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# Integrated nutrient management in cotton-sunflower cropping system in the sandy loam soils of north India

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**Abstract**

Two sets of field experiments were conducted during *kharif* and *rabi* seasons of 2002-'03 and 2003-'04 at New Delhi under irrigated conditions to formulate site-specific nutrient management strategies for cotton-sunflower cropping system. The *kharif* experiments on cotton consisted of eight treatments *viz.*, 100% recommended dose of fertilizers (RDF; 60:30:30 N, $P_2O_5$ and $K_2O$ kg $ha^{-1}$), 50% RDF, mung bean intercrop incorporation (MII), farm yard manure (FYM; 12 t $ha^{-1}$), 50% RDF+MII, 50% RDF+FYM, 50% RDF+FYM+MII and control, and it was laid out in a randomized block design with three replications. For the succeeding sunflower crop (*rabi*), each cotton plot was subdivided into three, and 0, 50 and 100% RDF were applied adopting a split plot design. Highest values for seed cotton yield and NPK uptake were observed for the combined application of all three nutrient sources. Nutrient management of cotton also exerted a marked effect on seed yield and NPK uptake of the succeeding sunflower crop. However, direct application to sunflower had a more pronounced effect than the residual effects.

**Keywords:** Mung bean incorporation, nutrient uptake, residual fertility

## Introduction

Cotton (*Gossypium hirsutum* L.), the king of fibre crops, is an industrial commodity of worldwide importance. In India, cotton is grown by about 4 million farmers on an estimated 7.4 million ha of land (Mayee et al., 2004). Sunflower (*Helianthus annuus* L.) cultivation is also becoming common in this country because of its short duration, photo-insensitivity, wide adaptability and drought tolerance (Hegde, 2000). In particular, cotton-sunflower sequence is gaining popularity wherever the sowing of traditional *rabi* crops is delayed. Since both the crops are of exhaustive nature, there is a need to develop system-based and environmentally safe nutrient management strategies. For this, an understanding of the combinations of inorganic fertilizers and organic manures, which enhances nutrient use efficiency of different crops in the sequence is critical. To elucidate this, a study was conducted in the sandy loam soils of north India, wherein the effects of integrated nutrient management in cotton and its residual effects on a succeeding sunflower crop were evaluated.

## Materials and methods

The field experiments were laid out in the research farm of the Indian Agricultural Research Institute, New Delhi (28°58' N; 77°10' E and 228 m above mean sea level) during the *kharif* and *rabi* seasons of 2002-'03 and 2003-'04. The soil of the experimental site was having low available N, and medium P and K contents. The experiment on cotton was laid out in a randomized block design with eight treatments (Table 1), replicated thrice. In the treatments involving chemical fertilizers, 50% N and the entire quantity of P and K were applied basally and the remaining N top-dressed at square initiation stage. Incorporation of green gram or mung grown between rows of cotton (at 40 days) and farmyard manure

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(FYM) at 12 t $ha^{-1}$ constituted the green manure crop incorporation (MII) and FYM treatments respectively.

For the succeeding sunflower, however, a split plot design was adopted in which each cotton plot was subdivided into three, and 0, 50% and 100% RDF (60:30:30 N, $P_2O_5$ and $K_2O$ kg/ha) were applied (at random). Basal dose of fertilizers consisted of half the N (40 kg $ha^{-1}$), and full P (40 kg $ha^{-1}$) and K (40 kg $ha^{-1}$). Remaining N was supplied at 40 days after sowing (DAS). N, P and K concentrations of plant samples were estimated using standard procedures and the uptake values calculated.

**Results and discussion**

*Seed cotton yield*

In general, seed cotton yields increased significantly with increasing levels of applied nutrients, either through organic (FYM and green manure) or through inorganic means (Table 1). The highest seed cotton yields (2350 and 2690 kg $ha^{-1}$ during 2002 and 2003 respectively) were observed when all three sources of nutrients (organic, green manure and inorganic at 50% RDF) were applied in conjunction, which was, however, statistically at par with treatments such as 50% RDF+FYM, and 100% RDF. Lowest seed yields of 1660 and 1910 kg $ha^{-1}$ were recorded in the control. The results indicate the beneficial effects of combined application of FYM, green manure and reduced doses of chemical fertilizers (e.g., 50% RDF) on crop performance. Organic manures, presumably, play a key role in enhancing the efficiency of utilization of native as well as applied nutrients. In addition, they augment the availability of certain micro-nutrients and provide certain growth promoting substances, which promotes boll retention and improve boll weight in cotton (Katkar et al., 2002).

*Nutrient uptake*

Different nutrient management practices resulted in perceptible variations in N, P and K uptake of cotton (Table 1). Highest N removal (93.6 and 113.7 kg $ha^{-1}$ during 2002 and 2003, respectively) was observed for the combined application of 50% RDF, FYM and MII. As expected, the lowest N uptake of 65.5 and 75.6 kg $ha^{-1}$ during 2002 and 2003 respectively was observed in the control. Increased N uptake with combined application of organic and inorganic fertilizers, albeit at reduced levels, might be due to a steady supply of N and its decreased losses (Blaise and Singh, 2004).

Like N, highest P uptake (14.0 and 16.5 kg $ha^{-1}$ during 2002 and 2003 respectively) was observed for the 50% RDF+FYM+MII treatment, which was significantly superior to other treatments except the 50% RDF+FYM

Table 1. Effect of sources and levels of nutrients on seed cotton yield and total uptake of N, P and K.

| Treatments | Seed cotton yield (kg $ha^{-1}$) | | | Nutrient uptake (kg $ha^{-1}$) | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | N | | P | | K | |
| | 2002 | 2003 | Mean | 2002 | 2003 | 2002 | 2003 | 2002 | 2003 |
| Control | 1660 | 1914 | 1787 | 65.5 | 75.6 | 10.3 | 11.4 | 52.3 | 56.5 |
| 100% RDF | 2201 | 2539 | 2370 | 87.5 | 101.0 | 13.1 | 14.7 | 65.0 | 72.7 |
| 50% RDF | 1972 | 2267 | 2119 | 77.6 | 88.2 | 11.8 | 13.0 | 59.8 | 65.1 |
| MII | 1752 | 2007 | 1879 | 63.3 | 79.4 | 10.8 | 11.7 | 54.9 | 59.8 |
| FYM (12 t $ha^{-1}$) | 2069 | 2384 | 2226 | 81.5 | 94.2 | 12.5 | 13.9 | 62.2 | 68.9 |
| 50% RDF+MII | 2058 | 2362 | 2210 | 80.7 | 95.0 | 12.3 | 13.9 | 61.7 | 68.3 |
| 50% RDF+FYM | 2312 | 2661 | 2486 | 90.9 | 110.3 | 13.7 | 16.1 | 68.2 | 78.8 |
| 50% RDF+FYM+MII | 2347 | 2693 | 2520 | 93.6 | 113.7 | 14.0 | 16.5 | 69.6 | 80.9 |
| CD (0.05) | 171 | 174 | 167 | 4.6 | 5.8 | 0.69 | 0.74 | 3.01 | 3.35 |

RDF= recommended dose of fertilizers (80:40:40 N, $P_2O_5$ and $K_2O$ kg $ha^{-1}$); MII= mung bean intercrop incorporation; FYM= farm yard manure

(Table 1). Enhanced P uptake with combined application of FYM and inorganic fertilizers might be due to a combination of factors which enhance P availability in soils. This includes production of organic acids through decomposition of organic matter and a consequent release of phosphate ions, production of complexes involving Fe and Al ions and hydrous oxides which reduces soil P fixation, formation of phospho-humic complexes and isomorphous replacement of phosphate ions by humate ions. Such effects on soil P were reported by many workers previously and for a range of crops including cotton (e.g., Tarhalkar et al., 1996).

Highest K uptake of 69.6 and 80.9 kg $ha^{-1}$ also was observed when all three nutrient sources were combined. Increased K uptake with organically treated plots might be due to the priming effect of organic/green manures on the decomposition-related release of organic acids that solubilize native K (Singh et al., 1999).

*Sunflower seed yield*

Nutrient management practices of the preceding cotton crop exerted a significant influence on seed yield of sunflower in both years (Table 2). As expected, the residual effects of FYM were more pronounced than the non-FYM treatments. Indeed, the combined application of 50% RDF, FYM and MII recorded significantly higher seed yield over other treatments, except the 50% RDF+FYM. Lowest seed yields of 1810 and 1030 kg $ha^{-1}$ during 2002-'03 and 2003-'04 respectively were for the control. Favorable effects of FYM application either alone or in combination with other nutrient sources could be attributed to the better nutrient availability in these treatments, as explained by many previous workers (e.g., Ramprakash and Prasad, 2000).

Furthermore, direct application of fertilizers increased sunflower yield significantly and it was highest for the 100% RDF treatment (2200 and 1260 kg $ha^{-1}$ during 2002-'03 and 2003-'04 respectively). This is consistent with the findings of many previous workers (e.g., Edara and Patel, 2000).

*Nutrient uptake*

Organic and inorganic sources of nutrients to the preceding cotton crop exerted a profound impact on

Table 2. Residual and direct effect of treatments on sunflower seed yield, and uptake of total N, P and K

| Treatments | Sunflower seed yield (kg $ha^{-1}$) | | | Nutrient uptake (kg $ha^{-1}$) | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | N | | P | | K | |
| | 2002-03 | 2003-04 | Mean | 2002-'03 | 2003-'04 | 2002-'03 | 2003-'04 | 2002-'03 | 2003-'04 |
| **Residual effects** | | | | | | | | | |
| Control | 1810 | 1030 | 1420 | 83.9 | 58.8 | 26.1 | 16.9 | 83.4 | 69.3 |
| 100% RDF | 1840 | 1060 | 1450 | 85.4 | 59.5 | 26.4 | 17.5 | 84.4 | 70.7 |
| 50% RDF | 1830 | 1040 | 1440 | 84.8 | 59.6 | 26.2 | 17.2 | 84.1 | 70.0 |
| MII | 1890 | 1090 | 1490 | 90.1 | 61.8 | 27.2 | 17.9 | 86.6 | 71.9 |
| FYM (12 t $ha^{-1}$) | 1980 | 1170 | 1580 | 91.4 | 66.2 | 28.4 | 19.7 | 88.7 | 76.1 |
| 50% RDF+MII | 1930 | 1100 | 1510 | 89.5 | 62.5 | 27.7 | 18.2 | 87.7 | 72.5 |
| 50% RDF+FYM | 2040 | 1190 | 1620 | 93.6 | 67.2 | 29.1 | 20.1 | 89.7 | 76.7 |
| 50% RDF+FYM+MII | 2080 | 1240 | 1660 | 95.7 | 69.5 | 29.7 | 20.8 | 91.1 | 78.4 |
| CD (0.05) | 81 | 72 | 89 | 3.1 | 2.4 | 0.6 | 0.6 | 2.7 | 2.6 |
| **Direct effects** | | | | | | | | | |
| Control | 1650 | 960 | 1310 | 75.2 | 52.8 | 22.8 | 14.7 | 76.5 | 63.6 |
| 100% RDF | 2200 | 1250 | 1730 | 104.7 | 71.8 | 32.6 | 21.7 | 98.3 | 81.3 |
| 50% RDF | 1930 | 1130 | 1530 | 88.1 | 64.7 | 27.4 | 19.2 | 86.1 | 74.8 |
| CD (0.05) | 120 | 108 | 109 | 1.9 | 1.6 | 0.3 | 0.3 | 1.8 | 1.8 |

RDF= recommended dose of fertilizers (80:40:40 N, $P_2O_5$ and $K_2O$ kg $ha^{-1}$); MII= mung bean intercrop incorporation; FYM= farm yard manure

NPK removal by the succeeding sunflower crop (Table 2). Highest N uptake was recorded for the 50% RDF+ FYM+MII treatment both during 2002-'03 and 2003-'04 (95.7 and 69.5 kg $ha^{-1}$ respectively). Likewise, the highest P and K uptake were also noted for this treatment. Direct application of chemical fertilizers to the sunflower crop also stimulated N, P and K uptake and the highest nutrient uptake values were noted for the 100% RDF treatment (Table 2).

In summary, for sustained high productivity of a cotton-sunflower cropping system in the sandy loam soils of north India under irrigated conditions, integrated application of organic and inorganic nutrient sources (50% RDF+FYM +MII or 50% RDF+FYM) should be recommended to the first crop in the sequence (cotton), and 100% RDF for the succeeding sunflower crop.

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