

## Effect of moisture conservation and fertility on Indian mustard (*Brassica juncea*) and lentil (*Lens culinaris*) intercropping system under rainfed conditions

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### ABSTRACT

A field experiment was conducted in the winter season of 2003–04 and 2004–05 to study the effect of intercropping, moisture-conservation practices and fertility levels on the growth, yield and N and P uptake of rainfed 'Pusa Barani' Indian mustard [*Brassica juncea* (L.) Czernj. & Cosson] and 'L 7473' lentil (*Lens culinaris* Medikus). Indian mustard paired row (30/90 cm) + lentil (2 rows) intercropping system proved more productive, as it gave 3.7 q/ha extra seed yield of lentil without reducing significantly dry-matter accumulation, yield attributes and the seed yield of Indian mustard. Moisture-conservation practices increased the growth parameters and total N and P uptake. FYM + organic mulch + kaolin spray (6%) increased the seed yield of Indian mustard and lentil by 14.0 and 14.3% respectively. Dry-matter accumulation and yield attributes of Indian mustard and lentil and leaf-area index were recorded significantly higher with 50% and 100% recommended dose of fertilizer (RDF). The N and P uptake of Indian mustard and lentil increased significantly with the application of 50% RDF and 100% RDF. The maximum increment in seed yield of Indian mustard and lentil was recorded with 100% fertility level and it was 19.9 and 25.3% higher over the control respectively. The moisture-conservation practice of FYM + organic mulch + kaolin spray (6%) recorded highest water-use efficiency (10.1 kg/ha-mm) over the control.

**Key words :** Intercropping, Moisture conservation, Fertility, Yield, Mustard, Lentil, Water-use efficiency

Indian mustard and lentil are grown in sole as well as in mixed stands, because of their diverse morphology, growth rhythm and similar climatic conditions. However, its real advantage can be obtained if it is supplemented with adequate fertilizers and suitable moisture-conservation practices. Crops grown under rainfed conditions are prone to water stress, due to rapid loss of soil moisture and development of mechanical impedance to root growth. The stress can be alleviated by enlarging rooting volume in the soil and by regulating the supply of soil moisture. Rathore *et al.* (1998) reported better root growth and higher seed yield of both chickpea and Indian mustard under intercropping system with straw mulch than that in no-mulch plots. Sardana and Sidhu (1997) reported higher Indian mustard equivalent yield without significant reduction in the yield of main crop of Indian mustard, thus leading to higher income from Indian mustard-based intercropping systems. Hence present investigation was undertaken to find out the suitability of Indian mustard paired row (30/90 cm) + lentil (2 rows) intercropping system, appropriate moisture-conservation practices and fertility levels on the growth parameters, yield and N and P uptake of Indian mustard and lentil.

### MATERIALS AND METHODS

The field experiment was conducted in winter season of 2003–04 and 2004–05 at the Agronomy Research Farm, Division of Agronomy, Indian Agricultural Research Institute, New Delhi. The soil was a sandy loam with slightly alkaline reaction (pH 7.7) and poor in organic carbon (0.37%). The total available N, P and K were 262.5, 16.4 and 316 kg/ha respectively. The treatments were tested in split-plot design replicated thrice with 3 cropping systems [sole Indian mustard, sole lentil and Indian mustard paired row (30/90 cm) + lentil (2 rows) intercropping] and 3 moisture-conservation practices [control, organic mulch + kaolin spray (6%) and farmyard manure (FYM) @ 5 tonnes/ha + organic mulch + kaolin spray (6%)] in the main plots and 3 fertility levels of N and P [control, 50% recommended doses of fertilizer (RDF) and 100% RDF] in sub-plots. The recommended dose of 60 kg N and 30 kg P/ha to Indian mustard, while 20 kg N and 40 kg P/ha to lentil was applied on row basis before sowing the seed. However, 100 and 50% RDF for Indian mustard were applied to the intercropping system. The FYM (0.5% N, 0.2% P and 0.6%) was incorporated 1 month before sowing in allotted treatment plots to

conserve some soil moisture. Mulching was done with chopped organic waste of farm like maize and pearl millet stubbles, dry weeds etc. It was spread uniformly with 5 cm thickness 25 days after sowing. Kaolin (6% suspension) was sprayed 90 days after sowing. While chemical fertilizers (diammonium phosphate and urea) were applied at plough sole depth (15 cm below soil surface) 2 days before sowing during both the years.

'Pusa Barani' Indian mustard and 'L 7473' lentil were sown 60 and 30 cm apart during the second fortnight of October (20 and 21 October during both the years), using 6 and 35 kg seed/ha, respectively, for sole cropping. However, in Indian mustard + lentil intercropping, the plant population of the Indian mustard was maintained as in case of sole cropping system, but 2 rows of lentil were adjusted in between pairs, using seed rate of 6 and 15 kg/ha for Indian mustard and lentil respectively. The crop received 15.8 and 39.4 mm rainfall during the growth period of 2003–04 and 2004–05 respectively. The seed yield was pooled on the basis of net plot (2.4 m × 3.0 m) harvested, and total N and P uptake were computed by multiplying N and P content of seed and straw. Water-use efficiency (WUE) was worked out by dividing the economic yield in terms of Indian mustard-equivalent yield by consumptive use of water.

## RESULTS AND DISCUSSION

### Growth and yield attributes

The growth parameters indicated significant differences for leaf-area index (LAI) and dry-matter accumulation of Indian mustard under cropping systems. Indian mustard +

lentil intercropping system recorded significantly superior values of LAI and dry-matter accumulation than sole Indian mustard stand (Table 1). It was not only due to individual better performance of plants under intercropping but reduced spacing under paired row planting, as dry-matter accumulation of both cropping system were non-significant at later growth stage. While sole lentil recorded significantly superior values of dry-matter accumulation than that in Indian mustard + lentil intercropping system. It may be due to shading effect of Indian mustard on lentil in intercropping system (Table 2). Similar findings were also reported by Singh *et al.* (2000).

The FYM + organic mulch + kaolin spray (6%) recorded significantly higher values of dry-matter accumulation and leaf-area index of Indian mustard than no-mulch treatments (Table 1). It may be due to better plant water status during crop growth and reduced row spacing under intercropping. Sharma *et al.* (2002) also reported that straw mulch improved the soil-moisture status of upper soil layer. Moisture-conservation practices significantly influenced the dry-matter accumulation of lentil and at harvest FYM + organic mulch + kaolin spray (6%) treatment was significantly superior to no-mulch treatment (Table 2). It may be mainly owing to the shading effect of tall Indian mustard on lentil.

The leaf-area index of Indian mustard increased with the increase of fertility levels (Table 1). Dry-matter accumulation in Indian mustard increased with increase in fertility levels of recommended levels at harvest which may be due to moisture availability for longer period resulted balanced nutrition absorption. The highest value of dry-

**Table 1.** Effect of intercropping, moisture-conservation practices and fertility levels on growth and yield attributes of Indian mustard (pooled over 2 years)

| Treatment                                           | Dry-matter accumulation (g/m) | Leaf-area index | Siliquae/plant | Siliqua weight (g) | Siliqua length (cm) | Seeds/siliqua | Test weight (g) |
|-----------------------------------------------------|-------------------------------|-----------------|----------------|--------------------|---------------------|---------------|-----------------|
| <i>Cropping system</i>                              |                               |                 |                |                    |                     |               |                 |
| Sole Indian mustard                                 | 847.2                         | 2.71            | 373.8          | 0.18               | 4.6                 | 15.0          | 5.9             |
| Sole lentil                                         |                               |                 |                |                    |                     |               |                 |
| Indian mustard paired row (30 cm) + lentil (2 rows) | 797.7                         | 7.53            | 349.4          | 0.19               | 4.3                 | 14.8          | 5.8             |
| CD (P=0.05)                                         | NS                            | 0.43            | NS             | NS                 | 0.2                 | NS            | NS              |
| <i>Moisture-conservation practice</i>               |                               |                 |                |                    |                     |               |                 |
| No mulch                                            | 761.3                         | 4.72            | 342.8          | 0.16               | 4.3                 | 14.6          | 5.8             |
| Organic mulch + kaolin spray (6%)                   | 828.4                         | 5.01            | 365.8          | 0.17               | 4.5                 | 14.9          | 5.9             |
| FYM + organic mulch + kaolin                        | 877.5                         | 5.63            | 376.3          | 0.18               | 4.6                 | 15.2          | 6.0             |
| CD (P=0.05)                                         | 69.6                          | 0.54            | NS             | NS                 | 0.2                 | NS            | NS              |
| <i>Fertility levels (N+P)</i>                       |                               |                 |                |                    |                     |               |                 |
| Control                                             | 737.3                         | 4.73            | 337.1          | 0.15               | 4.2                 | 13.9          | 5.7             |
| 50% Recommended dose of fertilizer (RDF)            | 839.7                         | 5.17            | 361.4          | 0.17               | 4.6                 | 15.2          | 5.9             |
| 100% RDF                                            | 885.1                         | 5.51            | 386.3          | 0.19               | 4.9                 | 15.5          | 6.0             |
| CD (P=0.05)                                         | 67.0                          | 0.33            | 28.4           | 0.02               | 0.03                | 1.1           | 0.2             |

matter accumulation of lentil recorded with 100% RDF at all growth stages (Table 2).

Cropping systems and moisture-conservation practices in general did not have marked variation in yield attributes of Indian mustard, whereas fertility levels enhanced all the yield attributes of Indian mustard over the control. However, the yield attributes of lentil except test weight and seeds/pod, had marked variations with cropping system and moisture-conservation practices, whereas fertility levels enhanced all yield attributes except test weight of lentil. These results are in close conformity with the results of Singh *et al.* (2000).

### Seed yield

Seed and straw yields of Indian mustard was not affected significantly by Indian mustard paired row (30/90 cm) + lentil (2 rows) intercropping, whereas lentil seed and straw yields were reduced significantly under intercropping system (Table 3). The reduction in lentil yield was mainly due to reduced plant population per unit area and lower values of growth parameters. Tiwari *et al.* (1992) reported similar results.

Seed and straw yields of Indian mustard and lentil were enhanced by moisture-conservation practices (Table 3). FYM + organic mulch + kaolin recorded highest seed and straw yields of Indian mustard and lentil which are significantly more than no-mulch owing to better growth and development. These results confirm the finding of Kushwaha (1992). A 100% RDF level recorded significantly higher seed and straw yields of Indian mustard and lentil over the control, but it remained non-significant with

50% RDF treatment.

Significantly higher Indian mustard-equivalent yield was recorded with Indian mustard paired row + lentil (2 rows) over the sole Indian mustard and sole lentil. The FYM + organic mulch + kaolin spray 6% resulted significantly higher Indian mustard equivalent yields over the control. The 100% RDF was found significantly superior to the control in terms of Indian mustard-equivalent yield.

### Nitrogen and phosphorus uptake

Sole Indian mustard and lentil recorded higher total N and P uptake than Indian mustard + lentil intercropping system. It is because of the higher biomass production under sole cropping system. Moisture-conservation practices enhanced the N and P uptake of Indian mustard and lentil. The highest N and P uptake of Indian mustard and lentil was with FYM + organic mulch + kaolin 6% spray. Total N and P uptake of Indian mustard and lentil increased with the increase in fertility levels. The 100% fertility level recorded highest N and P uptake of Indian mustard which was significant to the control as well as 50% RDF. Similar results were reported by Singh *et al.* (2003). Total N uptake increased up to 50% RDF fertility level in lentil, whereas P uptake increased up to 100% RDF.

Total N and P uptake of the system was recorded significantly superior in Indian mustard + lentil intercropping to the sole Indian mustard and sole lentil. Moisture-conservation practices enhanced total N and P uptake in cropping system (Table 3). The FYM + organic mulch + kaolin spray (6%) recorded significantly higher N and P uptake over no-mulch treatment. A 100% RDF also recorded

**Table 2.** Effect of intercropping, moisture-conservation practices and fertility levels on growth and yield attributes of lentil (pooled over 2 years)

| Treatment                                    | Dry-matter accumulation (g/m) | Pods/plant | Seed weight (g/plant) | Seeds/pod | Test weight (g) |
|----------------------------------------------|-------------------------------|------------|-----------------------|-----------|-----------------|
| <i>Cropping system</i>                       |                               |            |                       |           |                 |
| Sole Indian mustard                          |                               |            |                       |           |                 |
| Sole lentil                                  | 154.1                         | 62.6       | 1.74                  | 1.8       | 15.9            |
| Mustard paired row (30 cm) + lentil (2 rows) | 93.4                          | 44.5       | 1.37                  | 1.6       | 15.8            |
| CD (P=0.05)                                  | 11.7                          | 4.4        | 0.12                  | NS        | NS              |
| <i>Moisture-conservation practice</i>        |                               |            |                       |           |                 |
| No mulch                                     | 115.6                         | 49.5       | 1.40                  | 1.6       | 15.8            |
| Organic mulch + kaolin spray (6%)            | 123.9                         | 54.6       | 1.60                  | 1.7       | 15.9            |
| FYM + organic mulch + kaolin                 | 131.8                         | 56.8       | 1.65                  | 1.8       | 15.9            |
| CD (P=0.05)                                  | 14.4                          | 5.4        | 0.16                  | NS        | NS              |
| <i>Fertility levels (N+P)</i>                |                               |            |                       |           |                 |
| Control                                      | 112.1                         | 46.6       | 1.34                  | 1.5       | 15.8            |
| 50% recommended dose of fertilizer (RDF)     | 126.5                         | 55.1       | 1.60                  | 1.7       | 15.9            |
| 100% RDF                                     | 132.7                         | 59.1       | 1.73                  | 1.8       | 16.0            |
| CD (P=0.05)                                  | 12.8                          | 4.3        | 0.13                  | 0.2       | NS              |

**Table 3.** Effect of intercropping, moisture-conservation practices and fertility levels on seed yield, total productivity and N and P uptake, consumptive use and water-use efficiency of Indian mustard and lentil

| Treatment                                              | Yield of<br>Indian<br>mustard<br>(q/ha) | Yield<br>of<br>lentil<br>(q/ha) | Mustard<br>equivalent<br>yield<br>(q/ha) | Nurient uptake<br>by Indian<br>mustard |      | Nutrient<br>uptake<br>by lentil |      | Nutrient<br>uptake by<br>cropping<br>system (kg/ha) |      | Consumeptive<br>water use<br>(mm) | Water-<br>use effi-<br>ciency<br>(kg/ha-mm) |
|--------------------------------------------------------|-----------------------------------------|---------------------------------|------------------------------------------|----------------------------------------|------|---------------------------------|------|-----------------------------------------------------|------|-----------------------------------|---------------------------------------------|
|                                                        |                                         |                                 |                                          | (kg/ha)                                |      | (kg/ha)                         |      | (kg/ha)                                             |      |                                   |                                             |
|                                                        |                                         |                                 |                                          | N                                      | P    | N                               | P    | N                                                   | P    |                                   |                                             |
| <i>Cropping system</i>                                 |                                         |                                 |                                          |                                        |      |                                 |      |                                                     |      |                                   |                                             |
| Sole Indian mustard                                    | 20.7                                    |                                 | 20.9                                     | 115.8                                  | 30.0 |                                 |      | 115.8                                               | 30.0 | 217                               | 9.7                                         |
| Sole lentil                                            |                                         | 14.5                            | 19.5                                     |                                        |      | 119.2                           | 16.9 | 119.2                                               | 16.8 | 183                               | 9.5                                         |
| Indian mustard paired row<br>(30 cm) + lentil (2 rows) | 19.5                                    | 3.7                             | 22.5                                     | 105.7                                  | 27.4 | 35.8                            | 5.1  | 141.5                                               | 32.5 | 299                               | 10.3                                        |
| CD (P=0.05)                                            | NS                                      | 0.7                             | 1.5                                      | 7.1                                    | 2.0  | 4.1                             | 0.7  | 8.2                                                 | 2.5  |                                   |                                             |
| <i>Moisture-conservation practice</i>                  |                                         |                                 |                                          |                                        |      |                                 |      |                                                     |      |                                   |                                             |
| No mulch                                               | 18.6                                    | 8.4                             | 19.4                                     | 101.8                                  | 26.2 | 71.9                            | 10.0 | 173.9                                               | 36.2 | 204                               | 9.6                                         |
| Organic mulch + kaolin<br>spray (6%)                   | 20.4                                    | 9.3                             | 20.7                                     | 113.0                                  | 28.9 | 78.3                            | 11.1 | 193.3                                               | 40.0 | 210                               | 9.0                                         |
| FYM+organic mulch + kaolin                             | 21.2                                    | 9.6                             | 21.3                                     | 118.7                                  | 30.8 | 82.4                            | 11.8 | 201.1                                               | 42.6 | 216                               | 10.1                                        |
| CD (P=0.05)                                            | 1.8                                     | 0.9                             | 1.7                                      | 8.7                                    | 2.4  | 5.0                             | 0.8  | 9.3                                                 | 2.8  |                                   |                                             |
| <i>Fertility level (N+P)</i>                           |                                         |                                 |                                          |                                        |      |                                 |      |                                                     |      |                                   |                                             |
| Control                                                | 18.1                                    | 7.9                             | 18.4                                     | 99.6                                   | 25.1 | 68.2                            | 9.5  | 167.8                                               | 34.6 | 119                               | 9.3                                         |
| 50% RDF                                                | 20.5                                    | 9.5                             | 20.5                                     | 113.1                                  | 29.1 | 80.0                            | 11.3 | 193.1                                               | 40.4 | 212                               | 9.9                                         |
| 100% RDF                                               | 21.7                                    | 9.9                             | 22.3                                     | 120.6                                  | 31.8 | 84.4                            | 12.2 | 205.0                                               | 44.0 | 211                               | 10.2                                        |
| CD (P=0.05)                                            | 1.5                                     | 0.9                             | 1.5                                      | 7.0                                    | 2.0  | 4.7                             | 0.7  | 8.7                                                 | 2.6  |                                   |                                             |

highest N and P uptake of the system, which was significantly superior over control.

#### Consumptive use and water-use efficiency (WUE)

Consumptive use was more with Indian mustard paired row (30/90 cm) + lentil (2 rows) intercropping system (229.5 mm) than with pure stand of Indian mustard (21.1 mm) and lentil (183.2 mm). Moisture-conservation practices enhanced the consumptive use of moisture. The maximum consumptive use of moisture was observed with FYM + organic mulch + kaolin 6% (216.5 mm), followed by organic mulch + kaolin 6% (210.3 mm). Among the fertility levels, 100% RDF has higher values of consumptive use of moisture (219.9 mm), followed by 50% RDF (211.8 mm) and control (119.3 mm). Rathore *et al.* (1998), also reported similar results.

Water-use efficiency (WUE) was higher in Indian mustard paired row (30/90 cm) + lentil (2 rows) intercropping systems compared with pure stands of the component crops. The maximum WUE was observed with Indian mustard paired (30/90 cm) + lentil (2 rows) intercropping system, followed by sole mustard and sole lentil.

The maximum WUE was noted with FYM + organic mulch + kaolin 6% spray, followed by organic mulch +

kaolin 6% spray and the control. The successive increment in fertility levels also increased the WUE. The maximum WUE was recorded with 100% RDF, followed by 50% and the control. These results confirm those of Singh *et al.* (2000).

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