Effect of Planting Patterns on Dry Matter Accumulation of Soybean Plants

Kulathungam WIJEYATHUNGAM, Hideho MIURA
and Takuma GEMMA

Abstract

A field experiment was conducted to study the dry matter accumulation of soybean plants under three planting patterns namely, rectangular, square and triangular plantings at two levels of planting density.

The dry matter accumulation was influenced by planting patterns within planting densities. At the standard density the total dry weight of square planting was higher than the other two planting patterns. The seed yield was similar in both square and triangular plantings and these were higher than that of rectangular planting. At the high density, triangular planting gave more total dry weight and seed yield than the other two planting patterns. From these results, it was found that the equidistant arrangement of plants tended to perform better than traditional rectangular planting in dry matter accumulation.

The branch weight showed the same response as total dry weight to planting patterns at both the densities. The response of branch seed yield was the same as that of total plant seed yield including main stem seed yield. But higher total dry weight within particular planting patterns did not always give higher seed yield.

Introduction

It has been suggested that higher yield could be obtained by the improvement in the partitioning of assimilates into the harvested fractions[3]. SHIBLES and WEBER[7] found that the seed yield of soybean [*Glycine max* (L.) Merr.] was not correlated with total dry matter produced and the seed yield was a function of different utilization of photosynthates between vegetative growth and seed production.

It was shown in our previous papers[4, 5] that the seed yield of soybean and the growth of branches varied with planting patterns, which refered to the different ways of plant arrangement under given planting densities. It has also been noted that there is a drastic

Laboratory of Forage Crops, Obihiro University of Agriculture and Veterinary Medicine, Obihiro 080, Japan.

reduction in branching with increasing planting density[1,6,9]. It is reasonable to think that there will be changes in partitioning of assimilates among different parts of the plant with changes in interplant competition. It is expected that the dry matter accumulation in different plant parts will be influenced by planting patterns.

The objective of this experiment was to compare the dry matter accumulation in different parts of soybean plants under three planting patterns, namely rectangular, square and triangular plantings at two levels of planting density.

Materials and Methods

During the 1986 growing season, the experiment was conducted at the experimental field of Obihiro University of Agriculture and Veterinary Medicine. The soil type of the field was stratic fluffy brown andosols (Entic Hapludands). Two determinate cultivars, Toyosuzu and Suzuhime, were used in this experiment. The area of a plot was 3.9m × 3.5m. The arrangement of plants under rectangular, square and triangular plantings at two levels of planting density are given in Table 1.

All plots were seeded at the rate of four seeds per hill on May 22 and thinned to two plants four weeks after planting. Compound fertilizer was applied at the rate of 0.2g-N, 1.9g-P and 1.0g-K per hill as the basal dressing. Weed, insect and disease controls were carried out whenever it was necessary.

Six plants from three hills were taken from each plot at the following developmental stages as defined by KALTON *et al.*[2]: stage 2 – three trifoliate leaves completely unrolled; stage 3 – five to six trifoliate leaves completely unrolled; stage 5 – plants in full bloom; stage 7 – beginning of seed formation; and stage 9 – maximum dry matter accumulation stage. At harvest maturity stage, 10 plant samples from five hills in each plot were taken. For the analysis of dry matter accumulation in plant parts, each plant sample of all stages was separated into leaves, petioles, stems and branches, pods and seeds (when that part was present). Leaf area of each sample was measured with an automatic leaf area meter (Hayashidenko AAM-7). The plant parts were dried separately at 70℃ for 48 hours and weighed.

Table 1. Arrangement of plants under rectangular, square and triangular plantings at the two levels of planting density.

Planting pattern	Planting density	
	Standard 800 hills/a[1)]	High 1200 hills/a
Rectangular	66.0cm × 19.0cm	66.0cm × 12.6cm
Square	35.5cm × 35.5cm	28.9cm × 28.9cm
Triangular	38.0cm × 33.0cm	31.0cm × 26.9cm

1) Each hill consists of two plants.

Results

Dry matter accumulation

The total dry weight, excluding the weights of fallen leaves and roots, and the dry matter accumulation in different parts of the plant of two cultivars, under different planting patterns at the two levels of planting density are illustrated in Fig. 1a-d. Total dry weight and reproductive dry weight are as per unit area of land (m²).

At the standard density, Suzuhime showed no difference in total dry weight among planting patterns during early stages but square planting gave higher total dry weight than the other two planting patterns at the beginning of seed formation stage and the maximum dry matter accumulation stage. At harvest maturity, total dry weight and reproductive dry weight of this cultivar in both square and triangular plantings were almost the same. Toyosuzu also showed the same response as did Suzuhime to planting patterns. But total dry weight and reproductive dry weight in square planting were higher than those of the other two planting patterns at all stages.

At the high density, the response of Suzuhime and Toyosuzu to planting patterns was similar. Although there were no differences among planting patterns during early stages, triangular planting tended to give more total dry weight and reproductive dry weight than the other two planting patterns at all stages after the three trifoliate stage. The total dry weight and reproductive dry weight of rectangular planting were higher than that of square planting at all stages, except at harvesting stage.

Leaf area index (LAI)

As shown in Fig. 2, at the standard density, triangular planting gave the highest LAI in Suzuhime through various developmental stages, whereas it was highest under square planting in Toyosuzu. The maximum LAI was at the beginning of seed formation stage for both cultivars.

At the high density, triangular planting gave the maximum LAI of 5.9 in Suzuhime and 4.8 in Toyosuzu. Rectangular planting had higher LAI than the other two planting patterns at the beginning of seed formation stage in both the cultivars.

Branch weight and stem weight

The dry weights of main stem and branches were taken separately at harvest maturity and are given in Fig. 3. It was found that at the standard density, square planting gave higher main stem and branch weights in both the cultivars. However, the branch weight per plant was reduced in square and rectangular plantings in both the cultivars at the high density with a drastic reduction in the former. The branch weight in triangular planting was not affected by planting density.

Seed Yield

There were little differences between cultivars in response of the seed yield per unit area to planting patterns. As shown in Fig. 4, at the standard density the seed yield was almost the same for square and triangular plantings, but higher than that in rectangular planting. On the other hand, at the high density, triangular planting gave the highest seed yield. These responses of seed yield to planting patterns and densities were dependent on the response of branch seed yield rather than main stem seed yield.

Discussion

The results showed that branch weight was reduced in rectangular and square plantings at the high density in both the cultivars. But branch weight in triangular planting was not affected by planting density.

As Miura *et al.*[5] suggested, at the high planting density, plants grown under rectangular planting are closely spaced within rows, and thus branching is restricted in the direction of rows. The plants, however, can extend the branches towards the interrow spaces. On the other hand, the plants grown under square planting are crowded in both directions, thus branching is restricted more than in rectangular planting. In the case of triangular planting, plants are arranged alternatively in rows, so it seems that more space is available between the adjacent plants, allowing the plants to spread the branches well in all directions even at the high density.

When the branch weight is more, the weights of the associated parts such as leaves and petioles also increase, thus resulting in higher total dry weight. In the experimental results, the response of branch weight and the total dry weight to planting patterns was the same. But higher maximum LAI did not always associate with higher total dry weight among planting patterns. One of the reasons for this seemed to be that superfluous leaf area probably resulted in photosynthates being used inefficiently[7].

It was clear that the dry matter accumulation in different parts of soybean plants was influenced by planting patterns within planting densities (Fig. 1a-d). The response of total dry weight was dependent on that of branch weight, and the seed yield was dependent on branch seed yield. There was a positive correlation between the maximum total dry weight and the seed yield over planting patterns, densities and cultivars ($r=0.69^{*}$). However, higher total dry weight within particular planting patterns did not always give higher seed yield. Similar results were reported[7,8], but the detailed reasons are still uncertain. Therefore, further studies are needed to elucidate the exact role of branches, by comparing the dry matter accumulation and seed yield of debranched plants with that of normal plants.

References

1) COSTA, J.A., E.S.OPLINGER, and J.W. PENDELTON 1980. Response of soybean cultivars to planting patterns. Agron. J. **72**: 153-156.

2) KALTON, R.R., C.R.WEBER, and J.C. ELDREDGE 1949. The effect of injury simulating hail damage to soybeans. Iowa Agri. Exp. Sta. Res. Bul. 359.

3) LOOMIS, R.S., R. RABBINGE, and E.NG 1979. Explanatory models in crop physiology. Ann. Rev. Plant Physiol. **30**:339-367.

4) MIURA, H. and T.GEMMA 1986. Effect of square planting on yield and its components of soybean under different levels of planting density. Japan. Jour. Crop Sci. **55**: 483-488.

5) MIURA, H., K. WIJEYATHUNGAM and T. GEMMA 1987. Variation in seed yield of soybean as affected by planting patterns. Japan. Jour. Crop Sci. **56** (in press).

6) NAKASEKO, K. and K. GOTOH 1981. Comparative studies on dry matter production, plant type and productivity in soybean, azuki bean and kidney bean. III. Dry matter production of soybean plant at various population densities. Japan. Jour. Crop Sci. **50**: 38-46. *

7) SHIBLES, R.M. and C.R.WEBER 1965. Leaf area, solar radiation interception and dry matter production by soybeans. Crop Sci. **50**: 38-46. *

8) TANNER, J.W. and A. SHABIR 1974. Growth analysis of soybeans treated with TIBA. Crop Sci. **14**: 371-374.

9) WEBER, C.R., R.M. SHIBLES and D.E.BYTH 1966. Effect of plant population and row spacing on soybean development and production. Agron. J. **58**: 99-102.

* In Japanese with English summary.

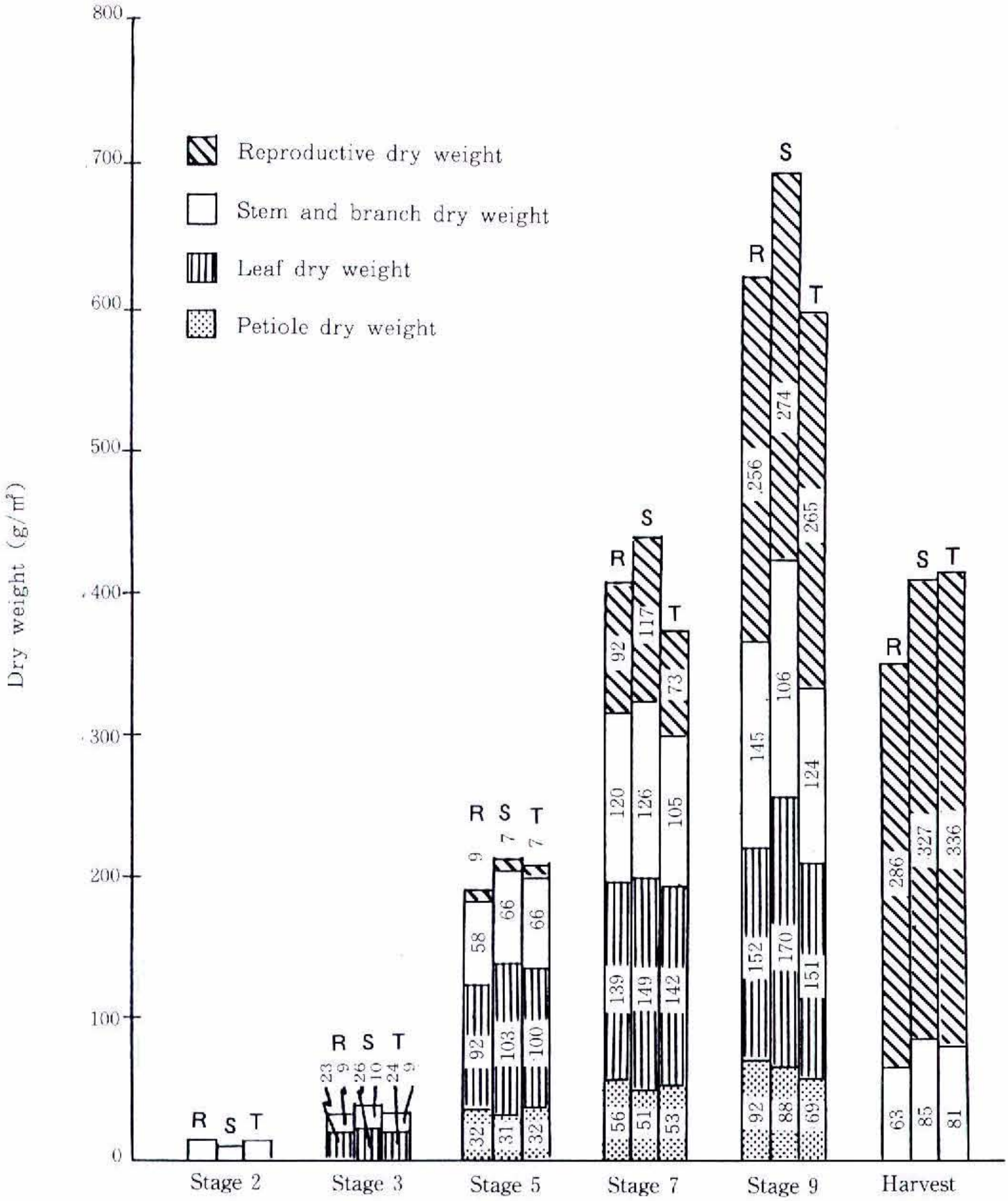

Fig. 1a. Dry weight of plant parts of Suzuhime at various stages of growth as influenced by planting patterns at the standard density.
R, S, T: Rectangular, Square and Triangular plantings respectively.

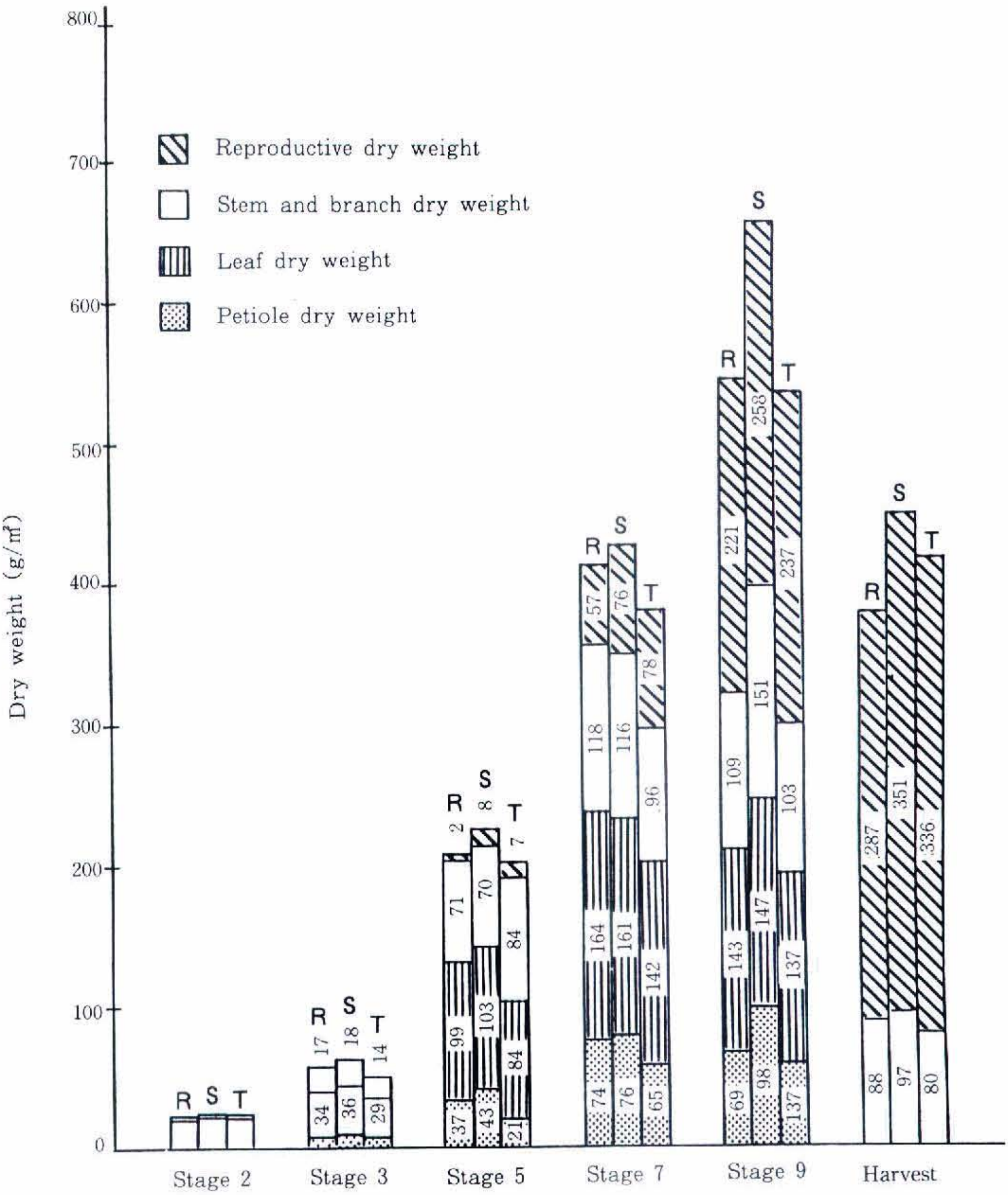

Fig. 1b. Dry weight of plant parts of Toyosuzu at various stages of growth as influenced by planting patterns at the standard density.
R, S, T: Rectangular, Square and Triangular plantings respectively.

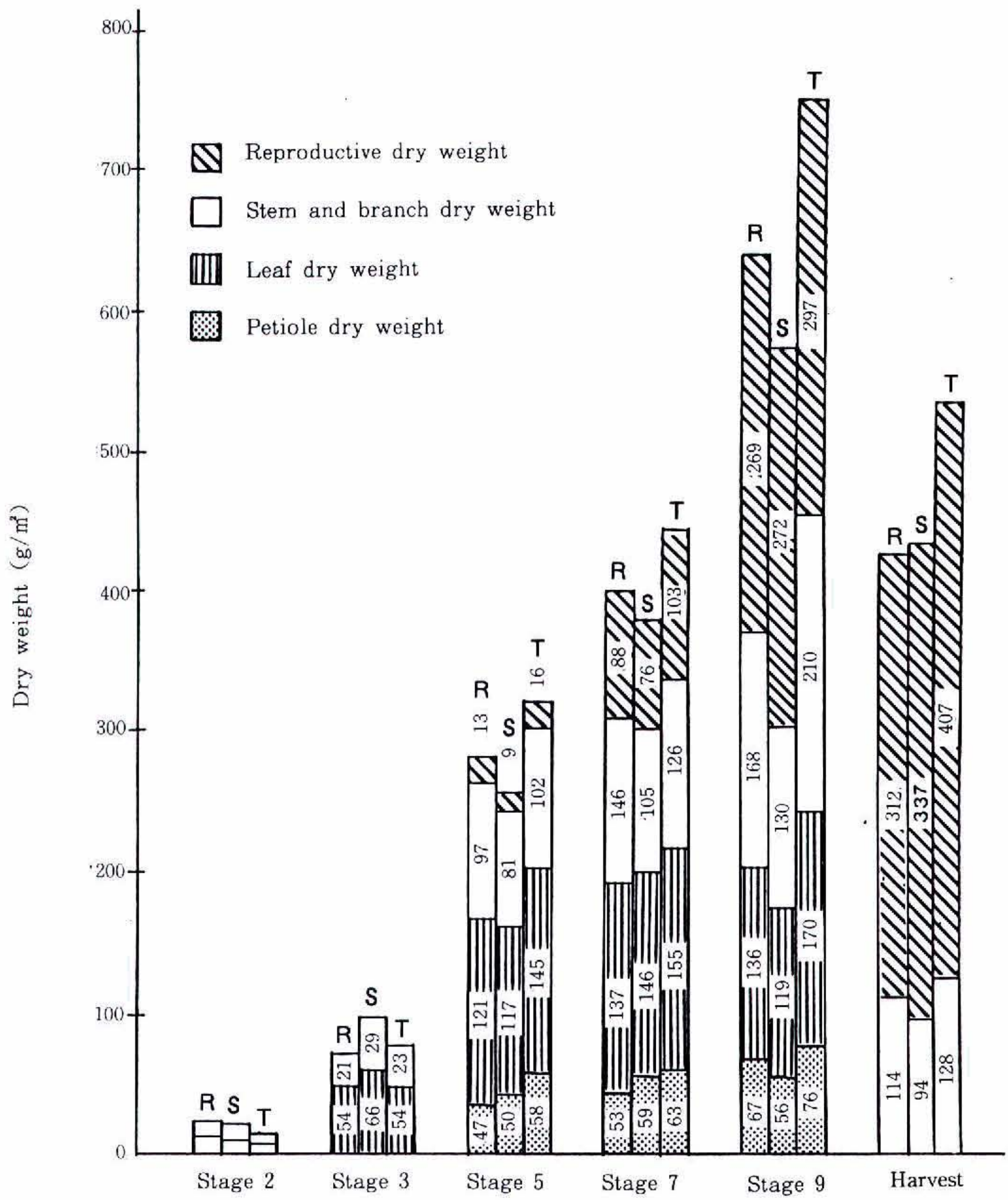

Fig. 1c. Dry weight of plant parts of Suzuhime at various stages of growth as influenced by planting patterns at the high density.
R, S, T: Rectangular, Square and Triangular plantings respectively.

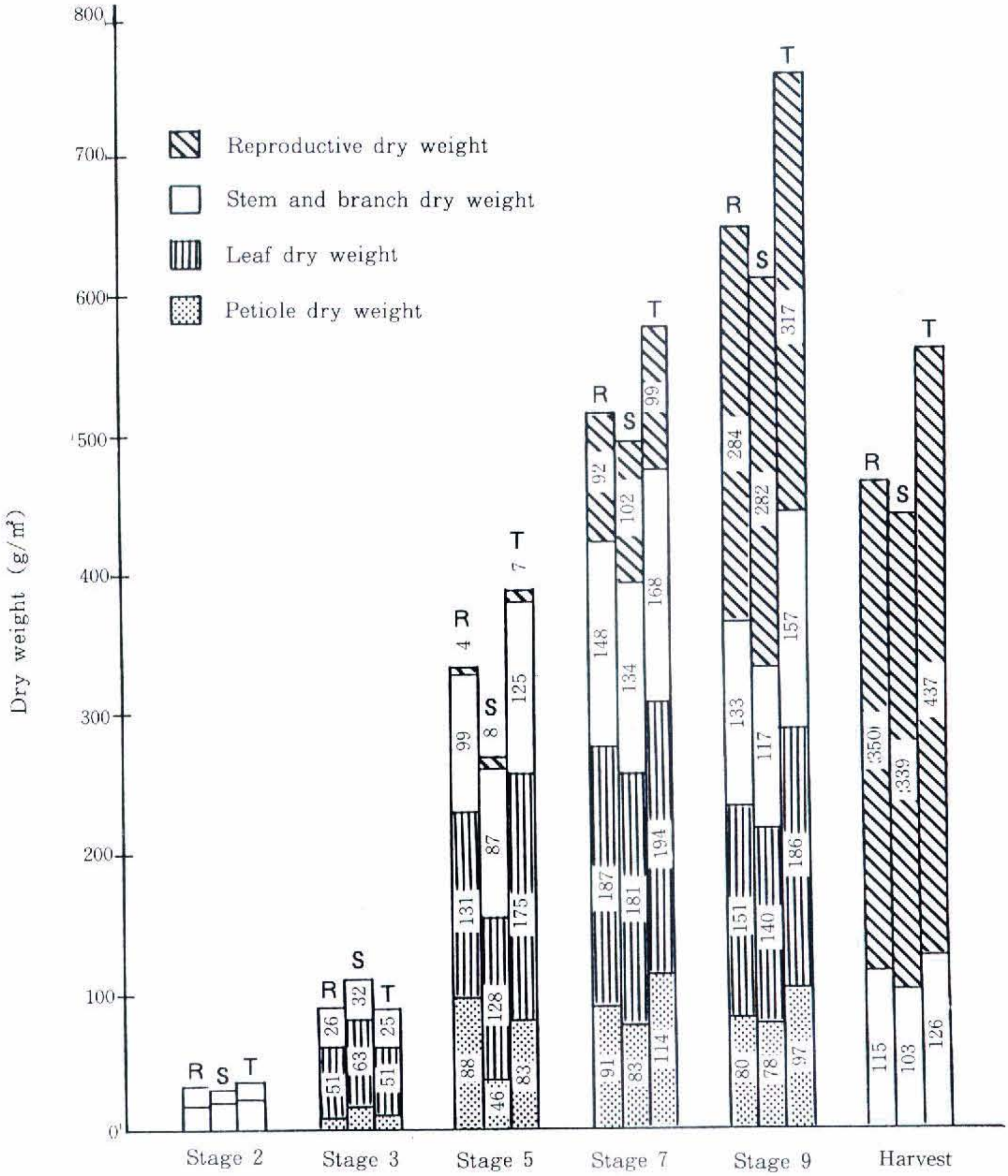

Fig. 1d. Dry weight of plant parts of Toyosuzu at various stages of growth as influenced by planting patterns at the high density.
R, S, T: Rectangular, Square and Triangular plantings respectively.

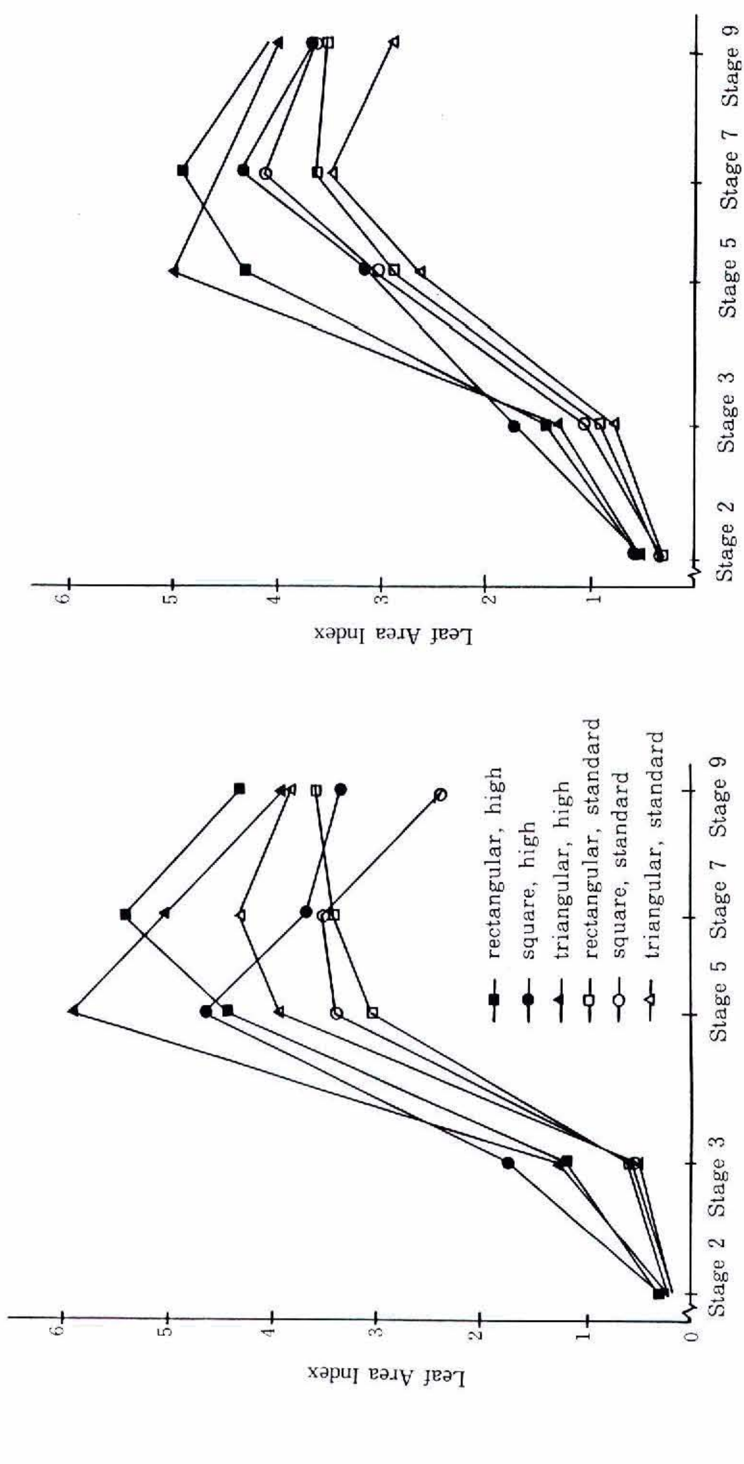

Fig. 2. Leaf Area Index of Suzuhime (left), and Toyosuzu (right) at various stages of growth as influenced by planting patterns at the two planting densities.

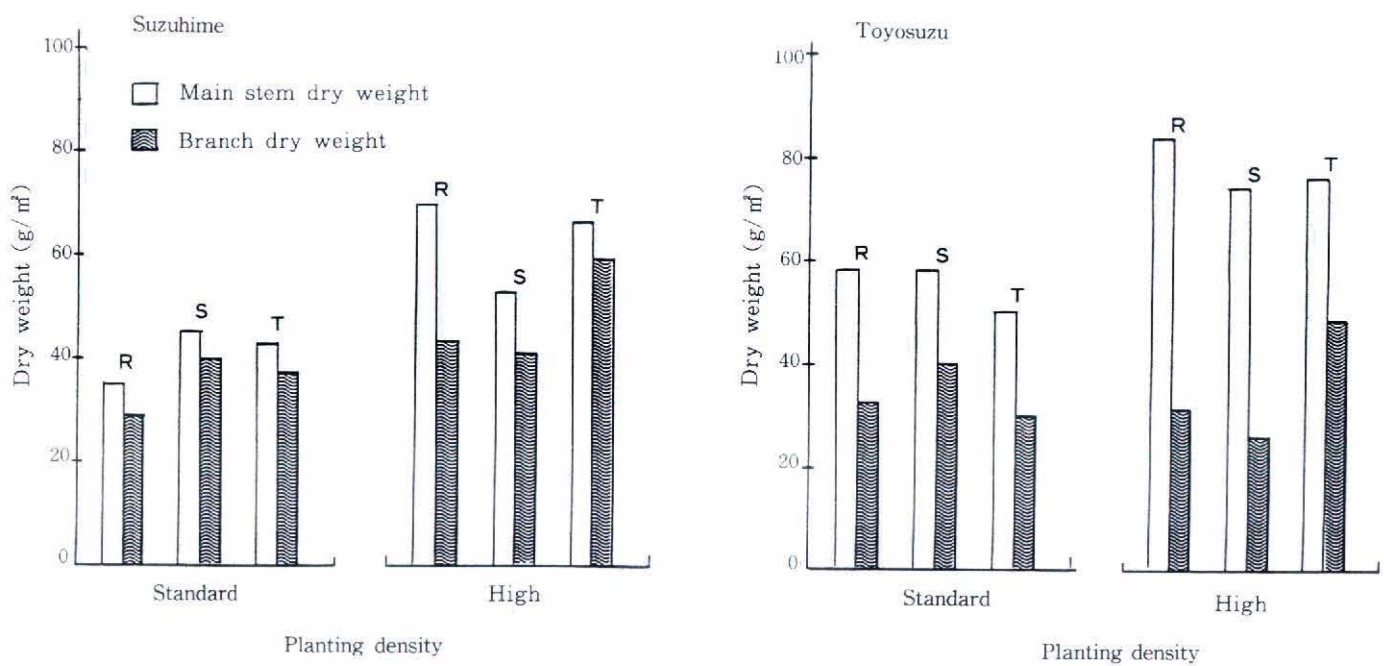

Fig. 3. Main stem and branch dry weights of Suzuhime (left), and Toyosuzu (right) taken at harvesting stage as influenced by planting patterns at the two planting densities.
R, S, T: Rectangular, Square and Triangular plantings respectively.

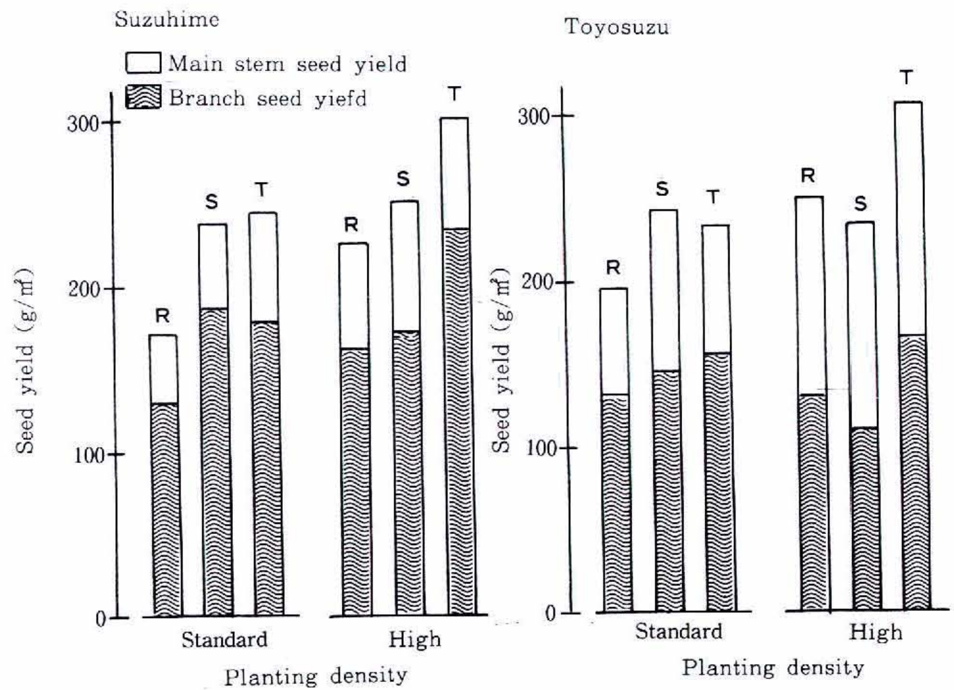

Fig. 4 Branch seed yield and main stem seed yield per square meter of Suzuhime (left) and Toyosuzu (right) taken at harvesting stage as influenced by planting patterns at two planting densities.
R, S, T: Rectangular, Square and Triangular plantings respectively.

栽植様式の違いがダイズの乾物生産に及ぼす影響

K. ウイジェヤトゥンガム・三浦秀穂・源馬琢磨
帯広畜産大学飼料作物学研究室
（北海道帯広市稲田町）

摘　　要

栽植様式の違い（長方形植え，正方形植え，および正三角形植え）が，ダイズの生育と乾物生産に及ぼす影響を標準密度区（800株／a；1株2本立て）と高密度区（1200株／a）で検討した。試験は，トヨスズとスズヒメの2品種を用いて，1986年に帯広畜産大学作物試験圃場で行われた。

単位面積当たりの全乾物重は，生育期間を通じて栽植様式によって影響を受けた。標準密度区では，正方形植えが他の二つの栽植様式より高い乾物生産を示した。しかし，高密度区では，正三角形植えが高い乾物生産を示した。子実収量は，標準密度区で正方形植えと正三角形植えが高く，高密度区では正三角形植えが他の二つの栽植様式を上回った。栽植様式の違いに対する品種間の反応の差異は，全乾物重，子実収量とも小さかった。

分枝乾物重の栽植様式に対する反応は，生育期間を通じて全乾物重の反応とほぼ一致した。子実収量の反応は，分枝の子実収量に依存していた。最大全乾物重と子実収量の間には，栽植様式，密度及び品種をこみにしたとき，正の相関関係が認められたが（$r=0.69^*$），栽植様式についてのみみたとき，これらの関係は必ずしも明らかでなかった。