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# Effect of dates of sowing on dry matter production and partitioning in yam bean (*Pachyrrhizus erosus* (L) Urban)

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## ABSTRACT

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Climatic factors like temperature, relative humidity, rainfall, day length, and soil edaphic factors influence the growth and yield of a crop. The rate of dry matter accumulation remains faster at higher than lower temperature. However, high temperatures decrease the proportion of dry matter translocated to the tuber. Hence a field experiment was conducted in 1995 to 1996 at the Regional Centre of Central Tuber Crops Research Institute, Bhubaneswar to study the effect of climatic factors on dry matter production and partitioning in yam bean (*Pachyrrhizus erosus* (L) Urban). The results revealed no genotypic differences in dry matter production and yield, indicating that all genotypes used were equally efficient in dry matter production and partitioning. However, date of sowing has marked influence on dry mater production and yield. Sowing on the 17th of August led to the production of higher dry matter with the highest tuber yield comparable with those sown on the 1st of September because of their higher partitioning efficiency. Although the partitioning efficiencies of the October 1st and September 16th sowings were higher, these resulted in lower yield due to lack of sufficient dry matter. These findings clearly indicated that early sowing between the 17th of August and the 1st of September is essential for higher tuber yield in fertile acid laterite soil.

Keywords: distribution ratio, dry matter production, partitioning, yield

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## INTRODUCTION

Yam bean (*Pachyrrhizus erosus* (L) Urban) called "potato bean" in English,belongs to the family Leguminoceae and subfamily Fabaceae. It is a starchy root crop with comparatively high sugar content and moderately good amount of ascorbic acid. The crop has been cultivated in Mexico and South America from the pre-Colombian period and has originated from the moist region of the river Amazon (Varma *et al.*, 1996). The crop is now being cultivated in the Philippines, China, Indonesia, Cambodia, foot hills of the Himalayas in Nepal, Bhutan, Burma and India. In India, it is mostly grown in Assam, Bihar, Orissa, Eastern Utter Pradesh, and West Bengal. Young tubers are crisp, succulent, and sweet. Tuber contains more than 82% water. Because of the high water content, low calories, and bulky nature, it is good for salad preparation. Tender tubers are eaten raw or cooked as vegetable or made into pickles and chutney in Latin America. In China, mature dried tubers are reported to be used as cooling agent for people suffering from high fever (Varma *et al.*, 1996).

Climatic factors like temperature, relative humidity, rainfall, day length and soil edaphic factors influence the growth and yield of a crop. The rate of dry matter accumulation remains faster at higher than at lower temperature. However, high temperatures decrease the proportion of dry matter translocated to the tuber. Traditionally, yam bean is sown during June-July with the onset of rain in north and eastern India and is usually harvested in December-January. Early sowing enhances excessive vegetative growth with profuse flowering. When the crop is sown late in September and harvested in December-January, it gives relatively lower yield due to smaller size tubers. Hence, the present study was conducted to find out the effects of date of sowing on dry matter production and partitioning in yam bean genotypes.

## MATERIALS AND METHODS

A field experiment was conducted for two consecutive years, 1995 and 1996, at the Regional Centre of Central Tuber Crops Research Institute, Bhubaneswar to study the environmental effects on dry matter production and partitioning in yam bean genotypes. The treatments consisted of four genotypes

(8 x 9, L. No.3, EC 100546, and L-19) and four dates of sowing (17th of August, 1st of September, 16th of September and 1st of October). The genotypes had short duration and had semi-spreading growth habit. The experiment was laid out in randomised block design (factorial concept) with three replications. The plant spacing of 60 x 4 cm was adopted. A fertilizer dose of 75:50:5 kg ha $^{-1}$ of N, P,K was applied. Half of the nitrogen and potash as well as full dose of phosphorus was applied as basal and the remaining half of nitrogen and potash were top dressed, 30 days after sowing. Other recommended package of practices was duly followed. The crop was harvested 90 days after sowing.

Climate at the experimental site changed drastically after August. Temperature and relative humidity decreased until December. Monsoon rain continued up to October and November. In December, the climate was dry. However, protective irrigation was provided whenever plant showed wilting symptoms.

Composite soil samples taken at 0-15 cm depth from the experimental site were analyzed for initial nutrient status. The soil organic carbon was estimated as per Chapman (1976). Available nitrogen, phosphorus and potassium were determined by alkaline per manganate method of Subbiah and Asija (1956), Bray I method of Jackson (1967) and flame photometer (Jackson, 1967), respectively.

Total dry matter accumulation was partitioned into shoot and tubers at 45, 60, 75, and 9 days after sowing (DAS), since at 30 DAS, there was no tuber development in all the treatment plots. Distribution ratio (DR) as defined here is a more sensitive measure of short term changes in assimilate partitioning than in harvest index (HI). These parameters were calculated as follow:

$$DR = \frac{\text{Change in tuber dry weight}}{\text{Change in total dry weight}}$$

$$HI = \frac{\text{Tuber dry weight at harvest}}{\text{Total dry weight at harvest}}$$

The data were statistically analyzed using the MICROSTAT program. Significance was tested by 'F' value at 0.05 level of probability. The least significant differences between treatment means were calculated following the method detailed in Panse and Sukhatame (1967).

## RESULTS AND DISCUSSION

### *Weather*

Fortnightly average weather data presented in Table 1 revealed that maximum, minimum and mean temperatures decreased progressively. The decrease in minimum temperature was highly conspicuous and recorded less than 15 $^{0}$C in the month of December during 1995 and 1996. Progressive fortnightly interval recorded successive decrease in mean temperature. Relative humidity had similar trends as temperature. Forenoon (FN) relative humidity did not deviate much in successive fortnight during the entire crop growth duration in both years of study. However, afternoon (AN) relative humidity remained constant till September and then declined sharply. Fortnightly average, mean relative humidity decreased with successive fortnight from August to December. The total rainfall received during cropping period of 1996 was far les than 1995. However, the crop was given protective irrigation, whenever wilting occurs during both years.

### *Soil*

The soil of the experimental site was laterite. Pre-experiment pH of the soil was 4.8 and 5.1 during the year 1995 an d1996, respectively, indicating the acidic nature of the soil. The initial nutrient status of the soil during the year 1995 and 1996 were as follows: Organic carbon 0.39 and 0.41%, nitrogen 245 and 253 kg ha$^{-1}$, phosphorus 46.8 and 51.7 kg ha$^{-1}$,and potassium 88.7 and 80.2 kg ha$^{-1}$, respectively. Thus the soil analysis showed the low fertility status of the experimental field during the two-year period.

Table 1. Fortnightly average temperature and realtive humidity as well as total rain fall during the crop peirod of 1995 and 1996

| Period | 1995 | | | | | | | 1996 | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Temperature (ºC) | | | Relative Humidity (%) | | | Rainfall | Temperature (ºC) | | | Relative Humidity (%) | | | Rainfall |
| | Max | Min | Mean | FN | AN | Mean | (mm) | Max | Min | Mean | FN | An | Mean | (mm) |
| 17-31 Aug. | 32.7 | 25.5 | 29.3 | 93.3 | 78.5 | 85.6 | 126.4 | 31.1 | 24.7 | 27.9 | 93.6 | 78.4 | 85.9 | 158.8 |
| 1-15 Sept. | 32.4 | 25.5 | 29.0 | 92.3 | 72.1 | 82.5 | 58.0 | 32.4 | 25.3 | 29.4 | 28.9 | 68.8 | 80.9 | 10.5 |
| 16-30 Sept. | 31.3 | 25.4 | 28.3 | 94.0 | 77.9 | 85.5 | 181.8 | 33.8 | 24.9 | 29.4 | 92.2 | 67.6 | 79.9 | 57.4 |
| 1-15 Oct. | 30.8 | 24.5 | 27.6 | 95.0 | 80.3 | 87.3 | 256.3 | 32.2 | 23.7 | 28.0 | 93.4 | 63.3 | 78.4 | 86.7 |
| 16-31 Oct. | 30.3 | 2.8 | 26.5 | 90.8 | 69.3 | 84.7 | 78.7 | 31.6 | 22.5 | 27.1 | 91.9 | 60.1 | 76.0 | 22.5 |
| 1-15 Nov. | 30.0 | 19.8 | 25.1 | 89.7 | 57.1 | 73.4 | 174.8 | 30.9 | 20.2 | 25.6 | 92.7 | 55.1 | 73.9 | 16.3 |
| 16-30 Nov. | 28.5 | 18.1 | 23.3 | 90.6 | 58.8 | 74.4 | 8.7 | 29.4 | 14.7 | 22.1 | 91.7 | 37.7 | 64.7 | - |
| 1-15 Dec. | 28.8 | 14.4 | 21.9 | 91.7 | 42.8 | 66.9 | - | 28.0 | 14.1 | 21.2 | 79.9 | 34.9 | 57.4 | - |
| 16-31 Dec. | 29.0 | 15.0 | 22.0 | 92.0 | 44.0 | 68.0 | - | 28.0 | 11.7 | 19.9 | 90.0 | 35.0 | 62.5 | - |

Max - Maximum
Min- Minimum
FN - Forenoon
AN - Afternoon

*Dry matter production and partitioning*

The genotypes were not significanlty different from each other as far as shoot,tuber, and total dry matter production per plant are concerned at 30, 45, 60, 75 and 90 days after sowing during the years 1995 and 1996 (Table 2). However, the genotype L-19 recorded higher dry matter in all the plant parts in all the stages regardless of the years of sowing. Delayed sowing resulted in progressive reduction in dry matter accumulation in various plant parts (Table 2). Significanlty higher shoot, tuber and dry matter accumulation was recorded on the 17th of August sowing compared to the other sowing dates at all crop growth stages. However, the tuber dry weight of the plant sown on the 17th of August was comparable with that from the 1st of September sowing at all stages of crop growth in both years of investigation. When sown on the 1st of October the lowest shoot, tuber and dry matter accumulation per plant were noted at all stages of crop growth during both years of study. The decrease in dry matter accumulation with successive delayed planting might be due to the lower temperatures and relative humidity. This can be viewed from the weather data presented in Table 1. Prevalence of higher maximum, minimum and mean temperatures as well as mean relative humidity at early stages of crop growth, when sown on the17th of August resulted in higher dry matter accumulation. On the other hand, lower maximum,minimum and mean temperatures as well as mean relative humidity on the 1st of October sowing, resulted in lesser biomass accumulation. Sen *et al*. (1996) also found similar effect of temperature on dry matter production in yam bean.

Regardless of genotypes and date of sowing of yam bean,the tuber dry weight per plant at harvest (90 DAS) was heavier than shoot weight, though tuberisation started between 30-45 DAS (Table 2). Thus, the distribution of dry matter for tuber development in yam bean followed the patern of phasic partitioning (as observed in potato, sweet potato an dcassava) incontrast to the balanced partitioning noticed in sugar beet in which the growth of the storage organ begins early in the seedling stage and continues throughout the vegetative period of the plant (Loomis and Rapport, 1977). Furthermore, tuberisation in yam bean requires an inductive environment just like in potato (Milthorpe,1967).

The data on total dry matter production accumulation in tubers (Table 2)

Table 2. Dry matter distribution in shoot and root of yam bean varieties as influenced by date of sowing

| Treatments | 30 DAS* | 45DAS | | | 60DAS | | | 75DAS | | | 90DAS | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Total | Shoot | Tuber | Total | Shoot | Tuber | Total | Shoot | Tuber | Total | Shoot | Tuber | Total |
| 1995 | | | | | | | | | | | | | |
| Genotypes | | | | | | | | | | | | | |
| 8x9 | 0.8 | 4.7 | 0.7 | 5.4 | 9.6 | 8.0 | 18.2 | 14.6 | 18.3 | 32.9 | 18.2 | 29.8 | 48.0 |
| L.No.3 | 0.8 | 4.4 | 0.7 | 5.1 | 9.9 | 7.3 | 17.2 | 14.7 | 16.2 | 30.9 | 17.6 | 27.3 | 44.9 |
| EC 100546 | 0.8 | 4.5 | 0.8 | 5.3 | 9.9 | 7.3 | 17.2 | 15.4 | 16.6 | 32.0 | 18.5 | 28.2 | 46.7 |
| L-19 | 0.8 | 4.8 | 0.8 | 5.6 | 10.0 | 8.5 | 18.5 | 15.5 | 18.7 | 34.2 | 19.8 | 32.2 | 52.0 |
| LSD (P=0.05) | NS | NS | NS | NS | NS | NS | NS | NS | NS | NS | NS | NS | NS |
| Date of Sowing | | | | | | | | | | | | | |
| 17th of August | 1.2 | 7.9 | 1.0 | 8.9 | 15.0 | 12.3 | 27.3 | 23.0 | 25.2 | 48.2 | 28.8 | 42.0 | 70.8 |
| 1st of September | 0.9 | 5.2 | 0.9 | 6.1 | 11.3 | 11.7 | 23.0 | 19.7 | 23.8 | 43.5 | 22.5 | 37.4 | 59.9 |
| 16th of Sept. | 0.6 | 3.2 | 0.6 | 3.8 | 8.0 | 6.2 | 14.2 | 10.8 | 10.9 | 21.7 | 13.9 | 22.7 | 36.6 |
| 1st of October | 0.4 | 2.1 | 0.5 | 2.6 | 5.3 | 3.9 | 9.2 | 6.7 | 8.1 | 14.8 | 8.9 | 18.0 | 26.9 |
| LSD (P=0.05) | 0.1 | 0.4 | 0.1 | 0.8 | 0.9 | 1.3 | 1.5 | 1.1 | 3.8 | 4.1 | 2.5 | 5.4 | 8.2 |
| 1996 | | | | | | | | | | | | | |
| Genotypes | | | | | | | | | | | | | |
| 8x9 | 0.7 | 4.3 | 0.7 | 5.0 | 8.8 | 7.1 | 15.9 | 13.3 | 16.6 | 29.9 | 17.6 | 26.0 | 43.6 |
| L.No.3 | 0.7 | 4.1 | 0.5 | 4.6 | 8.7 | 6.5 | 15.0 | 13.3 | 15.1 | 28.4 | 15.5 | 26.1 | 41.6 |
| EC 100546 | 0.7 | 4.2 | 0.6 | 4.8 | 8.5 | 7.0 | 15.6 | 13.8 | 16.1 | 29.9 | 16.9 | 27.2 | 44.1 |
| L-19 | 0.7 | 4.4 | 0.7 | 5.1 | 8.8 | 8.0 | 16.9 | 14.6 | 17.2 | 31.8 | 18.3 | 28.1 | 46.4 |
| LSD (P=0.05) | NS | NS | NS | NS | NS | NS | NS | NS | NS | NS | NS | NS | NS |
| Date of Sowing | | | | | | | | | | | | | |
| 17th of August | 1.2 | 7.0 | 0.9 | 7.9 | 13.6 | 13.2 | 26.8 | 20.6 | 24.0 | 44.6 | 26.2 | 37.5 | 63.7 |
| 1st of September | 0.8 | 5.1 | 0.8 | 5.9 | 9.9 | 12.1 | 22.0 | 17.2 | 22.0 | 39.2 | 21.2 | 36.3 | 57.5 |
| 16th of Sept. | 0.6 | 3.1 | 0.5 | 3.6 | 7.1 | 5.4 | 12.5 | 9.7 | 10.8 | 20.5 | 11.7 | 19.8 | 31.5 |
| 1st of October | 0.3 | 1.8 | 0.3 | 2.1 | 4.2 | 3.8 | 8.0 | 7.6 | 8.0 | 15.6 | 9.1 | 13.3 | 22.4 |
| LSD (P=0.05) | 0.1 | 0.4 | 0.2 | 0.6 | 0.6 | 1.5 | 1.8 | 0.9 | 2.2 | 3.7 | 2.7 | 2.5 | 5.3 |

DAS* - Days after sowing NS - not significant

Table 3. Distribution ratio of yam bean genotypes as influenced by dates of sowing

| Treatments | 0-45 DAS* | | 45-60 DAS | | 60-75 DAS | | 75-90 DAS | |
|---|---|---|---|---|---|---|---|---|
| | 1995 | 1996 | 1995 | 1996 | 1995 | 1996 | 1995 | 1996 |
| Genotypes | | | | | | | | |
| 8x9 | 0.13 | 0.14 | 0.57 | 0.59 | 0.70 | 0.68 | 0.76 | 0.69 |
| L. No. 3 | 0.14 | 0.11 | 0.55 | 0.58 | 0.65 | 0.64 | 0.79 | 0.83 |
| EC 100546 | 0.15 | 0.12 | 0.55 | 0.59 | 0.63 | 0.64 | 0.79 | 0.78 |
| L-19 | 0.14 | 0.14 | 0.60 | 0.62 | 0.65 | 0.62 | 0.76 | 0.75 |
| Date of sowing | | | | | | | | |
| 17th of August | 0.11 | 0.11 | 0.61 | 0.65 | 0.62 | 0.61 | 0.74 | 0.71 |
| 1st of September | 0.15 | 0.13 | 0.64 | 0.70 | 0.59 | 0.55 | 0.83 | 0.78 |
| 16th of Sept. | 0.16 | 0.14 | 0.54 | 0.55 | 0.63 | 0.68 | 0.79 | 0.82 |
| 1st of October | 0.19 | 0.14 | 0.52 | 0.59 | 0.75 | 0.55 | 0.82 | 0.78 |

DAS* - days after sowing

indicated that higher total dry matter divert more dry matter to storage roots than those with lower total dry matter regardless of genotypes and date of sowing. Huett and O'Neill (1976) as well as Li and Yen (1988), had similar observation in sweet potato. Although the total dry matter accumulation with the 1st of September sowing was significantly lower than that of the 17th of August sowing, the tuber dry matter accumulation was comparable in all stages. This might be efficient partitioning of dry matter to tubers formed from the 1st of September sowing compared to those from the 17th of August sowing.

The data of distribution ratio (DR) indicated the efficiency of partitioning. The distribution ratios of 1st of September sowing was higher than the 17th of August sowing (Table 3). However, the distribution ratios of 1st of October as well as the 16th of September sowings were higher than those in the earlier sowings although plants from these sowing did not produce higher tuber yield. This might be due to lack of sufficient photosynthates in the plants. The distribution ratio also indicated the level of current photosynthates diverted to the developing tubers. Although late sowing diverted higher percentage of current photosynthates, it did not result to higher tuber yield because of lesser total photosynthates. Thus, the source and sink potentials are equally important in determining the storage roots yield (Hatten and Garner, 1979; Li and Kao, 1985; Nakatani *et al.*, 1988; Li and Kao, 1990). Several studies revealed a

Table 4. Effect of sowing dates on yield and harvest index of yam bean genotypes

| Treatments | Tuber yield (t ha$^{-1}$) | | Harvest index* | |
|---|---|---|---|---|
| | 1995 | 1996 | 1995 | 1996 |
| Genotypes | | | | |
| S-9 | 5.14 | 4.01 | 0.62 | 0.60 |
| L No. 3 | 4.68 | 4.03 | 0.61 | 0.63 |
| EC 100546 | 4.61 | 4.19 | 0.60 | 0.62 |
| L-19 | 5.23 | 4.33 | 0.62 | 0.61 |
| LSD (P=0.05) | NS | NS | NS | NS |
| Date of sowing | | | | |
| 17th of August | 6.80 | 5.75 | 0.59 | 0.59 |
| 1st of September | 5.96 | 5.74 | 0.62 | 0.63 |
| 16th of Sept. | 4.10 | 3.19 | 0.61 | 0.63 |
| 1st of October | 2.89 | 2.05 | 0.67 | 0.59 |
| LSD (P=0.05) | 0.93 | 0.60 | - | - |

NS - not significant
* - statistically not analysed

positive correlation between shoot weight and storage root weight, indicating that storage root growth is closely associated with shoot growth (Li, 1965; Ghuman and Lal, 1983; Ashokan *et al.*, 1984; Varughese *et al.*, 1987; Ravindran and Bala, 1987; Vimala *et al.*, 1988; Syriac and Kunju, 1989; Sen *et al*, 1990; Goswami, 1991; Mukhopadhyay *et al.*, 1991; Nair and Nair, 1992; Mukhopadhyay *et al.*, 1993).

### *Tuber yield*

There was no significant difference in yield among the genotypes (Table 4). Thus, all the genotypes studied in this experiment were equally efficient in dry matter production and partitioning (Table 2 and Table 3). Harvest indices of the genotypes (Table 4) did not show marked deviations. However, the genotype L-19 recorded higher yield during the two years of study. This might be due to higher dry matter production and accumulation in tubers (Table 2) as well as higher distribution ratio at early stages of crop growth (Table 3). The differences in tuber yield per ha of yam bean sown at various dates were statistically observable with significant disparity between any two successive sowing dates. Maximum tuber yield ha$^{-1}$ (6.80 t ha$^{-1}$) was obtained with the

17th of August sowing which was significantly higher than those sown at other dates except the 1st of September sowing.

It was observed that thermoperiodism affected tuberisation. Yam bean requires 14-15 hours of photoperiod for good vegetative growth and shorter days for better tuberisation. The long hours of daylight during early growth of plants sown on the 17th of August led to higher tuber yield. The lowest tuber yield $ha^{-1}$ was recorded with the 1st of October sowing (Table 4). This might be due to the insufficient vegetative growth (Table 2) for tuber development, which resulted in lower tuber yield. Harvest indices of plants (Table 4) indicated that there was not much deviation in this parameter with fortnighlty delayed sowing. Further, it implied that sink size is proportional to source size. Similar findings were reported by Sen *et al* (1996). There was no interaction effect between genotypes and date of sowing on tuber yield during the two years of study.

## CONCLUSION

From the results of the study, it can be concluded that delayed sowing would result in reduced dry matter accumulation owing to the lower temperature and relative humidity, regardless of genotypes. The genotypic differences on dry matter production and tuber yield are not observed indicating that all the gentypes are equally efficient. More dry matter is diverted to storage root when total dry matter is high. Sink size is proportional to source size regardless of genotypes and date of sowing. Neither distribution ratio nor harvest index influenced the production of higher yield. Optimum dry matter production and distribution ratio were observed to be essential for hgiher yield. Thus, sowing of yam bean between the 17th of August and the 1st of September appears to be the optimum time for higher tuber production under low fertile acid laterite soil.

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