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# Response of sewage-irrigated wheat (*Triticum aestivum*) to level and timing of nitrogen application

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## ABSTRACT

A study was conducted during the winter season of 2001–02 and 2002–03 at sewage-irrigated farms in Sirsa (Haryana) for evaluating the optimal dose and time of application of nitrogenous fertilizers to wheat (*Triticum aestivum* L. emend. Fiori & Paol.). Seven fields, 0.4 ha each, were selected along the sewage drain during 2001–02 on the basis of variations in the build-up of organic matter (0.89–3.44%) vis-à-vis nitrogen (available N 191–413 kg/ha). Eight treatments consisting of different doses of fertilizer N (0, 60, 120 and 180 kg/ha) and times of application of 75 kg N/ha (50% of recommended N for normal soils of the area). First trial was repeated on eight other farmers' fields during 2002-03 with 1.19-3.01 per cent organic matter. The observations on wheat yield showed improvement in basic productivity of soils with accumulation of organic matter up to 2 per cent. The latter also defined the optimal doses of nitrogen, computed to be 55–119 kg/ha. Distinct possibility of producing high yield with reduced addition of N fertilizer was found in the immediate vicinity of the sewage-disposal sites. Under reduced doses, wheat responded better to a booster basal dose, followed by at crown-root initiation. Thus the recommendations to the farmers on the use of N fertilizers should be different for waste water-irrigated soils. The reduced use of nitrogen should further help in minimizing the pollution problems by $NO_3$-N, especially with shallow ground waters.

***Key words :*** Sewage irrigation, Time of N application, Waste water use, Wheat, Nitrate pollution

Farmers in the peri-urban areas utilize sewage water not only as a source of irrigation water but also for supplementing nutrients. Thus higher yields are often reported with the application of sewage waters than of the fresh waters (Day *et al.*, 1977; Chakrabarti and Chakrabarti, 1988; Pradhan *et al.*, 2001; Singh *et al.*, 1995). Zadhoosh and Fardad, 2001. Benefits of these nutrients depend on the concentration of nutrients in sewage waters, the quantities of water applied, the time of its application, the type and target yields of crops grown, and the fertility of the soil (Minhas and Samra, 2004). Since fertilization is inseparable from irrigation with sewage, the farmers using sewage for irrigation do not have the freedom in the rate, proportion and timing of nutrient application. Thereby decision about the correct dose of fertilizer and its timing is important. It is possible to produce high yield without the addition of fertilizers in the immediate vicinity of the disposal sites. Hence the recommendations to the farmers concerning the use of fertilizers, especially nitrogen, should be different for the crops irrigated with waste water. Since organic load in the sewage results in accumulation of organic matter vis-à-vis nutrient-supplying capacity of the soils, it was hypothesized that the content of organic matter should be taken as a critical factor for deciding on the quantity of nitrogenous fertilizers. Keeping this in view, an experiment was conducted with wheat (*Triticum aestivum* L. emend Firoi & Paol.) on the soils that had accumulated variable organic matter due to different vicinities vis-à-vis availability of irrigation water from a sewage drain in Sirsa district.

## MATERIALS AND METHODS

The experiment was conducted on farmers' fields during winter season of 2001-02 and 2002-03 at Sirsa in Haryana. Average water allowance in the district is 135 LPD, which results in an estimated sewage production of 21.1 MLD. Sewage water is collected at Samsabad Patti village, from where it is pumped into a 6 km long lined drain that ultimately joins Ghaggar river. Farmers owning land along this drain are using sewage water for irrigating various crops and the quantities utilized usually depend upon the vicinity to the drain.

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For evaluating the fertilizer nitrogen requirement of wheat and its time of application when irrigated with sewage water, a large number of soil samples were initially collected from the sewage-irrigated fields located along and lateral to the drain. Based on the analysis of these samples, seven fields (each 0.4 ha size) having uniform texture (sandy loam) but variable organic matter content (3.44, 1.56, 1.28, 1.26, 1.08, 0.89 and 0.88 per cent) were selected. During 2001-02 two different sets of treatments were imposed at each location. The first set consisted of four doses of nitrogenous fertilizers, viz. nil (control), 60, 120 and 180 kg/ha. Half the nitrogen and full dose of phosphorus @ 26 kg/ha were applied basal and the remaining nitrogen was applied in two equal splits each at crown-root initiation (CRI) and flowering. In the other set, timing of application of nitrogen was varied. Here the dose of N was kept as half the recommended dose for the area (75 kg N/ha) and it was applied: (i) at sowing as basal; (ii) half basal and half at corwn-root initiation (CRI); (iii) half basal and half at flowering; and (iv) half at CRI and half at milking stage. All the treatments were imposed in randomized block design with four replications. The experiment on variable rates of N application was repeated on eight other fields during 2002-03 that had organic matter contents of 3.01, 2.33, 2.15, 2.08, 1.87, 1.51, 1.24 and 1.19 per cent. Due to the accumulation of variable amount of organic matter in the soils, the contents of available nutrients also varied (N 191-413 and 169-304 kg/ha, P 14-52 and 12-29 kg/ha, and K 132-206 and 103-149 kg/ha during 2001-02 and 2002-03 respectively). During both the years wheat (variety 'PBW 343') was seeded in November and harvested at maturity in April. The crop was irrigated at the critical crop stages with sewage or tube-well waters as per availability. The sewage water contained 252, 44, 7, 7.4 and 1.2 ppm BOD, $NH_4$-N, $NO_3$-N, P and K respectively. Grain and straw samples were drawn from all the treatments and analysed for nitrogen. Nitrogen-use efficiency (NUE %) was compuated.

## RESULTS AND DISCUSSION

### *Effect of rate of N application*

During both the years, the average yields showed a definite trend of accumulated organic matter due to sewage irrigation, which improved the overall productivity of the soils (Table 1). Assuming that the basic productivity (without the application of N fertilizer) depends on organic matter and is independent of the season, the data for the two years were normalized into relative yield (RY) fractions using the least square method. A linear increase in basic productivity (RY = 0.325 + 0.328x OM; r = 0.86*) up to organic matter content of 2 per cent was evident and thereafter it became more or less constant.

**Table 1.** Grain yield of wheat and N-use efficiency (NUE) as affected by nitrogen application on sewage-irrigated fields varying in organic matter content

| Field with organic matter (%) | Grain yield (t/ha)* 0 | 60 | 120 | 180 | Mean |
|---|---|---|---|---|---|
| | | *2001-02* | | | |
| 3.44 | 5.61 | 6.07(44) | 6.19(50) | 6.05(52) | 5.98 |
| 1.56 | 5.12 | 5.36(39) | 5.52(42) | 5.52(40) | 5.38 |
| 1.28 | 3.99 | 4.86(60) | 5.30(52) | 5.57(46) | 4.93 |
| 1.26 | 3.54 | 3.82(39) | 3.89(46) | 4.13(43) | 3.85 |
| 1.08 | 4.09 | 4.33(19) | 4.55(32) | 4.98(39) | 4.49 |
| 0.89 | 3.95 | 4.27(13) | 4.41(22) | 4.82(31) | 4.36 |
| 0.88 | 3.12 | 3.76(19) | 3.87(21) | 3.99(27) | 3.69 |
| Mean | 4.20 | 4.64 | 4.82 | 5.01 | |
| LSD (p=0.05) | N level: 0.11 | | Org. matter: 0.15 | | |
| | | *2002-03* | | | |
| 3.01 | 4.88 | 4.92(38) | 4.90(27) | 4.71(20) | 4.85 |
| 2.33 | 4.96 | 5.30(36) | 5.00(25) | 4.98(19) | 5.06 |
| 2.15 | 4.90 | 5.34(40) | 5.14(26) | 4.84(18) | 5.06 |
| 2.08 | 5.02 | 5.54(38) | 5.67(30) | 5.16(23) | 5.35 |
| 1.87 | 4.92 | 5.10(31) | 5.20(26) | 5.00(23) | 5.06 |
| 1.51 | 4.53 | 4.86(44) | 4.98(28) | 4.52(22) | 4.72 |
| 1.24 | 4.09 | 4.27(29) | 4.43(24) | 4.40(20) | 4.30 |
| 1.19 | 3.30 | 3.46(23) | 3.62(21) | 3.62(20) | 3.50 |
| Mean | 4.57 | 4.85 | 4.87 | 4.65 | |
| LSD (p = 0.05) | N level: 0.03 | | Org. matter: 0.04 | | |

*Values in parentheses are NUE (%)

Since the sewage contains most of the nutrients essential for crop growth, the yields of crops irrigated with sewage waters showed an overall improvement (Chakrabarti and Chakrabarti, 1988; Singh *et al.*, 1991; Pradhan *et al.* 2001; Zadhoosh and Fardad, 2001; Minhas and Samra, 2004).

The crop also showed considerable response to the applied nitrogen during both the years. On an average, the yield improved by 10.5, 14.8 and 19.3 per cent with N @ 60, 120 and 180 kg/ha during 2001-02, and the counter values for 2002-03 were only 6.1, 6.6 and 1.8 per cent. But on the whole, the response to nitrogen application was more in the soils accumulating lower organic matter. Rather a decline in yield was noticed in the soils with higher organic matter at higher dose of N (180 kg/ha). To develop production function between the organic matter content and N applications, the yields under different treatments, after normalizing the data for two years, can be represented ($R^2 = 0.74$) as:

$$Y = 68.2 \times 10^{-2} + 80.9 \times 10^{-2} \log_{10} OM + 15.7 \times 10^{-4} N - 44.3 \times 10^{-7} N^2 - 15.2 \times 10^{-4} N \times \log_{10} OM$$

This production function differentiated for the prefixed values of organic matter (0.8-3.2%) was utilized to arrive at the optimal values of nitrogen doses for different or-

**Table 2.** Grain yield of wheat as affected by different times of nitrogen application (50% of recommended dose)

| Time of N application | Grain yield (t/ha) in field with organic matter (%) | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | 3.44 | 1.56 | 1.28 | 1.26 | 1.08 | 0.89 | 0.88 | Mean |
| Basal (full) | 5.99 | 5.32 | 4.74 | 3.46 | 4.32 | 4.13 | 3.77 | 4.53 |
| ½ basal + ½ at CRI | 5.95 | 5.24 | 4.65 | 3.20 | 4.07 | 3.97 | 3.54 | 4.38 |
| ½ basal + ½ at flowering | 5.91 | 5.16 | 4.67 | 3.21 | 4.17 | 3.95 | 3.50 | 4.37 |
| ½ at CRI + ½ at milking | 5.95 | 5.00 | 3.89 | 3.12 | 4.06 | 3.94 | 3.50 | 4.21 |
| Mean | 5.95 | 5.18 | 4.49 | 3.25 | 4.16 | 4.00 | 3.58 | |
| LSD (p= 0.05) | Org. matter: 0.04 | | Time of N application: 0.03 | | | | | |

ganic matter accumulations in the soils, considering the price of wheat grain Rs 6.40/kg and that of nitrogen Rs 10.39/kg. The optimal values of N were computed to be 119, 100, 87, 77, 68 and 55 kg/ha for the soils with organic matter content of 0.8, 1.2, 1.6, 2.0, 2.4 and 3.2 per cent respectively. This indicates that optimal yields of sewage-irrigated crops can be achieved at reduced doses of applied nitrogen, which has implications in terms of pollution of ground waters. The nitrogen-use efficiency was also affected both by the initial productivity as evident from organic matter and the rates of applied nitrogen (Table 1). Nitrogen-use efficiency decreased with the rate of N application, which was 33-40 and 20-35 per cent in 2001-02 and 2002-03 respectively. Similarly, NUE also improved with organic matter accumulation, being 22-50 and 21-30 per cent respectively during these years.

### *Effect of time of application*

The grain yield of wheat was affected by the timing of N application and was higher when the whole amount of nitrogen was applied basal (Table 2), indicating that a booster dose of nitrogen is essential even under higher accumulations of organic matter in the soil. This was followed by the application of nitrogen in two split doses at sowing and crown-root initiation, whereas the lowest yields were obtained with delayed application of nitrogen, i.e. in two splits at CRI and milking stage. However, the N-use efficiency was more (22%) when N was applied in two splits as basal and flowering, whereas NUE was 9-17 per cent.

It was concluded that optimal yield of wheat and better N-use efficiency can be obtained even by applying lower doses of nitrogen, based on the build up of organic matter due to sewage irrigation. The lower rate of N should be used basal for boosting the initial growth of plants. The study has implications in terms of reducing the $NO_3$ pollution of ground water in sewage-irrigated areas.

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