustochrepts, alluvial soil                             | Semiarid | 7.8 | 0.24               | 119                         | 10.4 | 176 |
| Ludhiana   | Ustochrepts-Ustipsamments association, alluvium, sandy loam | Semiarid | 7.7 | 0.52               | 366                         | 26.9 | 70  |
| Sabour     | Eutrochrepts, lowland clayey                                | Subhumid | 7.3 | 0.39               | 225                         | 22.5 | 155 |
| Ranchi     | Ultic Paleustalfs, red loams                                | Subhumid | 6.4 | 0.57               |                             | 9.7  | 180 |
| Raipur     | Ochraqualfs-Ochraquals association, fine loamy soils        | Subhumid | 6.9 | 0.57               |                             | 17.0 | 814 |
| Rewa       | Ustochrepts-Vertic association, fine loamy soils            | Subhumid | 7.6 | 0.74               | 282                         | 14.0 | 784 |
| Jabalpur   | Chromusterts, deep black soils                              | Subhumid | 7.8 | 0.70               | 267                         | 18.0 | 728 |

Table 2. Average grain yield (kg/ha) in rice-wheat sequence with different input levels (1986-89)

| Treatment                                                   | R. S. Pura |       | Faizabad |       | Kanpur |       | Ludhiana |       | Sabour |       |
|-------------------------------------------------------------|------------|-------|----------|-------|--------|-------|----------|-------|--------|-------|
|                                                             | Rice       | Wheat | Rice     | Wheat | Rice   | Wheat | Rice     | Wheat | Rice   | Wheat |
| V <sub>1</sub> D <sub>1</sub> P <sub>1</sub> F <sub>2</sub> | 5,025      | 3,074 | 5,306    | 4,962 | 2,551  | 4,110 | 5,575    | 3,731 | 4,176  | 2,565 |
| V <sub>1</sub> D <sub>2</sub> P <sub>1</sub> F <sub>2</sub> | 4,125      | 3,372 | 3,217    | 3,181 | 2,495  | 3,633 | 4,681    | 3,812 | 3,694  | 1,982 |
| V <sub>1</sub> D <sub>2</sub> P <sub>2</sub> F <sub>2</sub> | 4,175      | 3,304 | 3,374    | 3,115 | 2,546  | 3,629 | 5,078    | 3,934 | 3,800  | 2,089 |
| V <sub>1</sub> D <sub>2</sub> P <sub>2</sub> F <sub>3</sub> | 4,109      | 3,413 | 3,750    | 3,409 | 2,450  | 3,770 | 5,002    | 3,853 | 3,879  | 2,086 |
| V <sub>1</sub> D <sub>2</sub> P <sub>2</sub> F <sub>3</sub> | 4,102      | 3,480 | 4,020    | 3,640 | 2,454  | 3,996 | 4,816    | 3,811 | 3,986  | 2,307 |
| V <sub>2</sub> D <sub>2</sub> P <sub>2</sub> F <sub>2</sub> | 4,196      | 3,085 | 3,577    | 3,315 | 2,641  | 3,250 | 4,718    | 4,306 | 3,143  | 2,117 |
| CD (P = 0.05)                                               | 161        | 71    | 431      | 627   | 245    | 236   | 177      | 102   | 111    | 63    |
| V <sub>1</sub> D <sub>1</sub> P <sub>1</sub> F <sub>1</sub> | 4,293      | 2,834 | 4,825    | 3,894 | 2,979  | 4,066 | 4,994    | 4,268 | 3,840  | 2,317 |
| V <sub>1</sub> D <sub>2</sub> P <sub>1</sub> F <sub>1</sub> | 3,692      | 2,904 | 3,408    | 2,631 | 2,710  | 3,579 | 4,465    | 3,640 | 3,621  | 1,665 |
| V <sub>1</sub> D <sub>2</sub> P <sub>2</sub> F <sub>1</sub> | 3,865      | 2,844 | 3,233    | 2,600 | 2,633  | 3,706 | 4,760    | 3,830 | 3,689  | 1,984 |
| V <sub>1</sub> D <sub>2</sub> P <sub>2</sub> F <sub>2</sub> | 4,057      | 3,243 | 3,496    | 2,994 | 2,748  | 3,785 | 4,731    | 3,769 | 3,666  | 1,983 |
| V <sub>1</sub> D <sub>2</sub> P <sub>2</sub> F <sub>2</sub> | 4,086      | 3,264 | 3,585    | 3,367 | 2,606  | 3,787 | 4,895    | 3,754 | 3,733  | 2,182 |
| V <sub>2</sub> D <sub>2</sub> P <sub>1</sub> F <sub>1</sub> | 3,958      | 2,820 | 3,483    | 2,715 | 2,833  | 3,568 | 4,520    | 4,406 | 3,105  | 1,978 |
| CD (P = 0.05)                                               | 179        | 70    | 363      | 341   | 245    | 236   | 177      | 102   | 112    | 66    |
| Treatment                                                   | Ranchi     |       | Raipur   |       | Rewa   |       | Jabalpur |       |        |       |
|                                                             | Rice       | Wheat | Rice     | Wheat | Rice   | Wheat | Rice     | Wheat |        |       |
| V <sub>1</sub> D <sub>1</sub> P <sub>1</sub> F <sub>2</sub> | 1,361      | 1,650 | 4,288    | 2,169 | 4,816  | 2,892 | 2,084    | 3,578 |        |       |
| V <sub>1</sub> D <sub>2</sub> P <sub>1</sub> F <sub>2</sub> | 1,166      | 1,383 | 3,713    | 1,709 | 4,262  | 1,904 | 1,376    | 4,059 |        |       |
| V <sub>1</sub> D <sub>2</sub> P <sub>2</sub> F <sub>2</sub> | 1,016      | 1,455 | 3,927    | 2,036 | 4,389  | 2,099 | 1,637    | 4,625 |        |       |
| V <sub>1</sub> D <sub>2</sub> P <sub>2</sub> F <sub>3</sub> | 939        | 1,455 | 4,152    | 1,950 | 4,618  | 2,143 | 1,588    | 4,968 |        |       |
| V <sub>1</sub> D <sub>2</sub> P <sub>2</sub> F <sub>3</sub> | 1,277      | 1,438 | 4,137    | 1,971 | 4,300  | 2,287 | 1,614    | 5,084 |        |       |
| V <sub>2</sub> D <sub>2</sub> P <sub>2</sub> F <sub>2</sub> | 838        | 1,322 | 4,498    | 2,019 | 4,070  | 1,896 | 836      | 3,453 |        |       |
| CD (P = 0.05)                                               | 151        | 443   | 89       | 91    | 214    | 120   | 163      | 202   |        |       |
| V <sub>1</sub> D <sub>1</sub> P <sub>1</sub> F <sub>1</sub> | 1,461      | 1,489 | 3,977    | 2,174 | 4,523  | 2,557 | 1,745    | 3,122 |        |       |
| V <sub>1</sub> D <sub>2</sub> P <sub>1</sub> F <sub>1</sub> | 1,133      | 1,111 | 3,649    | 1,789 | 4,082  | 1,773 | 1,355    | 3,928 |        |       |
| V <sub>1</sub> D <sub>2</sub> P <sub>2</sub> F <sub>1</sub> | 1,055      | 1,294 | 3,549    | 1,821 | 4,157  | 1,775 | 1,366    | 3,847 |        |       |
| V <sub>1</sub> D <sub>2</sub> P <sub>2</sub> F <sub>2</sub> | 972        | 1,500 | 3,898    | 1,959 | 4,129  | 1,948 | 1,281    | 4,391 |        |       |
| V <sub>1</sub> D <sub>2</sub> P <sub>2</sub> F <sub>2</sub> | 1,072      | 1,439 | 3,793    | 2,101 | 4,676  | 2,160 | 1,325    | 4,490 |        |       |
| V <sub>2</sub> D <sub>2</sub> P <sub>1</sub> F <sub>1</sub> | 955        | 1,200 | 4,141    | 1,796 | 3,816  | 1,637 | 912      | 3,016 |        |       |
| CD (P = 0.05)                                               | 107        | 43    | 89       | 91    | 141    | 159   | 163      | 202   |        |       |

Details of treatments are given under Materials and Methods

sowing had slightly higher adverse effect at recommended fertilizer level than at reduced fertilizer level.

#### *Effect of varietal substitution*

Substitution of variety used for normal sowing by a variety suited for late sowing had no significant beneficial effect on the productivity of rice and wheat at most of the locations except at R. S. Pura and Raipur (Madhya Pradesh) in rice and at Ludhiana (Punjab) and Sabour in wheat. It is possible that yield potential of varieties recommended for late-sown conditions at other locations is lower than that of varieties suited for normal sowing but sown late.

#### *Effect of increased plant population*

Increasing plant population by 25% had significant beneficial effect on the grain yield of late-sown rice only at Ludhiana, Raipur and Jabalpur with recommended fertilizer application. However, beneficial effect of increased population was also noted at Ranchi (Bihar) with higher fertilizer. The productivity of late-sown wheat increased significantly at increased plant population at most of the centres except at R. S. Pura, Faizabad and Kanpur (Uttar Pradesh) with recommended level of fertilizer. Averaged over all the locations, 25% increase in plant density at recommended fertilizer use increased the productivity by 4% in rice and 6% in wheat. Increased plant population is expected to partly compensate for poor tillering under late-sown conditions.

#### *Effect of higher fertilizer use*

Increasing fertilizer application by 25% over the recommended level significantly increased the grain yield of rice and wheat at 6 and 7 locations respectively. However, in rice it was beneficial at both the recommended and higher plant population

levels at Faizabad, Sabour and Raipur; it was beneficial only with optimum plant population at Ludhiana, Rewa (Madhya Pradesh) and Jabalpur. In wheat, higher fertilizer application was beneficial at both recommended and higher plant density levels except at 2 places (Ranchi and Raipur), where it was useful only at optimum plant density.

When both plant population and fertilizer levels were increased by 25%, their significant additive effect was observed on the productivity of late-sown wheat only at Sabour and Rewa. At all the other locations the yield increase owing to combined increase in plant density and fertilizer was significantly not different from the yield increase due to increase in either of the inputs.

#### *Economic analysis*

Increasing fertilizer application in rice at the recommended plant stand was beneficial at most of the locations, except at R. S. Pura, Kanpur and Ranchi (Table 3). However, at higher plant stand it was of no benefit at most of the locations except at Faizabad, Sabour and Raipur. It was possible to reduce the investment in fertilizer use in rice under late-sown conditions at most of the places, except at R. S. Pura, Ludhiana and Raipur when recommended plant stand was maintained. However, with higher plant density similar reduction was possible only at Kanpur, Sabour, Ranchi and Jabalpur.

The trend was slightly different in wheat. Increase in fertilizer application was profitable at most of the places, except at R. S. Pura, Ludhiana and Ranchi at optimum plant density and at Ludhiana, Ranchi and Raipur at higher plant density. There was no scope for curtailment in fertilizer use at any of the places with optimum level of plant

**Table 3.** Grain or loss in value of rice and wheat yields per rupee increase or decrease in nutrient over the recommended level under delayed sowing

| Location                         | Rice               |                    | Wheat              |                    |
|----------------------------------|--------------------|--------------------|--------------------|--------------------|
|                                  | Increased nutrient | Decreased nutrient | Increased nutrient | Decreased nutrient |
| <i>Recommended plant density</i> |                    |                    |                    |                    |
| R. S. Pura                       | -0.14              | -3.10              | 0.40               | -3.32              |
| Faizabad                         | 4.37               | -0.72              | 2.79               | -4.44              |
| Kanpur                           | -0.35              | -0.29              | 1.16               | -1.75              |
| Ludhiana                         | 3.23               | -2.67              | 0.37               | -1.17              |
| Sabour                           | 2.19               | -0.53              | 1.37               | -4.14              |
| Ranchi                           | -2.71              | 1.91               | 0.75               | -4.05              |
| Raipur                           | 3.40               | -1.93              | 2.05               | -1.44              |
| Rewa                             | 2.87               | -0.38              | 2.12               | -1.55              |
| Jabalpur                         | 1.64               | 0.57               | 8.05               | -4.10              |
| <i>25% higher plant density</i>  |                    |                    |                    |                    |
| R. S. Pura                       | -0.64              | -1.94              | 1.72               | -4.13              |
| Faizabad                         | 5.30               | -2.89              | 6.42               | -9.38              |
| Kanpur                           | -0.71              | 0.21               | 1.38               | -0.69              |
| Ludhiana                         | -2.63              | -1.36              | -1.11              | 0.69               |
| Sabour                           | 2.20               | -0.52              | 2.84               | -2.58              |
| Ranchi                           | -3.09              | -0.20              | -0.18              | -1.51              |
| Raipur                           | 1.62               | -1.89              | -0.64              | -2.38              |
| Rewa                             | -0.72              | -4.19              | 1.67               | -3.50              |
| Jabalpur                         | -0.18              | 0.32               | 4.07               | -5.70              |

Prices taken for the analysis: N, Rs 5.11/ha;  $P_2O_5$ , Rs 5.95/kg;  $K_2O$ , Rs 2.20/kg; rice, Rs 2.05/kg; wheat, Rs 2.25/kg

density. However, with higher plant density, there was a scope for the curtailment of fertilizer use in wheat at Kanpur and Ludhiana only.

In general, increased fertilizer use was beneficial both in rice and wheat at most of the locations. It was more beneficial with recommended level of plant density than with higher plant density under the late-sown conditions. Reduction in fertilizer application to late-sown rice had less adverse effect on productivity and profitability than that on late-sown wheat.

The reduced fertilizer use had more effect at higher plant density than with recommended plant density both in rice and wheat crops.

## REFERENCES

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