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# Effect of moisture-conservation practices on productivity and water use in maize (*Zea mays*)-based intercropping systems under rainfed conditions

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## ABSTRACT

A field experiment was carried out during the rainy season *(kharif)* of 2001 and 2002 to study the relative moisture utilization by maize *(Zea mays* L.) grown in a mixed or in a sole situation. The maize equivalent was higher in maize paired row (40/80 cm) + 2 rows of mungbean (*Phaseolus radiatus* L.) than the sole maize crop. An increase in water-use efficiency (WUE) was observed in intercropping systems. The water-use efficiency was the highest (10.14 maize equivalent use/ha/mm) in maize paried row (40/80 cm) + 2 rows of mungbean. Growth, yield attributes and yield as well as maize equivalent were significantly improved with farmyard manure (FYM) + dust mulch + straw mulch treatment over no mulch. Among the moisture-conservation practices, higher WUE was recorded under FYM+dust mulch + straw mulch, closely followed by Kaolin + dust mulch + straw mulch.

***Key words :*** Maize, Intercropping, Mungbean, FYM, Moisture conservation, Water-use efficiency

Maize, a widely spaced crop, provides ample opportunity for raising short-duration varieties of mungbean and the resource-utilization efficiency can be greatly enhanced. The suitable intercropping systems might increase the total production through efficient utilization of production factors like space, water, nutrient etc. Since major source of soil moisture loss is evapo-transpiration, its favourable regulation is needed to go a long way in overcoming the problem of soil-moisture loss. Organic manure, and mulches play a significant role in soil-moisture conservation particularly under dryland condition. This communication attempts to analyse the relative moisture utilization by maize grown as sole crop as well as intercrop combinations with various moisture- conservation practices.

## MATERIALS AND METHODS

The field experiment was conducted during the rainy *(kharif)* seasons of 2001 and 2002 at the Indian Agricultural Research Institute, New Delhi. Treatments comprising 3 cropping systems [maize sole (60 cm), maize paired row (40/80 cm) + 1 row of mungbean and maize paired row (40/80 cm) + 2 rows of mungbean] as main plots and 6 moisture-conservation practices (no mulch dust mulch + straw mulch, kaolin+straw mulch, kaolin+dust mulch + straw mulch, farmyard manure (FYM) @ 5 tonnes/ha and FYM @ 5 tonnes/ha + dust mulch + straw mulch) as subplots were replicated thrice in split-plot design. Maize 'Pusa Composite 3' was sown on 21 June 2001 and 29 June 2002 using 20 kg seeds/ha and mungbean cv. 'Asha' at 16 kg seeds/ha was sown on the same day in the plots having intercrop treatment. The soil was sandy loam, low in organic carbon (0.4%), available N (270 kg N/ha) and medium in available P (14 kg/ha) and K (204 kg/ha) and pH was 7.1. The soil had an available water of 180 mm in top 1 m profile. Water-use efficiency was worked out by dividing the economic yield in terms of maize equivalent by consumptive use of water. The rainfall received during first and second year was 480 and 410 mm respectively.

## RESULTS AND DISCUSION

### *Growth and yield attributes*

Maize paired row (40/80 cm) + 1 row of mungbean recorded significantly higher plant height and yield attributes, *viz.* cobs/plant, cob length, grains/cob and grain weight/cob, compared to sole maize but were at par with maize paired row (40/80 cm) + 2 rows of mungbean (Table 1).

Plant height and yield attributes also exhibited an improvement owing to moisture-conservation practices applied during crop-growth period. Farmyard manure (FYM) + dust mulch + straw mulch resulted maximum increase in plant height and yield attributes, followed by Kaolin + dust mulch + straw mulch. The adequate availability of moisture to plant which might be due to combined effect of both FYM and straw mulch, resulted in more foliage development, greater photosynthetic rate and consequently better plant growth, manifested in terms of plant height and yield attributes. This confirms the findings of and Kaushik and Lal (1997).

### Yield and equivalent yield of maize

Grain yield of maize as well as maize-equivalent yield revealed that intercropping (40/80 cm + 2 rows of mungbean) gave significantly higher grain yield of maize over the sole crop. However, the yields in intercropping of maize paired row (40/80 cm + 1 row of mungbean) and maize paired row (40/80 cm) + 2 rows of mungbean were statistically at par with each other. Intercropping systems also gave significantly higher maize-equivalent yield over sole maize. The maize-equivalent yield in paired row of maize + 2 rows of mungbean intercropping system was 5.2 and 44.10 % higher over maize-equivalent yield recorded under maize paired row + 1 row of mungbean and sole maize respectively. This increase was mainly owing to additional yield advantage of intercropping as well as higher market price of grain legumes than that of maize grain. The improvement in yield could be assigned to the synergistic effect of maize and mungbean association. Similar results were obtained by Gupta (1989).

Significant improvement in grain yield as well as maize-equivalent yield was recorded under FYM + dust mulch + straw mulch treatment, followed by Kaolin + dust mulch + straw mulch. The different mulches might have resulted in decreased evapo-transpiration (ET) losses either by interception of insulation or increasing the leaf albedo or improving the physico-chemical properties of the soil, as the case may be. The results are in close conformity with those of Singh *et al.* (1997). The FYM + dust mulch + straw much gave the highest maize-equivalent yield. These results are in conformity with the findings of Kaushik and Lal (1997).

### Soil-moisture extraction pattern

Maize paired row + 2 rows of mungbean plots depleted moisture remarkably compared to sole maize and maize paired row + 1 row of mungbean in different soil layers.

All the moisture-conservation practices influenced the soil-moisture extraction pattern. The least soil-moisture depletion was recorded in FYM + dust mulch + straw mulch treatment compared to other moisture-conservation practices. It might be due to high moisture-holding capacity of FYM.

### Consumptive use

The cropping system treatments substantially increased the consumptive use of water (Table 2). The highest consumptive use was recorded in maize paired row (40/80 cm) + 2 rows of mungbean. It was the lowest in sole maize. Other cropping system of maize paired row (40/80 mm) +1 row of mungbean also showed higher values of consumptive use over the sole crop of maize. Reddy *et al.* (1980) also reported higher consumptive use of water due to intercropping systems compared with sole cropping.

Maximum consumptive use of water was recorded in FYM + dust mulch + straw mulch, followed by Kaolin + dust mulch + straw mulch. The increase in consumptive water use by maize due to moisture-conservation treatments could be attributed to vigorous crop growth from

**Table 1.** Growth, yield attributes and yield of maize as influenced by cropping systems and moisture-moisture conservation practices (mean data of 2 years)

| Treatment | Plant height (cm) | Cobs/ plant | Length of cob (cm) | Grains/ cob | Grain weight/ cob (g) | 1,000-grain weight (g) | Maize grain yield (q/ha) | Grain yield of mungbean (q/ha) | Maize-equivalent yield (q/ha) |
|---|---|---|---|---|---|---|---|---|---|
| *Cropping system* | | | | | | | | | |
| Maize sole (60 cm) | 164.6 | 1.19 | 15.20 | 336.0 | 71.26 | 249.1 | 31.33 | | 31.33 |
| *Maize + mungbean (1:1)* | 185.7 | 1.35 | 17.48 | 367.3 | 91.95 | 252.6 | 35.77 | 2.82 | 43.47 |
| Maize + mungbean (1:2)* | 187.9 | 1.41 | 17.66 | 371.4 | 95.37 | 259.8 | 36.29 | 3.37 | 45.57 |
| CD (P=0.05) | 7.1 | 0.07 | 0.88 | 18.1 | 4.12 | NS | 2.00 | | 1.91 |
| *Moisture-conservation practice* | | | | | | | | | |
| No mulch (control) | 168.5 | 1.14 | 15.52 | 328.0 | 74.42 | 247.3 | 31.58 | 2.36 | 35.82 |
| Dust mulch+straw mulch | 179.3 | 1.35 | 16.81 | 361.0 | 87.91 | 255.3 | 34.31 | 3.12 | 40.02 |
| Kaolin+straw mulch | 177.9 | 1.32 | 16.67 | 357.0 | 86.55 | 253.3 | 33.72 | 3.05 | 39.19 |
| Kaolin+dust mulch+straw mulch | 182.3 | 1.35 | 16.95 | 363.0 | 88.87 | 257.6 | 35.46 | 3.47 | 41.18 |
| FYM @ 5 tonnes/ha | 176.9 | 1.30 | 16.44 | 353.3 | 85.65 | 250.1 | 33.39 | 2.98 | 38.44 |
| FYM+dust mulch+straw mulch | 191.6 | 1.44 | 18.33 | 387.3 | 93.94 | 259.6 | 38.33 | 3.66 | 44.93 |
| CD (P=0.05) | 8.2 | 0.07 | 0.99 | 21.0 | 4.43 | NS | 2.15 | | 2.06 |

*Maize in paired rows (40/80cm)

**Table 2.** Soil-moisture extraction pattern (%), consumptive water use (mm), use rate (mm/day) and water-use efficiency (kg MEY/ha-mm) as influenced by intercropping systems and moisture-conservation practices (mean data of 2 years)

| Treatment | Soil-moisture extraction pattern (%) from soil depth (cm) | | | Consumptive water use | Water-use rate | Water-use efficiency |
|---|---|---|---|---|---|---|
| | 0–30 | 30–60 | 60–90 | | | |
| *Cropping system* | | | | | | |
| Maize sole (60 cm) | 43.30 | 31.21 | 24.21 | 312.50 | 3.12 | 9.97 |
| Maize + mungbean (1:1)* | 42.20 | 30.82 | 24.10 | 232.70 | 2.23 | 10.10 |
| Maize + mungbean (1:2)* | 42.10 | 30.50 | 23.84 | 328.10 | 3.28 | 10.14 |
| *Moisture-conservation practice* | | | | | | |
| No mulch (control) | 43.21 | 31.65 | 24.44 | 305.92 | 3.05 | 10.22 |
| Dust mulch+straw mulch | 42.53 | 31.00 | 22.91 | 323.15 | 3.23 | 10.15 |
| Kaolin+straw mulch | 42.75 | 31.21 | 24.10 | 322.32 | 3.22 | 10.13 |
| Kaolin+dust mulch+straw mulch | 42.10 | 30.10 | 23.72 | 330.36 | 3.30 | 10.30 |
| FYM @ 5 tonnes/ha | 43.10 | 31.32 | 23.31 | 314.96 | 3.14 | 10.35 |
| FYM+dust mulch+straw mulch | 41.40 | 29.74 | 22.64 | 333.10 | 3.33 | 10.40 |

MEY, Maize-equivalent yield * Maize in paired row (40/80 cm)

increased availability of soil moisture as well as nutrient in FYM and straw mulch-treated plots (Kaushik and Lal, 1997).

### Water use rate

The highest water use was recorded in maize paired row (40/80 cm) + 2 rows of mungbean (Table 2). Sole maize (60 cm) showed the lowest water use rate. Daily water use increased considerably due to moisture conservation. The FYM + dust mulch + straw mulch recorded maximum water use rate (3.33 mm/day). The increase in rate of daily water use due to vigorous crop growth resulting from increased availability of soil moisture and nutrient (Kaushik and Lal, 1997).

### Water-use efficiency

The water-use efficiency (WUE) was higher in intercropped treatments than that of a sole maize crop (Table 2). The increase in WUE in an intercrop was achieved owing to increase in total grain production per unit of water use (Reddy *et al.,* 1980). The maximum water-use efficiency was recorded under maize paired row (40/80 cm) + 2 rows of mungbean [11.14 kg maize-equivalent yield (MEY)/ha/mm]. The lower values of WUE were estimated from maize sole and maize paired row (40/80 cm) + 1 row of mungbean.

Water-use efficiency increased appreciably due to moisture-conservation treatments. Maximum water-use efficiency was recorded under FYM + dust mulch + straw mulch treatment. The increase in water-use efficiency due to moisture-conservation practices was apparently because of their higher maize-equivalent yield in moisture-conservation treatment over the control and more moisture was also stored by moisture-conservation treatment compared to no-moisture treatments. Therefore, the higher water-use efficiency, which is directly affected by grain yield and evaporation. Similar results were reported by Singh *et al.* (1997).

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