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# Yield performance and complementarity of rice (*Oryza sativa*) with greengram (*Phaseolus radiatus*), blackgram (*Phaseolus mungo*) and pigeonpea (*Cajanus cajan*) under different rice-legume associations

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## ABSTRACT

In a field investigation during the wet season of 1991 and 1992, the performance of rice (*Oryza sativa* L.) with associated legumes, viz. greengram (*Phaseolus radiatus* (L.) Millsp.], blackgram (*Phaseolus mungo* L.) and pigeonpea (Cajanus cajan L.) was studied under different inter- and mixed cropping systems. In rice, the number of effective tillers/$m^2$, number of filled grains/panicle, 1,000-grain weight and grain yield increased when intercropped with greengram and blackgram and decreased when mixed cropping of rice + pigeonpea was practiced. In associated greengram, blackgram and pigeonpea, the total number of branches/plant, number of filled pods/plant, number of seeds/pod, 1,000-seed weight and seed yield increased in different intercropping systems. The highest net returns and net return/rupee of investment were obtained from sole crop of pigeonpea. The relative crowding coefficient (RCC) and competitive ratio (CR) values were always greater than unity with all the intercropping systems. The land-equivalent ratio (LER) and monetary advantage (MA) were the highest with rice+greengram intercropping system at a higher level of fertility, whereas rice+pigeonpea intercropping system at a higher level of fertility showed the highest values of area-time equivalent ratio (ATER).

***Key words :*** Rice-based intercropping system, Greengram, Blackgram, Pigeonpea, Yield, LER, RCC

A major reason for the predominance of intercropping in poorly developed agriculture is that it can give greater stability of yield over a number of seasons. The basis for this is that if one crop fails or grows poorly, the other component crop or crops compensate; such compensation is not possible when the crops are grown separately. When crops of different growth habits are put together in an inter or mixed

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cropping system, it provides greater opportunity to secure higher yield from the same piece of land. Further, intercropping of legumes with cereals offers scope for developing energy-efficient and sustainable agriculture. The common characteristics of different forms of intercropping are that they have the effect of intensifying crop production and exploiting more efficiently environments with limiting or potentially limiting growth resources (Trenbath, 1982). The present investigation was carried out with an aim to study the yield complementarity of rice and associated crops when grown in different inter- and mixed cropping systems under typical rainfed upland condition.

## MATERIALS AND METHODS

The experient was carried out during the wet season of 1991 and 1992 under typical rainfed upland conditions at Kalyani. The soil of the experimental plot was well-drained sandy loam, having soil pH 7.4, organic carbon 0.67%, total N 0.073%, available P 13.76 kg/ha and available K 149.4 kg/ha. The experiment was laid out in randomized complete block design with 12 treatments replicated thrice. The details of the treatments are :

$T_1$:sole crop of rice (IR 36) 20 cm apart with 60:13.1:25 (N, P and K kg/ha); $T_2$ : sole crop of pigeonpea (UPAS 120) 30 cm apart with 20:17.5:0 (N, P and K kg/ha); $T_3$ : sole crop of greengram (B 105) 30 cm aprt with 20:17.5:0 (N, P and K kg/ha); $T_4$ : sole crop of blackgram (B 76) 30 cm apart with 20:17.5:0 (N, P and K kg/ha); $T_5$ : rice + pigeonpea (3 : 2), rice on wide-bed furrows (60 cm) and pigeonpea on raised beds (60 cm) with fertilizer dose as in $T_1$ ; $T_6$: same as $T_5$ with fertilizer dose as in $T_2$ ; $T_7$ : rice + greengram (3 : 2), rice on wide-bed furrows (60 cm) and greengram on raised beds (60 cm) with fertilizer dose as in $T_1$; $T_8$ : same as $T_7$ with fertilizer dose

**Table 1.** Yield components and yield of rice as influenced by different rice-legume associations (pooled data of 2 years)

| Treatment | No. of effective tillers/m² | No. of filled grains/panicle | No. of unfilled spikelets/panicle | Test wt (g) of 1,000 grains | Grain yield (kg/ha) |
|---|---|---|---|---|---|
| $T_1$ | 364.5 | 72.8 | 10.5 | 21.7 | 2,163 |
| $T_2$ | 191.0 | 71.2 | 15.3 | 22.2 | 1,110 |
| $T_3$ | 176.1 | 68.9 | 15.9 | 22.2 | 1,018 |
| $T_7$ | 236.5 | 78.3 | 12.2 | 23.5 | 1,418 |
| $T_8$ | 219.9 | 76.5 | 13.3 | 23.5 | 1,320 |
| $T_9$ | 228.3 | 77.7 | 13.2 | 23.0 | 1,358 |
| $T_{10}$ | 211.2 | 75.4 | 14.2 | 23.4 | 1,303 |
| $T_{11}$ | 155.8 | 66.3 | 17.1 | 22.6 | 875 |
| $T_{12}$ | 167.1 | 67.0 | 16.1 | 22.3 | 980 |
| CD (P = 0.05) | 28.3 | 7.4 | 2.0 | NS | 302 |

Treatment details are given under Materials and Methods

as in $T_2$; $T_9$ : rice + blackgram (3:2), rice on wide-bed furrows (60 cm) and blackgram on raised beds (60 cm) with fertilizer dose as in $T_1$; $T_{10}$ : same as $T_9$ with fertilizer dose in $T_2$; $T_{11}$ : rice + pigeonpea mixed cropping with fertilizer dose as in $T_2$; and $T_{12}$ : same as $T_{11}$ with fertilizer dose as in $T_1$.

In the component crops the yield and yield attributes were recorded at harvest. Greengram and blackgram were harvested in three pickings, whereas pigeonpea was picked only once. The net return, rice-equivalent yield and net return/rupee of investment were calculated.

## RESULTS AND DISCUSSION

### *Yield components and yield of rice*

In rice the sole crop always showed significantly higher numer of effective tillers/$m^2$ over ther treatments. Among the other intercropping treatments, the highest number of effective tillers/$m^2$ was recorded with rice + greengram intercropping system at a higher level of fertility ($T_7$), which indicated the effect of temporal complementarity. As the two crops, rice and greengram, differed remarkably in their durations of growth, the competition for growth resources at any particular stage between them was remarkably less. Singh and Jha (1984) also reported less risk from sorghum-based intercroppings with legumes where the difference in time between the harvests of component crops was 3-4 weeks. Due to the same reason, rice + blackgram systems gave significantly higher number of effective tillers/unit area over rice + pigeonpea intercropping combinations at the same level of fertility (Table 1). Observations on filled grains/panicle revealeld that legumes had some beneficial effect toward the number of filled grains/panicle in comparison with sole-crop plot of rice. However, in rice + pigeonpea system, both under mixed and intercropping combinations, the number of filled grains/panicle in rice was found to be significantly lower in comparison with that of the sole-crop plot. These systems also recorded higher number of unfilled spikelets/panicle. Though 1,000-grain weight did not follow any regular trend, it was also significantly influenced due to different inter- and mixed cropping systems during 1992 (Table 1). For the yield of rice, sole rice ($T_1$) produced significantly higher amount of grain yield over different inter- and mixed cropping systems. Again, at the same level of fertility, rice + greengram intercropping system always recorded significantly higher grain yield than rice + blackgram and rice + pigeonpea intercropping systems (Table 1). This was mostly due to early harvest of greengram, after which the resources were effectively utilized by rice, leading to development of temporal complementarity. Mandal *et al.* (1990) also found higher grain yield of rice in rice + greengram intercropping systems. The lower yield of rice in this system over other treatment combinations was mostly due to the effect of shading offered by pigeonpea. Sharma and Modgal (1984) also reported that the cultivation of pigeonpea on the ridges significantly decreased the rice yield.

### *Yield components and yields of pulse crops*

In greengram, blackgram and pigeonpea the number of total branches/plant, number

of filled pods/plant, number of seeds/pod and 1,000-seed weight were higher in different intercropping combinations over their respective crops (Table 2). These indicated better utilization of the resources (i.e. space and nutrient). Devi Dayal and Reddy (1991) also reported that paired row planting was advantageous in resource utilization and resulted in increased productivity of crops in different intercropping systems. Rice + pigeonpea mixed cropping systems also showed more number of total branches/plant, which indicated better utilization of space (Table 2).

Sole crops of greengram, blackgram and pigeonpea gave higher yields than their respective intercropping combinations. Among the different intercropping systems, higher seed yields of greengram, blackgram and pigeonpea were recorded at a higher level of fertility, indicating greater competition for nutrients between the component crops at the lower level of fertility. Mahapatra and Satpathy (1988) also found higher seed yield of pigeonpea in rice + pigeonpea intercropping system at a higher level of fertility. Again, in pigeonpea, at the same level of fertility, higher seed yield was obtained in intercropping than in the mixed cropping systems, indicating greater competition for light and nutrients in a mixed cropping system (Table 2).

### Economics

Sole crop of pigeonpea ($T_2$) showed the highest net return during both the years of experimentation. Among the different treatment combinations, sole crop of rice gave the lowest value of net return (Table

**Table 2.** Yield components and seed yield of greengram, blackgram and plgeonpea as influenced by different rice-legume associations (pooled data of 2 years)

| Treatment | No. of total branches/plant | No. of filled pods/plant | No. of seeds/ pod | Test wt (g) of 1,000 seeds | Seed yield (kg/ha) |
|---|---|---|---|---|---|
| *Greengram* | | | | | |
| $T_3$ | 9.3 | 191.0 | 11.4 | 30.0 | 1,078 |
| $T_7$ | 12.5 | 250.0 | 11.9 | 31.1 | 700 |
| $T_8$ | 11.8 | 217.6 | 11.5 | 31.2 | 610 |
| *Blackgram* | | | | | |
| $T_4$ | 6.9 | 147.9 | 6.8 | 39.4 | 1,008 |
| $T_9$ | 9.1 | 182.6 | 6.8 | 40.2 | 635 |
| $T_{10}$ | 8.7 | 174.4 | 6.9 | 40.5 | 580 |
| *Pigeonpea* | | | | | |
| $T_2$ | 10.3 | 354.5 | 4.9 | 126.0 | 1,605 |
| $T_5$ | 13.3 | 405.8 | 5.3 | 126.8 | 1,025 |
| $T_6$ | 12.4 | 385.6 | 5.0 | 126.3 | 895 |
| $T_{11}$ | 11.2 | 342.0 | 4.6 | 124.5 | 810 |
| $T_{12}$ | 11.5 | 369.0 | 5.0 | 125.8 | 905 |

**Table 3.** Effect of different rice-legume associations on eonomics (pooled data of 2 years)

| Treatment | Net return (Rs/ha) | Rice-equivalent yield | Net return/ rupee investment |
|---|---|---|---|
| $T_1$ | 4,683 | 2,163 | 1.07 |
| $T_2$ | 11,225 | 4,018 | 2.33 |
| $T_3$ | 8,180 | 3,230 | 1.72 |
| $T_4$ | 5,385 | 2,523 | 1.15 |
| $T_5$ | 8,620 | 3,665 | 1.38 |
| $T_6$ | 7,814 | 3,433 | 1.28 |
| $T_7$ | 7,885 | 3,515 | 1.23 |
| $T_8$ | 6,469 | 3,150 | 1.02 |
| $T_9$ | 5,727 | 2,970 | 0.89 |
| $T_{10}$ | 4,921 | 2,753 | 0.78 |
| $T_{11}$ | 6,110 | 2,903 | 1.08 |
| $T_{12}$ | 7,424 | 3,245 | 1.29 |

3). The net-return values were higher with a higher level of fertility, which resulted from higher yield of intercrops. Among the different inter- and mixed cropping systems, the highest net returns were obtained from rice + pigeonpea intercropping system at a higher level of fertility ($T_5$) during 1991 and rice + greengram during 1992.

Rice + blackgram intercropping system recorded higher rice-equivalent yield over the respective sole crops. Though during 1992 the rice + greengram intercropping recorded higher values of rice-equivalent yield over respective sole crops, during 1991 only at higher level of fertility intercropping system showed higher values over sole crop of greengram, mostly due to lower yield of component crops during this year. In pigeonpea the sole-cropped plots always showed better performance over those of different mixed and intercroping systems regarding rice-equivalent yield and net return/rupee investment, due to higher yield of pigeonpea from sole-crop plots coupled with better market price in comparison with rice. Further, different rice + pigeonpea mixed cropping systems recorded lower values of rice-equivalent yield due to poor performance of the component crops (Table 3).

### *Assessment of complementarity of rice-legume associations*

It was found that the coefficient values of rice were always greater than unity, indicating that rice produced more yield than expected. Pigeonpea also followed a similar trend.

However, the actual yields of grengram and blackgram were less than expected with lower level of fertility. But all the intercropping systems by far were found to be advantageous, as the product values (K) were always greater than unity (Table 4).

The CR values of rice were always greater than unity, which indicated that this crop was more competitive than legumes, whereas the legumes were found to be less competitive because the values were always less than unity (Table 4). Patra *et al.* (1990) also reported that cereal crop was more competitive compared with the legumes in maize-based intercropping systems .

The LER values in all the cases were always greater than unity, indicating yield advantage from all the intercropping combinations (Table 4). Rao *et al.* (1982) and Mandal *et al.* (1990) also reported similar

findings. Again, it was found that rice + greengram intercropping system at a higher level of fertility ($T_7$) recorded the highest LER values, indicating a considerable increase in resource-use efficiency. All the intercropping systems showed higher MA compared with sole crops, as the values of LER were always greater than unity (Table 4). When the values of ATER were considered, only rice + pigeonpea at a higher level of fertility ($T_5$) during 1991 appeared to be advantageous. During 1992, all the intercropping systems except rice + greengram and rice + blackgram at a lower level of fertility were found advantageous when crops duration was taken into consideration (Table 4). All the intercropping combinations gave 'RVT' values greater than unity, indicating that intercropping resulted in higher productivity/unit land over monoculture of the intercrop components. These were always higher at a higher level of fertility, mostly due to better yield of the component crops (Table 4).

Considering the differential cost of cultivation of rice-based intercropping systems in comparison with sole crop of rice, it was found that growing of greengram, blackgram and pigeonpea between rice rows was profitable, because the values of $RNR_{rice}$ exceeded unity in all the intercropping systems except in rice + blackgram at lower level of fertility during 1991. Rice + pigeonpea always showed higher values of RNR, mostly due to higher yield of pigeonpea. Patra *et al.* (1990) also obtained similar results in maize + pigeonpea intercropping system. However, the RNR values with respect to yield were always less than unity, except in rice + blackgram

**Table 4.** Effect of different rice-legume associations on competitive ratio (CR), relative crowding co-efficient (RCC), land-equivalent ratio (LER), monetary advantage (MA), area time equivalent ratio (ATER), relative value total (RTV) and relative net return (RNR) (pooled data of 2 years)

| Treatment | CR | | RCC* | LER | MA | ATER | RVT | RNR** | |
|---|---|---|---|---|---|---|---|---|---|
| | $CR_{Rice}$ | $CR_{Rice}$ | | | | | | $RNR_{Rice}$ | $RNR_{Legume}$ |
| $T_5$ | 1.20 | 0.85 | 1.85 | 1.14 | 1,796 | 1.01 | 1.70 | 1.48 | 0.83 |
| $T_6$ | 1.17 | 0.87 | 1.36 | 1.07 | 836 | 1.02 | 1.59 | 1.39 | 0.78 |
| $T_7$ | 1.50 | 0.67 | 3.58 | 1.30 | 3,259 | 0.94 | 1.63 | 1.39 | 0.96 |
| $T_8$ | 1.62 | 0.62 | 2.10 | 1.18 | 1,899 | 0.86 | 1.16 | 1.23 | 0.85 |
| $T_9$ | 1.47 | 0.70 | 3.05 | 1.27 | 2,507 | 1.02 | 1.36 | 1.13 | 1.00 |
| $T_{10}$ | 1.53 | 0.67 | 2.06 | 1.19 | 1,772 | 0.96 | 1.28 | 1.00 | 0.93 |

interropping system at lower level of fertility during 1991. It was mostly due to higher price of greengram, blackgram and pigeonpea which offered greater return from the respective sole crops over different intercropping systems.

Thus, it can be concluded that intercropping of rice + pulses like greengram, blackgram and pigeonpea is advantageous under rainfed upland conditions.

## REFERENCES


Devi Dayal and Reddy, P.S. 1991. Intercropping of rainfed groundnut with annual oilseed crops under different planting patterns. *Indian Journal of Agricultural Sciences* **61**(5) : 229-302.

Mahapatra, P.K. and Satpathy, D. 1988. Response of a pigeonpea and rice intercropping system to nitrogen fertilizer. *International Pigeonpea Newsletter* **8** : 8-9.

Mandal, B.K., Dhara, M.C., Mandal, B.B., Das, S.K. and Nandy, R. 1990. Rice, mungbean, soybean, peanut, ricebean and blackgram yields under different intercropping systems. *Agronomy Journal* **82** (6) : 1063-1066.

Patra, B.C., Mandal, B.K. and Mandal, B.B. 1990. Profitability of maize-legume intercropping systems. *Indian Agriculturist* **34** (4) : 227-233.

Rao, M.V., Jha, K.P., Moorthy, B.T.S. and Mandal, B.K. 1982. Intercropping greengram and groundnut with rice and fingermillet in the rainy season and the feasibility of a second crop in winter on rainfed uplands of coastal Orissa. *Indian Journal of Agricultural Sciences* **52** (10) : 657-664.

Sharma, H.L. and Modgal, S.C. 1984. Studies on agronomic control of soil moisture in upland rainfed crop. *Himachal Journal of Agricultural Science* **10** (1) : 23-26.

Singh, S.P. and Jha, D. 1984. Stability of sorghum based intercropping systems under rainfed condition. *Indian Journal of Agronomy* **29** (1) : 101-106.

Trenbath, B.R., 1982. *Proceedings of Frontiers of Research in Agriculture,* pp. 265-286. Golden Jubilee, International Conference, Indian Statistical Institute, Calcutta.