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# Effect of cropping systems and fertilizers on pigeonpea (*Cajanus cajan*) and wheat (*Triticum aestivum*) in pigeonpea–wheat sequence

**D. R. SHIVRAN AND I.P.S. AHLAWAT**

*Division of Agronomy, Indian Agricultural Research Institute, New Delhi 110 012*

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## ABSTRACT

A field experiment was conducted at New Delhi during 1997–98 and 1998–99 on sandy-loam soil analysing low in N and medium in available P, K and S. The growth and yield attributes, and yield of pigeonpea [*Cajanus cajan* (L.) Millsp.] in sole pigeonpea and pigeonpea intercropped with blackgram (*Phaseolus mungo* L.) did not differ significantly. A significant increase in growth and yield attributes, and yield of pigeonpea was noted with each increment of fertilizer dose up to 100% of recommended dose. The wheat (*Triticum aestivum* L. emend. Fiori & Paol) following pigeonpea or blackgram ( stover incorporated) intercropping recorded markedly higher growth and yield attributes, and yield of wheat over wheat following sole pigeonpea and pigeonpea or blackgram (stover removed) intercropping. The residual effect of fertilizers applied to preceding crops on wheat was marked up to 75% of the recommended dose in 1998–99 only. The wheat crop responded favorably up to direct application of 75% of the recommended dose of fertilizers in respect of yield attributes and yield. The highest mean net return was obtained from pigeonpea or blackgram (stover incorporated–wheat cropping system, where rainy-season crop and wheat were fertilized with 100 and 75% of the recommended dose of fertilizers respectively.

***Key words :*** Pigeonpea, Wheat, Fertilizers, Cropping system

The introduction of short-duration varieties of pigeonpea and late-sown varieties of wheat has made pigeonpea–wheat sequence more feasible and acceptable to farmers in the wheat belt of North India, especially in areas with assured irrigation. The inclusion of legumes and stover incorporation in a cropping system improves the productivity of soil, and the yield of subsequent non-legume gradually increases owing to provision of nitrogen and other growth-promoting factors such as increased nutrient availability, improved soil structure, reduced disease incidence and increased mycorrhizal colonization (George, 1987).

Generally fertilizer dose is recommended on the basis of individual crop re-

sponse to direct application of nutrients, without apportioning the weighage to the previous crops and fertilizers applied to them in sequence. Since a limited part of the applied nutrients is utilized by a crop, fertilizer requirement of the succeeding crop may be modified by the residual nutrients. Studies on legume and wheat system have shown that where the legume crop removed less applied phosphorus, yield of succeeding crop increased (Mahajan and Khanna, 1968). An experiment was therefore conducted to study the effect of cropping systems and fertilizers on yield attributes and yield of pigeonpea and wheat in pigeonpea–wheat sequence.

## MATERIALS AND METHODS

A field experiment was conducted at the Indian Agricultural Research Institute, New Delhi, during 1997–99. The soil was sandy loam with pH 8.0–8.2, organic carbon 0.37–0.39%, total N 0.037–0.039%, available P 10.4–10.6 kg/ha, available K 169.90–173.49 kg/ha and available S 14.2–14.3 kg/ha. In the rainy season, the treatments comprising 3 cropping systems [pigeonpea–wheat, pigeonpea + blackgram (blackgram stover removed)–wheat and pigeonpea + blackgram (blackgram stover incorporated)–wheat] and 3 fertilizer levels (none, 75 and 100% of the recommended dose of fertilizer) were replicated thrice in randomized block design. In the winter season, the rainy-season treatments constituted the main plots and 3 fertilizer levels applied to wheat (none, 75 and 100% of the recommended dose of fertilizers) as subplot, replicated thrice in the split-plot design. The recommended dose of fertilizers (RDF) for rainy-season crops and wheat were 18 : 46 : 20 : 20 kg/ha of N : $P_2O_5$ : $K_2O$ : S and 120 : 60 : 40 kg/ha of N : $P_2O_5$ : $K_2O$ respectively.

In rainy-season crops, all the N, P and K fertilizers (diammonium phosphate and muriate of potash) were applied at sowing, while sulphur (elemental sulphur) was applied 3 weeks before sowing. In wheat, entire P and K, and half of the N (diammonium phosphate, urea and muriate of potash) was applied at sowing, and the remaining N (urea) at the first irrigation. Each year, pigeonpea cv. ' UPAS 120' and blackgram cv. 'T 9' were sown in the last week of June and the following wheat cv. 'UP 2338' in the second week of December. Other management practices were adopted as per recommendations of the crops.

## RESULTS AND DISCUSSION

### *Effect of cropping system on pigeonpea*

The cropping systems did not affect the growth and yield attributes, viz. plant height, branches/plant, leaf-area index (LAI), pods/plant, seeds/pod and 1,000-seed weight, and yield of pigeonpea in both the seasons (Table 1).

The pigeonpea/blackgram (SR) intercropping was on par with the same system where stover of blackgram was incorporated, and these 2 systems recorded markedly higher pigeonpea equivalent than sole pigeonpea in both the years.

### *Effect of fertilizers on pigeonpea*

Application of fertilizers to rainy-season crops up to 75% of the recommended dose (RD) significantly enhanced the growth

**Table 1.** Effect of cropping system and fertilizers on growth and yield attributes of pigeonpea

| Treatment | Plant height (cm) | | Branches/ plant | | Leaf-area index | | Pods/ plant | | Seeds/ pod | | 1,000-grain weight (g) | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1997 | 1998 | 1997 | 1998 | 1997 | 1998 | 1997 | 1998 | 1997 | 1998 | 1997 | 1998 |
| *Cropping system* | | | | | | | | | | | | |
| Pigeonpea–wheat | 148.6 | 138.9 | 15.8 | 14.2 | 1.72 | 1.66 | 164.0 | 160.5 | 2.86 | 2.82 | 67.7 | 66.8 |
| Pigeonpea/blackgram (SR)–wheat | 146.9 | 140.1 | 14.9 | 14.3 | 1.69 | 1.63 | 165.3 | 161.1 | 2.78 | 2.75 | 67.1 | 66.2 |
| Pigeonpea/blackgram (SI)–wheat | 146.0 | 140.9 | 15.1 | 14.8 | 1.69 | 1.62 | 165.5 | 161.6 | 2.81 | 2.78 | 67.0 | 66.6 |
| CD (P = 0.05) | NS | NS | NS | NS | NS | NS | NS | NS | NS | NS | NS | NS |
| *Fertilizer (rainy season crops)* | | | | | | | | | | | | |
| None | 139.6 | 132.8 | 12.9 | 12.2 | 1.63 | 1.57 | 153.0 | 149.4 | 2.65 | 2.62 | 64.3 | 63.6 |
| 75% of recommended fertilizer dose | 147.5 | 140.3 | 16.2 | 15.3 | 1.69 | 1.62 | 165.8 | 161.9 | 2.81 | 2.77 | 68.1 | 67.4 |
| 100% of recommended fertilizer dose | 154.3 | 146.8 | 16.7 | 15.8 | 1.78 | 1.72 | 176.1 | 171.9 | 3.00 | 2.96 | 69.4 | 68.7 |
| CD (P = 0.05) | 11.7 | 9.7 | 1.0 | 0.8 | 0.12 | 0.12 | 9.0 | 9.8 | 0.26 | 0.09 | 4.4 | 4.9 |

SR, Stover removed; SI, Stover incorporated

attributes, viz. plant height, branches/plant and LAI of pigeonpea (Table 1).. The increasing rates of fertilizers in the rainy-season crops up to 100% recommended dose of fertilizers (RDF) markedly increased the pods/plant in both the years and seeds/pod in 1998 only. However, this level of fertilizer (100% RDF) resulted in significant increase in seeds/pod in 1997 and 1,000-seed weight in both the years over no fertilizer application (Table 1). The overall improvement in growth of pigeonpea with the addition of fertilizers could be ascribed to their pivotal role in several physiological and biochemical processes, viz. root development, photosynthesis, energy transfer reactions and symbiotic biological N-fixation process (Lakkineni and Abrol, 1994). The improvement in yield components might have resulted from favourable influence of fertilizers on the growth attributes, viz. plant height, branching, LAI and dry-matter accumulation, and efficient and greater partitioning of metabolites and adequate translocation of photosynthates and nutrients to developing reproductive structure (Tisdale *et al.,* 1995). These observations are in line with the findings of Sharma and Rajput (1997).

The fertilization of rainy-season crops at increasing rates up to 100% RDF significantly improved the seed yield of pigeonpea and pigeonpea equivalent in both the seasons and pooled data (Table 3). The increased yield of pigeonpea by application of fertilizers was largely a function of improved growth and consequent increase in yield-attributing characters. Our results are in conformity with those of Singh and Ali (1994) and Jat (1999).

### *Effect of cropping system on wheat*

Wheat crop after pigeonpea and blackgram (SI) intercropping recorded significantly higher values of growth and yield attributes, viz. tillers/m row length, spikes/m row length, grains/spike and 1,000-grain weight, and yield compared with wheat following sole pigeonpea and pigeonpea and blackgram (SR) intercropping (Table 2). The latter 2 systems recorded similar growth and yield attributes of wheat. This could be attributed to the fact that stover incorporation resulted in better soil physical condition (Hulugalle *et al.,* 1996) and increased nutrient availability (Collins *et al.,* 1992) which in turn favoured growth and development of yield attributes, and yield. The results confirm the findings of Shivakumar (1999).

### *Residual effect of fertilizers on wheat*

The residual effect of fertilizers was evident on growth and yield attributes, and yield of wheat in 1998–99 and pooled data. The effect on plant height was, however, marked in both the seasons. Application of 75% of the recommended dose (RD) of fertilizers being on a par with 100% of the RD to preceding rainy-season crops significantly increased the growth and yield attributes, viz. tillers/m row length, spikes/m row length, grains/spike and 1,000-grain weight, and yield of wheat over on fertilizer (Tables 2, 3). The plant height recorded marked increase at 100% of the RDF only over no fertilizer. The increased vigour and growth in terms of plant height and tillering

**Table 2.** Effect of cropping system, and direct and residual fertilization on yield attributes of wheat

| Treatment | Plant height (cm) | | Tillers/m row length | | Spikes/m row length | | Grains/ spike | | 1,000-grain weight (g) | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 1997–98 | 1998–99 | 1997–98 | 1998–99 | 1997–98 | 1998–99 | 1997–98 | 1998–99 | 1997–98 | 1998–99 |
| *Cropping system* | | | | | | | | | | |
| Pigeonpea–wheat | 76.5 | 72.1 | 94.0 | 90.0 | 79.4 | 72.6 | 35.2 | 32.5 | 46.4 | 43.1 |
| Pigeonpea/blackgram (SR)–wheat | 78.6 | 74.0 | 95.7 | 91.7 | 80.1 | 74.1 | 35.9 | 33.3 | 46.8 | 43.8 |
| Pigeonpea/blackgram (SI)–wheat | 79.4 | 74.9 | 98.5 | 95.1 | 86.0 | 77.0 | 39.1 | 34.5 | 48.0 | 46.6 |
| CD (P = 0.05) | 1.0 | 1.0 | 1.9 | 2.8 | 2.1 | 1.9 | 1.0 | 0.8 | 1.1 | 1.2 |
| *Fertilizer (rainy season crops)* | | | | | | | | | | |
| None | 77.4 | 72.9 | 95.2 | 89.2 | 80.7 | 72.5 | 36.2 | 32.2 | 46.5 | 43.3 |
| 75% RDF | 78.2 | 73.7 | 96.2 | 92.6 | 82.0 | 74.8 | 37.0 | 33.7 | 47.2 | 45.0 |
| 100% RDF | 78.9 | 74.4 | 96.7 | 95.0 | 82.8 | 76.3 | 37.1 | 34.4 | 47.4 | 45.2 |
| CD (P = 0.05) | 1.0 | 1.0 | NS | 2.8 | NS | 1.9 | NS | 0.8 | NS | 1.2 |
| *Fertilizer (wheat crop)* | | | | | | | | | | |
| None | 75.9 | 71.5 | 90.9 | 87.2 | 75.8 | 68.4 | 33.0 | 30.0 | 44.9 | 42.3 |
| 75% of recommended dose of fertilizer | 79.9 | 75.1 | 97.6 | 93.8 | 84.3 | 77.1 | 38.2 | 35.0 | 47.7 | 45.1 |
| 100% of recommended dose of fertilizer | 78.7 | 74.3 | 99.7 | 95.8 | 85.4 | 78.2 | 39.1 | 35.3 | 48.6 | 46.1 |
| CD (P = 0.05) | 1.5 | 1.5 | 3.1 | 3.9 | 3.6 | 2.4 | 1.4 | 1.1 | 1.6 | 1.8 |

SR, Stover removed; SI, stover incorporated

**Table 3.** Yield of pigeonpea and wheat, and the net return as affected by cropping systems and fertilizers

| Treatment | Pigeonpea yield (q/ha) | | | Pigeonpea equivalent (q/ha) | | Wheat yield (q/ha) | | | Net return (Rs/ha) (mean of 2 years) |
|---|---|---|---|---|---|---|---|---|---|
| | 1997 | 1998 | Pooled | 1997 | 1998 | 1997–98 | 1998–99 | Pooled | |
| *Cropping system* | | | | | | | | | |
| Pigeonpea–wheat | 14.98 | 13.83 | 14.41 | 14.98 | 13.83 | 31.66 | 28.44 | 30.06 | 20,621 |
| Pigeonpea/blackgram (SR)–wheat | 15.00 (2.85) | 14.63 (1.88) | 14.82 (2.37) | 17.85 | 16.51 | 31.68 | 29.29 | 30.48 | 23,584 |
| Pigeonpea/blackgram (SI)–wheat | 15.01 (2.69) | 14.73 (1.99) | 14.87 (2.34) | 17.70 | 16.72 | 32.71 | 30.49 | 31.60 | 23,867 |
| CD (P = 0.05) | NS | NS | NS | 1.30 | 1.37 | 0.77 | 0.89 | 0.71 | |
| *Fertilizer (rainy-season crops)* | | | | | | | | | |
| None | 13.41 (2.25) | 12.26 (1.81) | 12.84 (2.03) | 14.90 | 13.47 | 31.80 | 28.45 | 30.13 | 20,731 |
| 75% RDF | 15.01 (2.85) | 14.71 (1.96) | 14.86 (2.41) | 16.91 | 16.02 | 32.01 | 29.75 | 30.88 | 22,836 |
| 100% RDF | 16.57 (3.22) | 16.21 (2.04) | 16.39 (2.63) | 18.72 | 17.57 | 32.24 | 30.01 | 31.13 | 24,504 |
| SEm ± | 0.49 | 0.47 | 0.42 | 0.45 | 0.44 | 0.25 | 0.29 | 0.23 | |
| CD (P = 0.05) | 1.52 | 1.48 | 1.31 | 1.30 | 1.37 | NS | 0.89 | 0.71 | |
| *Fertilizer (wheat crop)* | | | | | | | | | |
| None | | | | | | 29.97 | 27.28 | 28.63 | 22,712 |
| 75% of recommended dose of fertilizer | | | | | | 32.95 | 30.21 | 31.58 | 22,815 |
| 100% of recommended dose of fertilizer | | | | | | 33.12 | 30.74 | 31.93 | 22,545 |
| CD (P = 0.05) | | | | | | 1.35 | 1.24 | 1.04 | |

Figures in parentheses indicate yield of blackgram.
SR, Stover removed; SI, Stover incorporated

owing to residual fertility led to better development of yield attributes and finally resulted in increased yield of wheat. These results confirm the findings of Nimje and Bhandakar (1996).

### *Direct effect of fertilizers on wheat*

The fertilization of wheat at 75% RDF being on a par with 100% RDF significantly enhanced the growth and yield attributes, viz. plant height, tillers/m row length, spikes/m row length, grains/spike and 1,000-grain weight, and yield of wheat over no fertilizer in both the seasons and pooled data (Tables 2, 3). This could be ascribed to continued and balanced supply of nutrients. The increased availability of nutrients and their active involvement in vegetative growth, was later translated into higher yield attributes and yield of wheat. Similar findings were also reported by Sharma and Rajput (1997).

### *Economics of cropping system*

The pigeonpea + blackgram (SI)–wheat cropping system fetched the highest mean net return. The rainy-season crops fertilized with 100% RDF recorded the maximum net return from the sequence. Direct application of 75% of the RD to wheat accrued the maximum net return from the pigeonpea–wheat system (Table 3). The results are in line with those of Sharma and Rajput (1997), and Shivakumar (1999).

## REFERENCES

Collins, H.P., Rasmussen, P.E. and Douglas, C.L. (Jr). 1992. Crop rotation and residue management effects on soil carbon and microbial dynamics. *Soil Science Society of America Journal* **56** (3) : 783–788.

George, M. 1987. 'Studies on the effect of cereal-cereal and cereal–legume cropping systems on the productivity and fertility of soil.' Ph.D. Thesis, Indian Agricultural Research Institute, New Delhi.

Hulugalle, N.R., Larsen, D.L. and Henggeler, S. 1996. Effect of broad beds and *Dolichos* residue management on properties of an irrigated vertisol. *Soil Technology* **8** (4) : 275–286.

Jat, H.S. 1999. 'Effect of layout, post-monsoon irrigation and fertilizers on pigeonpea (*Cajanus cajan* (L.) Millsp.).' M.Sc. Thesis, Indian Agricultural Research Institute, New Delhi.

Lakkineni, K.C. and Abrol, Y.P. 1994. Sulphur requirement of crop plants : Physiological analysis. *Fertiliser News* **39** (3) : 11–18.

Mahajan, K.K. and Khanna, S.S. 1968. Study on the recovery of added phosphorus in legume–wheat sequence. *Journal of Research, Punjab Agricultural University, Ludhiana* **5** : 545–548.

Nimje, P.M. and Bhandarkar, D.M. 1996. Effect of pigeonpea (*Cajanus cajan*) + soybean (*Glycine max*) intercropping and phosphorus fertilization on nitrogen requirement of wheat (*Triticum aestivum*). *Indian Journal of Agricultural Sciences* **66** (6) : 321–327.

Sharma, R.K. and Rajput, O.P. 1997. Production potential of pigeonpea (*Cajanus cajan*) intercropped with groundnut followed by wheat (*Triticum aestivum*) in sequence. *Indian Journal of Agronomy* **42** (1) : 53–55.

Shivakumar, B.G. 1999. 'Performance of greengram–wheat cropping system as influenced by land configuration, nutrient and stover management under limited water supply.' Ph.D. Thesis, Division of Agronomy, Indian Agricultural Research Institute, New Delhi.

Singh, B.N. and Ali, M. 1994. Response of *kharif* pulses to phosphorus and sulphur. *Fertiliser News* **39** (9) : 43–45.

Tisdale, S.L., Nelson, W.L., Beaton, J.D. and Havlin, J.L. 1995. *Soil Fertility and Fertilizers,* edn 5, pp. 62–675. Prentice Hall of India, Pvt. Ltd, New Delhi.