

## Application of Targeted Yield Concept for Efficient and Economic Fertilizer Use for Wheat in Arid Zone of Punjab

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**Abstract:** The validity of the fertilizer adjustment equations was tested by conducting yield target trials with wheat var. PWB 343 for two years at farmers' fields in Bathinda district. The results indicated that actual yields were 46.1, 51.2, 55.7 and 60.4 q ha<sup>-1</sup> with target of 45, 50, 55 and 60 q ha<sup>-1</sup> and when the fertilizers were applied on the basis of soil tests. Thus, the utility of this approach was established for recommending soil-test-based fertilizers for wheat crop to the farmers. Every kg of applied nutrient produced 26.3, 25.4, 24.4, 21.3 kg of wheat grain for target of 45, 50, 55, 60 q ha<sup>-1</sup> and (22.4 and 23.2) and (19.4 and 19.8) for STRD and FP, respectively. It clearly pointed out higher fertilizer-use efficiency when fertilizer was applied on the basis of targeted yield concept as compared to farmers' practices (FP). Moreover target yield approach was found to be superior upto 55 q ha<sup>-1</sup> target over FP and soil-test-based fertilizer recommended dose approach.

**Key words:** Yield target, wheat, arid zone, prescription-based fertilizer.

Fertilizer recommendations are based on the available nutrient status of a soil prior to raising the crop. Due to large scale variation from site to site, these generalized recommendations may not be suitable for whole state. The concept of fertilizer prescription for higher yield targets of corn, after knowing the fertility status of soil and requirements of crops, was first advocated by Troug (1960). The validity of such target yield equations has been verified at several locations in India (Suri and Verma, 1999).

In this paper an attempt has been made to verify these fertilizer recommendations for targeted yield of wheat (which had already been tested at other fields in Ludhiana and Gurdaspur districts) at farmers' fields of Bathinda district (arid zone, Punjab).

### Materials and Methods

Field experiments on wheat (var. PWB 343) were conducted at the farmers' fields in Bathinda district with texturally different soils, varying widely in organic carbon status. During rabi 1997-98 the wheat crop was sown from 5th to 7th November, 1997, and harvested from 15th to 20th April, 1998, while during 1998-99 it was sown from 9th to 18th November, 1998, and harvested from 9th to 15th April, 1999 at seven locations. The available N, P and K status of seven locations ranged from 86.9 to 127.0, 17.8 to 43.6 and 291 to 330 kg ha<sup>-1</sup>, respectively. Nutrient requirements of wheat crop for obtainable yield targets were worked out by Dhillon *et al.* (1997).

The fertilizers used were urea and diammonium phosphate. Full dose of P and half dose of N were applied at the

Table 1. Basic data and fertilizer adjustment equations used for wheat production

| Nutrient                      | NR   | CS    | CF    | Fertilizer equation                             |
|-------------------------------|------|-------|-------|---|
| N                             | 1.95 | 17.2  | 46.0  | FN = 4.23 T-0.374 SN                            |
| P <sub>2</sub> O <sub>5</sub> | 0.43 | 48.7  | 16.3  | FP <sub>2</sub> O <sub>5</sub> = 2.62 T-2.98 SP |
| K <sub>2</sub> O              | 3.73 | 286.0 | 204.0 | FK <sub>2</sub> O = 1.66 T-1.40 SK              |

NR, CS and CF represent nutrient requirement ( $\text{kg g}^{-1}$  grain), nutrient contribution from soil (%) and nutrient contribution from fertilizer (%), respectively.

FN, FP<sub>2</sub>O<sub>5</sub> and FK<sub>2</sub>O are the fertilizer nitrogen, fertilizer P<sub>2</sub>O<sub>5</sub> and fertilizer K<sub>2</sub>O ( $\text{kg ha}^{-1}$ ) respectively. SN, SP and SK are the soil test values for available N, P and K ( $\text{kg ha}^{-1}$ ) in their elemental forms, and T is the crop yield target in  $\text{q ha}^{-1}$ .

time of sowing. The remaining half dose of N was applied with first irrigation. Representative soil samples from 0-15 cm depth were drawn from each plot before application of fertilizer and sowing of the crops, and were analyzed for KMnO<sub>4</sub>-oxidisable N (Subbiah and Asija, 1956), 0.5 M NaHCO<sub>3</sub> (pH 8.5) extractable P (Olsen *et al.*, 1954) and 1 N HN<sub>4</sub>OAC extractable K (Hanway and Hiedal, 1952) (Table 2).

To formulate fertilizer recommendation for targeted yield, the following parameters are experimentally obtained for a given soil type crop-agroclimatic conditions: (i) nutrient requirement in kg per quintal of produce, (ii) per cent contribution of soil-available nutrients to total uptake and (iii) per cent contribution from applied fertilizer nutrients to total uptake.

From the data on soil test values, fertilizer doses to be applied were worked out using targeted yield model equation (Table 1). Each experiment comprised four treatments: (i) soil-test-recommended dose (STRD), (ii) farmers' practices (FP), (iii) fertilizer N, P and K needed to attain yield targets of 45 and 55  $\text{q ha}^{-1}$  during 1997-98, 50 and 60  $\text{q ha}^{-1}$  (grain) during 1998-99, for wheat, on the basis of soil test values. After the crop harvest, the wheat grain yield was

recorded for each treatment and economic aspects of each treatment were worked out.

## Results and Discussion

The experimental field soils varied widely in their nutrient availability with respect to available N, P and K (Table 2). Based on the pre-sowing soil analysis, fertilizer doses worked out for various targets of wheat crop also indicated wide ranges (Table 3).

The crop responded markedly to both native and applied nutrients (Table 4), and wide variation was observed in actual yields under different treatments. The mean grain yields of wheat were 46.1, 51.2, 55.7, 60.4 and (44.9 and 46.5) and (41.3 and 41.6)  $\text{q ha}^{-1}$  against the treatments of 45, 50, 55 and 60  $\text{q ha}^{-1}$  target and STRD and FP, respectively. It is seen that mean grain yield obtained was more or less equivalent to yield target fixed. The positive per cent deviations from yield targeted and actual yield were 2.44, 2.40, 1.27 and 0.67% with target of 45, 50, 55 and 60  $\text{q ha}^{-1}$ , respectively. The wide ranges in actual grain yields obtained may be due to the differences in management standards of various farms, deviations from ideal sowing dates, wide variations in physico-chemical characteristics of the soil under experimentation, residual effects of preceding crops, etc. Velayutham

Table 2. Soil-available N, P and K ( $\text{kg ha}^{-1}$ ) status of field soils before sowing of wheat

| Site                    | Available-N | Available-P | Available-K |
|-------------------------|-------------|-------------|-------------|
| 1. Kotrakorianwala      | 99.9        | 20.8        | 300         |
| 2. Dayalpura Bhaika-I   | 102.5       | 33.8        | 330         |
| 3. Dayalpura Bhaika-II  | 107.0       | 35.9        | 291         |
| 4. Nahianwala           | 89.2        | 43.6        | 297         |
| 5. Dayalpura Bhaika-III | 127.0       | 17.8        | 297         |
| 6. Gobind Pura          | 86.9        | 33.9        | 319         |
| 7. Dhan Singh Khana     | 127.0       | 33.5        | 330         |
| Range                   | 86.9-127.0  | 17.8-43.6   | 291-330     |
| Mean                    | 105.8       | 31.3        | 309         |

(1979) emphasized that this approach is more balanced, profitable and help in long term maintenance of soil fertility but, may deviate due to inadequacies in managerial skills and adverse weather conditions. Similar results have also been reported by Dhillon *et al.* (1997).

It is obvious from the data presented in Table 4 that actual grain yield obtained may be classified into different groups, based on per cent deviation of actual yield from targeted yield. In wheat, actual yields were within  $\pm 10\%$  of targeted yields in most of the cases for targets of 45, 50, 55 and 60  $\text{q ha}^{-1}$ .

Based on the data of mean fertilizer dose applied and average yield obtained, response ratio ( $\text{kg grain per kg of the nutrient applied}$ ) was worked out. Every  $\text{kg}$  of applied nutrient produced 26.3, 25.4, 24.4, 21.3  $\text{kg}$  of wheat grain for target of 45, 50, 55, 60  $\text{q ha}^{-1}$  and (22.4 and 23.2) and (19.4 and 19.8) for STRD and FP, respectively. It was observed that magnitude of response declined with high levels of yield targets. Dev *et al.* (1985) also observed that every  $\text{kg}$  of fertilizer nutrient applied to wheat produced 22.2 to 22.6  $\text{kg}$  of grain under various yield targets fixed. Sonar *et al.* (1990) indicated the utility of this

Table 3. Range and mean nutrient doses ( $\text{kg ha}^{-1}$ ) applied to wheat crop

| Target<br>( $\text{q ha}^{-1}$ ) | Nitrogen (N) |      | Phosphorus ( $\text{P}_2\text{O}_5$ ) |      | Potassium ( $\text{K}_2\text{O}$ ) |      |
|----------------------------------|--------------|------|---------------------------------------|------|------------------------------------|------|
|                                  | Range        | Mean | Range                                 | Mean | Range                              | Mean |
| 45                               | 150-157      | 153  | 0.0-56.0                              | 22.3 | 0                                  | 0    |
| 50                               | 164-179      | 171  | 30.0-31.0                             | 30.5 | 0                                  | 0    |
| 55                               | 193-200      | 196  | 14.0-43.4                             | 31.8 | 0                                  | 0    |
| 60                               | 206-220      | 211  | 57.0-104.0                            | 73.0 | 0                                  | 0    |
| STRD                             |              |      |                                       |      |                                    |      |
| 1997-98                          | 150-150      | 150  | 45.0-60.0                             | 50.0 | 0                                  | 0    |
| 1998-99                          | 150-150      | 150  | 45.0-60.0                             | 50.0 | 0                                  | 0    |
| FP                               |              |      |                                       |      |                                    |      |
| 1997-98                          | 145-157      | 152  | 57.0-75.0                             | 61.0 | 0                                  | 0    |
| 1998-99                          | 147-157      | 151  | 57.0-63.0                             | 59.0 | 0                                  | 0    |

STRD= soil test recommended dose of fertilizer; FP= farmers' practices (traditional system).

Table 4. Actual yield obtained ( $q\ ha^{-1}$ ) against various yield targets of wheat during 1997-98 and 1998-99

| Target<br>( $q\ ha^{-1}$ ) | 1997-98   |       | *Response<br>ratio | 1998-99   |      | *Response<br>ratio |
|----------------------------|-----------|-------|--------------------|-----------|------|--------------------|
|                            | Range     | Mean  |                    | Range     | Mean |                    |
| 45                         | 43.2-49.0 | 46.13 | 26.3               | —         | —    | —                  |
| 50                         | —         | —     | —                  | 51.1-51.3 | 51.2 | 25.4               |
| 55                         | 54.5-56.6 | 55.7  | 24.4               | —         | —    | —                  |
| 60                         | —         | —     | —                  | 57.8-64.5 | 60.4 | 21.3               |
| STRD                       | 40.5-51.4 | 44.9  | 22.4               | 45.1-49.0 | 46.5 | 23.2               |
| F.P.                       | 38.0-43.8 | 41.3  | 19.4               | 37.0-43.9 | 41.6 | 19.8               |

\*kg grain per kg nutrient applied.

approach for soil test-based fertilizer application to obtain sorghum yield upto  $60\ q\ ha^{-1}$  in Vertisols. It is also observed from the data that response ratio was higher where fertilizer was added on the basis of target yield approach as compared to FP. These results showed a very close correspondence between targeted yield and the yields actually obtained and are evidence of the usefulness of soil testing within tolerable limits of variation under field conditions. Results of this study have clearly brought out the superiority of fertilizer-based targeted yield concept in wheat crop over STRD and FP approach, as reflected through higher yields and higher profits.

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