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# Growth and Productivity Performance of Different Rainy Season Legumes in the Gangetic Plains of West Bengal

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## ABSTRACT

This paper presents the results of a rainfed field experiment conducted at the Viswavidyalaya Farm, during rainy seasons of 1998 and 1999 in the Indo-Gangetic soil (entisol) in West Bengal (India) to evaluate the relative performance of rainy season legumes as compared with direct-seeded rice. The experiment was laid out in randomized block design with treatments, consisting of different rainy season legumes, viz., greengram, blackgram, soybean, groundnut (all for seed), ricebean (green fodder) and cowpea (green pod) along with direct-sown rice. The growth stages of different crops were described. Soybean proved to be the most efficient crop in respect of leaf and shoot growth, LAI (5.34), CGR (20.87), NAR (5.80), seed yield (2.49 t $ha^{-1}$), biomass yield (10.14 t $ha^{-1}$), rice equivalent yield (11.77 t $ha^{-1}$, 96 kg $ha^{-1}day^{-1}$) and net return (Rs.22511 $ha^{-1}$) [mean of two years]. Cowpea presented lower values of leaf and shoot growth, LAI (1.05), CGR (5.39), LAD (35 days) but higher values of NAR (6.24), economic yield (5.36 t $ha^{-1}$), rice equivalent yield (8.47 t $ha^{-1}$, 123 kg $ha^{-1}$ $day^{-1}$) and net return (Rs.14367 $ha^{-1}$) than most of the crops. All the rainy season legumes proved to be better than direct-seeded rice, out of which soybean and cowpea were highly efficient.

***Key words :*** Dry matter accumulation, Leaf area duration, Rice equivalent yield.

Rice is a principal crop during rainy season in the plains of West Bengal. Although, a number of legume crops can also be grown successfully during this season under rainfed condition (Verma *et al.*, 1978). Nitrogen fixation in legumes usually exceeds N-harvested in seed (Evans, 1987).

These crops have beneficial effect on the succeeding winter crops also (Basak and Shah, 1993). Role of pulses, in supply of high quality dietary protein, as

well as, maintenance of soil health and sustenance of agricultural production, emphasizes alternating cropping system, instead of upland rice, particularly, when farmers are not getting proper remuneration from rice cultivation. In this context, the present experiment was undertaken with the objective to study the growth and yield performance of different legumes as compared to direct-seeded rice crop during rainy season.

## MATERIALS AND METHODS

A field experiment was conducted at the Instructional Farm of the Viswavidyalaya situated at 22°56′ N latitude, 88°32′ E longitude and 9.75 m above mean sea level, during *kharif* (wet/rainy) seasons of 1998 and 1999, in upland Indo Gangetic soil (entisol) of West Bengal, India. During June to September 82% annual rainfall (1358 mm) is received in this area. The experiment was laid out in randomized block design, consisting of rainy season legumes, viz., greengram (cv. T-44), blackgram (cv. B-76), soybean (cv. PK-327), groundnut (cv. JL-24), ricebean (cv. K-1) and cowpea (cv. Luffa), along with direct-sown rice (cv. MW-10). The crops were sown in the fourth week of June with seed rates of 15 kg $ha^{-1}$ for greengram, blackgram, cowpea and ricebean, while 60 kg $ha^{-1}$ for groundnut and 80 kg $ha^{-1}$ for soybean and rice. The spacing maintained was 45 cm × 10 cm for greengram, blackgram and ricebean, while 45 cm × 5 cm for soybean, and 45 cm × 15 cm for groundnut and cowpea. Rice was direct-sown at 20 cm apart rows. The fertilizer dose was 20 : 40 : 20 for greengram and cowpea , 20 : 40 : 00 for blackgram and ricebean, 20 : 60 : 40 and 20 : 30 : 45 for soybean and groundnut , and 60(20+20+20):30:30 for rice, as kg $ha^{-1}$ of N, $P_2O_5$ and $K_2O$, respectively. The crops were grown as rainfed with recommened package of practices. Greengram, blackgram, soybean, and groundnut were grown for seed, cowpea for green pod, ricebean for green fodder and rice for grain.

## RESULTS AND DISCUSSION

### Growth stages of different crops

Seedling emergence and flowering and pod/ panicle development stages of different crops have been shown in Table 1. Flowering was early in groundnut and late in blackgram and rice. Duration was shortest in cowpea and greengram and longest in blackgram and ricebean.

### Dry matter accumulation

**Leaf :** Cowpea and greengram recorded very low leaf growth (Fig.1). Leaf growth of groundnut increased slowly till harvest. Leaf growth of soybean increased at high rate upto 84 DAS, and declined thereafter. There was gradual increase in leaf growth of ricebean upto and after first cutting at 63 DAS. Blackgram recorded very high rate upto 42 DAS. The peak leaf growth was early (42 days) for greengram and cowpea, medium (63 days) for blackgram and rice, and late for soybean (84 days) and groundnut (105 days). Peak leaf growth was the highest in soybean, followed by blackgram and rice. Ricebean apparently showed lower leaf growth due to cutting at 63 DAS, but addition of two cuttings would show maximum leaf growth. Ricebean, being grown for green fodder, recorded maximum duration of leaf growth of 133 days, i.e., till harvest.

**Pods/panicle :** The reproductive growth of groundnut continued for much longer period than that of other crops (Fig.2). In legume crops, pod dry weight was maximum in soybean, followed by groundnut, blackgram and greengram. Cowpea apparently recorded the lowest pod growth, which was mainly due to regular picking of green pods. Panicle growth of rice was just lower than the pod growth of soybean, but higher than that of other legumes. Reproductive growth was early in greengram and cowpea, late in blackgram, and intermediate for groundnut, soybean and rice.

**Shoot :** The shoot growth was maximum in soybean, closely followed by rice (Fig. 3) blackgram, ricebean, groundnut, greengram and cowpea. In ricebean, addition of two cuttings showed the shoot growth (without reproductive growth) just lower than soybean, but higher than that of all other crops. The rate of shoot growth of the crops was usually high at the final stage due to their steep rate of growth of pod/panicle (Fig. 2). However, final shoot growth was low in ricebean, due to one cutting at 63 DAS and no reproductive growth, and in cowpea due to regular picking of green pods. The early growth rate was slow in soybean and groundnut, but rapid in blackgram. Shoot growth of groundnut increased at high rate during later stage. Total shoot growth of greengram and cowpea did not increase much at the later stage. Peak growth rate was early in blackgram, but late in soybean and rice.

### Leaf area index (LAI)

The maximum (i.e., peak) LAI was recorded at 84 DAS in blackgram, soybean and groundnut, and at 63 DAS in rice (Fig. 4). The LAI of ricebean increased steadily upto and after first cutting at 63 DAS. In greengram and cowpea, peak LAI was at 42 DAS. The peak LAI was the highest in ricebean, followed by blackgram, soybean and rice. The LAI peak was very low in groundnut, greengram and cowpea. Sustenance of high LAI for a period of two samplings was observed in blackgram, soybean and ricebean but not in other crops.

### Crop growth rate (CGR)

The CGR of soybean and groundnut (Table 2) reached the maximum value at harvest. The CGR of soybean (20.87) was the highest at harvest due to high pod growth (Fig. 3). Blackgram, greengram and cowpea showed the highest CGR values at the first stage (21-42 DAS), that declined thereafter. The CGR of rice declined at the last stage, and that of ricebean, attained a negative value (at 63-84 DAS) due to first cutting.

### Net assimilation rate (NAR)

The NAR values of the crops (Table 3) were generally the highest/high at the earlier stage (21-42 DAS), when there was very low LAI and no question of mutual shading. Among different crops (at this stage), blackgram showed the highest assimilating efficiency, followed by groundnut, cowpea and greengram; rice recording the lowest efficiency. The NAR values decreased with advancement of age. The NAR of groundnut was much higher than all other crops throughout the growing period. The lower leaf area, characteristic phyllotaxy and disposition of leaves, leading to low mutual shading, maintained the NAR of groundnut at high level throughout the growing period. Soybean showed this efficiency less than groundnut, but higher than the other crops. The NAR of ricebean reduced to even negative values due to first cutting, after which there was again increase of NAR values at 63-84 DAS, which declined thereafter. The NAR of rice was low but the rate was more or less steady throughout the growing period.

**Table 1** Growth stages (days) of different rainy season crops (mean of two years)

| Crops | Seedling emergence | Flower emergence | 50% flowering | Setting of pod/panicle | 50% pod or grain development | Maturity |
|---|---|---|---|---|---|---|
| Greengram | 3 | 31 | 42 | 39 | 50 | 69 |
| Blackgram | 3 | 62 | 80 | 91 | 122 | 133 |
| Soybean | 5 | 49 | 68 | 72 | 95 | 122 |
| Groundnut | 3 | 23 | 32 | 37 | 84 | 111 |
| Ricebean | 3 | - | - | - | - | 133 |
| Cowpea | 2 | 30 | 35 | 37 | 50 | 69 |
| Rice | 2 | 67 | 77 | 80 | 91 | 105 |

**Table 2** Crop growth rates of different crops at different stages of growth (mean of two years)

| Crops | CGR | | | | |
|---|---|---|---|---|---|
| | 21-42 DAs | 42-63 DAS | 63-84 DAS | 84-105 DAS | 105-126 DAS |
| Greengram | 6.13 | 2.07 | - | - | - |
| Blackgram | 9.91 | 7.30 | 2.56 | 1.65 | 3.25 |
| Soybean | 2.59 | 7.92 | 9.28 | 20.87 | - |
| Groundnut | 2.56 | 3.30 | 4.76 | 7.86 | - |
| Ricebean | 4.16 | 5.87 | -1.15/5.44 | 4.76 | 5.04 |
| Cowpea | 5.39 | 0.61 | - | - | - |
| Rice | 3.72 | 7.75 | 8.39 | 7.08 | - |

**Table 3** Net assimilation rate of crops at different stages of growth (mean of two years)

| Crops | NAR | | | | |
|---|---|---|---|---|---|
| | 21-42 DAs | 42-63 DAS | 63-84 DAS | 84-105 DAS | 105-126 DAS |
| Greengram | 5.79 | 2.59 | - | - | - |
| Blackgram | 11.09 | 2.60 | 0.44 | 0.66 | 1.95 |
| Soybean | 4.19 | 3.96 | 1.91 | 5.80 | - |
| Groundnut | 9.22 | 9.05 | 6.02 | 8.22 | - |
| Ricebean | 4.03 | 2.65 | – 0.27/1.92 | 1.07 | 0.79 |
| Cowpea | 6.24 | 1.03 | - | - | - |
| Rice | 2.12 | 2.41 | 2.12 | - | - |

**Table 4** Leaf area duration (LAD), Number of primary branches and yield components of different crops (mean of two years)

| Crops | LAD (days) | No. of primary branch | Yield components | | | |
|---|---|---|---|---|---|---|
| | | | No. of plant/effective tiller $m^{-2}$ | No. of filled pod $plant^{-1}$ | No. of seed $pod^{-1}/grain^{-1}$ /$panicle^{-1}$ | Test weight (g) |
| Greengram | 41 | 4.7 | 43.3 | 20.4 | 4.8 | 23.4 |
| Blackgram | 352 | 6.9 | 30.8 | 36.2 | 3.0 | 22.5 |
| Soybean | 258 | 6.9 | 36.1 | 124.3 | 2.4 | 80.7 |
| Groundnut | 52 | 10.0 | 14.4 | 31.9 | 1.9 | 309.9 |
| Ricebean | 434 | 8.8 | 34.0 | - | - | - |
| Cowpea | 35 | 5.3 | 15.6 | 8.1 | 7.5 | - |
| Rice | 193 | - | 358.3 | - | 62.2 | 23.4 |

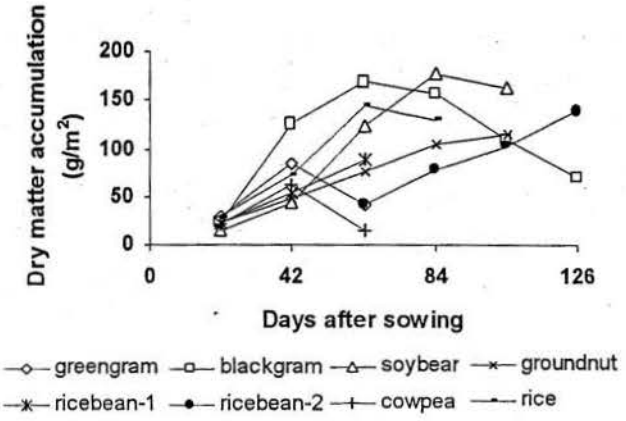


Fig 1 Dry matter accumulation in leaf of different crops at different growth stages [mean of two years]

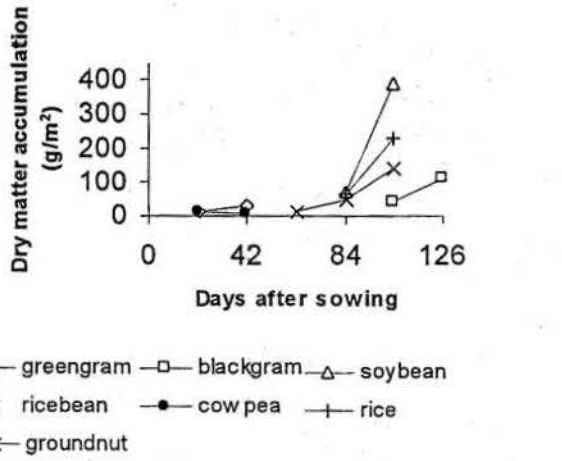


Fig 2 Dry matter accumulation in pod/ panicle of different crops at different growth stages [mean of two years]

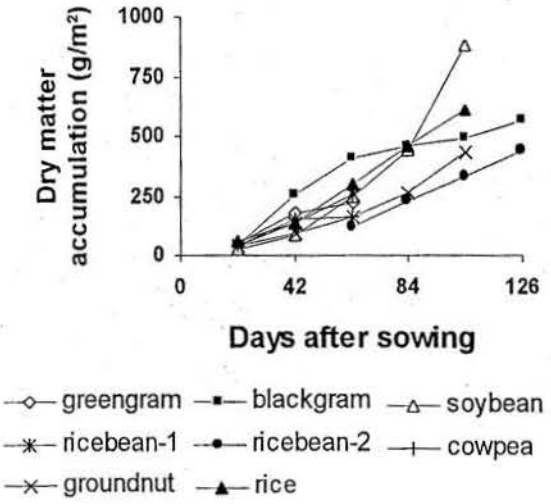


Fig 3 Dry matter accumulation in shoot of different crops at different growth stages [mean of two years]

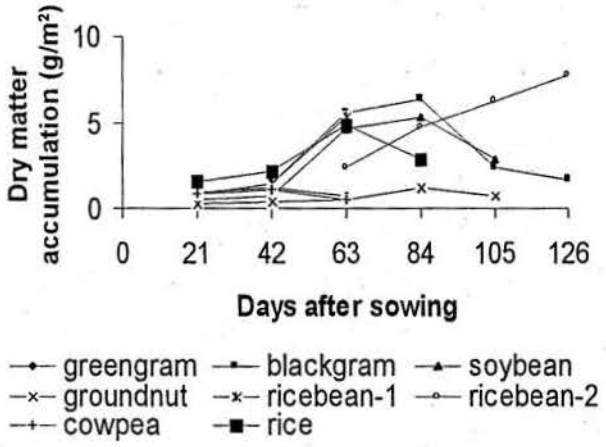


Fig 4 Leaf area index of different crops at different growth stages [mean of two years]

Table 5 Economic yield, rice equivalent yield, biomass yield and harvest index of different crops (mean of two years)

| Crop | Economic yield (t ha$^{-1}$) | Rice equivalent yield | | Biomass yield (t ha$^{-1}$) | Harvest index | Net return (Rs. ha$^{-1}$) |
|---|---|---|---|---|---|---|
| | | t ha$^{-1}$ | kg ha$^{-1}$ day$^{-1}$ | | | |
| Greengram | 0.48 | 3.79 | 55 | 2.57 | 0.18 | 5534 |
| Blackgram | 0.79 | 5.20 | 39 | 6.48 | 0.12 | 10773 |
| Soybean | 2.49 | 11.77 | 96 | 10.14 | 0.24 | 22511 |
| Groundnut | 1.07 | 5.27 | 47 | 4.93 | 0.22 | 10849 |
| Ricebean | 58.93 | 3.88 | 29 | 6.61 | 1.00 | 7452 |
| Cowpea | 5.36 | 8.47 | 123 | 1.89 | 0.84 | 14367 |
| Rice | 3.02 | 3.02 | 32 | 7.00 | 0.37 | 3494 |
| C.D. (P = 0.05) | 0.35 | 0.46 | 9.2 | 0.78 | | |

**Leaf area duration (LAD)**

Ricebean recorded the highest LAD value (Table 4), followed by blackgram and soybean, recording 125, 82 and 34 per cent higher LAD than that of rice, respectively. Cowpea, greengram and groundnut recorded 82, 79 and 73 per cent less LAD than rice, respectively.

**Number of branch per plant**

Number of primary branch per plant of legumes varied from crop to crop, mainly because of their own characteristics (Table 4), and was the highest in groundnut, followed by ricebean, soybean, blackgram and cowpea, and minimum in greengram.

**Yield components**

Among the legumes, the highest plant population was recorded in greengram, followed by soybean, ricebean and blackgram; the minimum being recorded in groundnut and cowpea (Table 4), depending on spacing. The number of filled pod per plant was the highest in soybean, followed by blackgram, groundnut and greengram. Cowpea recorded the lowest number. Cowpea, having much longer pod, recorded the highest number of seeds per pod, followed by greengram, blackgram, soybean and groundnut. Groundnut, having the largest seed size, recorded the highest test weight, followed by soybean. Test weights of greengram and rice were almost similar, and that of blackgram was slightly lower than the others.

**Economic yield**

Among the legumes, producing seed yield, soybean recorded the highest yield, followed by groundnut and blackgram; greengram producing the lowest yield (Table 5). In case of cowpea, green pod yield, and in ricebean, green fodder yield were taken as economic yields. Grain yield of direct-seeded rice was higher than the seed yield of soybean.

**Rice equivalent yield**

On the basis of rice equivalent yield, soybean was found to be the most productive one (Table 5), followed by cowpea, groundnut and blackgram. All the *kharif* legumes, producing different types of economic yields, recorded significantly higher equivalent yields than that of rice, indicating the legume crops to be more productive than the direct-seeded rice. Rice equivalent yield in terms of kg $ha^{-1}$ $day^{-1}$, was the highest in cowpea, followed by soybean, greengram, groundnut, blackgram and ricebean. The equivalent yields in terms of kg $ha^{-1}$ $day^{-1}$ of all the *kharif* legumes were higher than that of rice. This result emphasized the cultivation of *kharif* legumes instead of direct-sown rice in the upland of Gangetic alluvial soil of West Bengal.

**Biomass yield**

Biomass production indicated total dry matter production in shoot at final, i.e., the harvesting stage. It was the highest in soybean (Table 5), followed by rice, ricebean and blackgram. Biomass production in greengram and cowpea were much lower than that of the former ones; the cowpea producing the lowest biomass.

**Harvest index**

In ricebean, green shoot was the economic yield, and hence the economic yield and biological yield were the same (Table 5). In cowpea, green pods were harvested as economic yield, and therefore, the harvest index (HI) ratio was much higher than that of seed/grain yielding *kharif* crops. Among the latter crops, rice recorded the highest values of HI, indicating much higher efficiency in grain production than the legume crops grown for seed, which was obvious. Among the seed producing legumes, soybean showed the highest efficiency, followed by groundnut, greengram and blackgram, in terms of HI values.

**Net return**

Soybean recorded the highest net return, followed by cowpea, groundnut and blackgram (Table 5). The minimum return was obtained from direct-seeded rice.

Considering the economic use, rice equivalent yield, productivity and net return legumes were found to be superior to, and thus, better substitution of direct-seeded rice. Out of different *kharif* legumes, soybean was the best, followed by cowpea, groundnut and blackgram.

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