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Effect of Planting Arrangement and Late Season Weed Stress on the Yield and Yield Components of Maize in Maize-Soybean Intercrop

K.P.S.B. Premalal, T. Gemma[1] and H. Miura[1]

Department of Crop Science, Faculty of Agriculture
University of Peradeniya
Peradeniya.

ABSTRACT. A field study was conducted to determine the influence of late season weed stress on the yield components and yield of maize in an intercropping system with different planting arrangements. Six planting arrangements with different soybean densities within a constant maize population were tested over two years. There was an uneven response of kernel yield in relation to the prevalent climatic conditions. The treatment which consisted of three soybean rows in between two coupled maize rows showed 26% and 50% yield increment over the sole crop in 1992 and 1993, respectively. All intercropping treatments had less weeds. These results suggest the possibility of using the niche occupied by weeds to intercrop and obtain greater yields of the main crop, if crops are arranged in a systematic manner.

INTRODUCTION

Intercropping is an important feature of tropical agriculture. One advantage of this farming system is that it gives an insurance against crop failure, which is common in most developing countries. Another advantage of mixing of crop species is the yield and/or quality improvement compared with growing these crops alone (Andrews and Kassam, 1976; Willey, 1979; Ofori and Stern, 1989). The biological advantage of intercropping results from complimentary use of growth resources. The growth resources used by the component crop/s over time and space may be different, and when appropriate combinations of crops are grown together, the efficiency of resource use is greater than in mono-cropping. In addition, competition

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[1] Department of Agro-Environmental Science,
Obihiro University of Agriculture and Veterinary Medicine,
Obihiro, Hokkaido, Japan.

from weeds may be reduced by a combination of crop species occupying two or more niches in the field (Altieri and Liebman, 1986).

Intercropping can be an efficient means of weed control. Weed control studies of maize based intercropping systems, with species, such as, groundnut (*Arachis hypogaea* L.), mung bean (*Vigna radiata* L.) and sweet-potato (*Ipomoea batatas* L. Lam.) (Steiner, 1984) have been reported. Similar studies with soybean as the component crop, with reference to weed interference or effect of weed stress at the latter part of the crop growth on yield components and yields of maize are not widely reported. However, weed growth must be controlled initially to develop a canopy sufficient for weed suppression in intercropping systems (Ayeni *et. al.*, 1984). The objective of this study, therefore, was to examine the influence of late season weed stress on the yield and yield components of maize in intercropping systems with soybean, in different planting arrangements.

MATERIALS AND METHODS

Field experiments were conducted on volcanic ash soils (Andosols) during the 1992 and 1993 growing seasons, at the research field of Obihiro University of Agriculture and Veterinary Medicine, Obihiro, Hokkaido, Japan,. The meteorological data for 1992 and 1993 growing seasons (May-September) are presented in Figure 1.

The forms of treatment were arranged in a randomized complete block design with four replicates each year. All plots were kept weed-free, until the maize plants reached 75 cm in height (growth stage $V_{4/5}$). In addition, two other forms of sole crop treatment were kept completely weed-free throughout the growing season, in 1993. The plots were 4 x 3 m, and consisted of six different planting arrangements with a sole crop of maize (T1), soybean (T2) and complete weed free maize (WFm) as controls (Figure 2).

The mixtures used were:
1. Alternate soybean rows with maize (T3),
2. Three soybean rows in between two coupled maize rows (T4),
3. Alternate soybean rows with maize in which the soybean was planted at half the spacing as control (T5)
4. Two soybean rows with the same plant spacing in between two maize rows (T6).

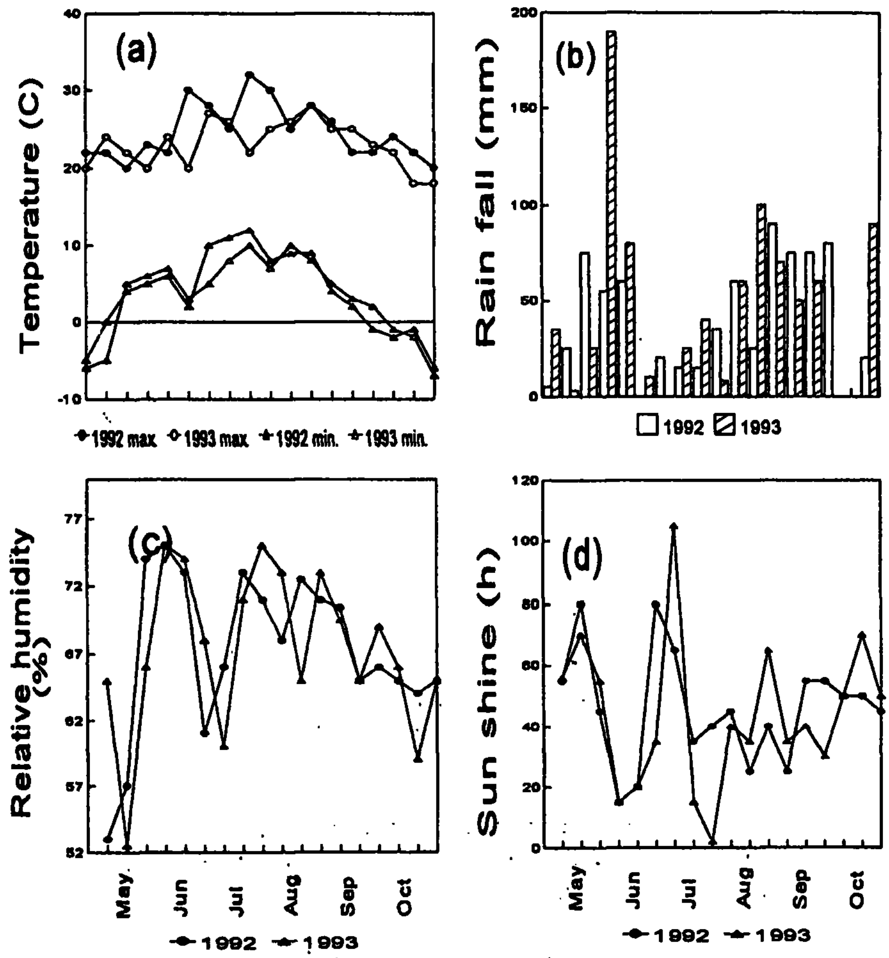


Figure 1. Meteorological data for 1992 and 1993. (a) Temperature; (b) Rain fall; (c) Relativr humidity; (d) Sun shine hours.

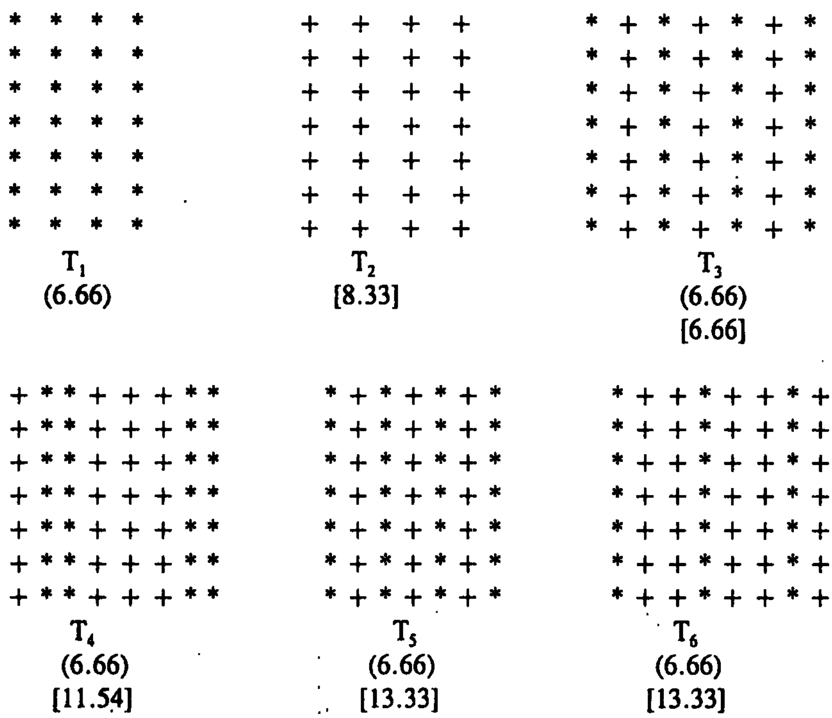


Figure 2. Planting arrangements and plant populations used in the experiments.

* maize; + soybean; (*) maize plants/m^2; [+] soybean plants/m^2; T_1 maize sole crop; T_2 soybean sole crop; T_3 alternative rows with the same plant spacing as sole crops; T_4 three soybean rows in between two coupled maize rows; T_5 soybean alternative rows with half of the plant spacing as sole crop; T_6 two soybean rows with the same plant spacing as the sole crop.

With different planting arrangements (Figure 2), the maize population was kept constant at 100%, while soybean population ranged from 76% to 160% in the mixtures.

A sweet corn cultivar, "Honey buntum" was intercropped with soybean cultivar, "Otofuke Ohsode". Maize was planted on the 19th of May in both years. Soybean was established on the 28th and 25th of May in 1992 and 1993, respectively, and the delay was to overcome frost damage. Fertilization was done as per recommendation for the respective crops in Tokachi district, Japan (Corn no.1, 1.5 g/plant contained 7.5% N, 18.5%

P, 10% K and 4.5% Mg for maize and S353, 9.37 g/plant contained 3% N, 25% P, 13% K and 5% Mg for soybean). Plots were weeded until the maize reached the $V_{4/5}$ growth stage (75 cm in height). One meter strips were marked in the center of each plot for final yield determination.

Maize was harvested at the stage when grain was suitable for human consumption (R_6 growth stage) and the entire plants suitable for silage production. The number of ears/m^2, the number of kernel rows/ear, the number of kernels/row, the number of kernels/ear, 1000 kernel weight and the total kernel yield/m^2 were measured. Soybean yield and yield components were also determined.

RESULTS AND DISCUSSION

The rainfall received during the experimental seasons (Figure 1) was greater than the 30 yr mean. This was more prominent in 1993. Very low temperature was recorded in 1993 summer and the sunshine hours were also low. The rainfall received in 1993 was much higher than in the 1992 experimental season. Hence, 1993 summer was not conducive for the production of warm season crops, such as, maize in the Hokkaido region.

Planting arrangements and intercropping had no significant influence on ears/m^2 in 1992 (Table 1), which was an average season. In 1992, all plants produced the same number of ears in all the forms of treatment. In contrast, the adopted form of treatment had a significant influence on the number of ears/m^2, in 1993. This was lower than in 1992, due to adverse climatic conditions, such as, low temperature, high rainfall and low sunshine hours. This indicated that planting arrangements and intercropping affects maize ear production under adverse weather conditions, weakening the total production of the system.

In 1993, the highest number of ears (4.8/m^2) was obtained from plots intercropped with three rows of soybean. The mono-cropped plots of corn had 3.6-4.5 ears/m^2. Thus, due to the beneficial effect of including a legume in cereal systems, intercropping with soybean had a significant impact on the productivity of maize (Ofori and Stern, 1989; Russel and Caidewell, 1989).

Table 1. Number of ears/m² and 1000 kernel weights of maize in the two experiments.

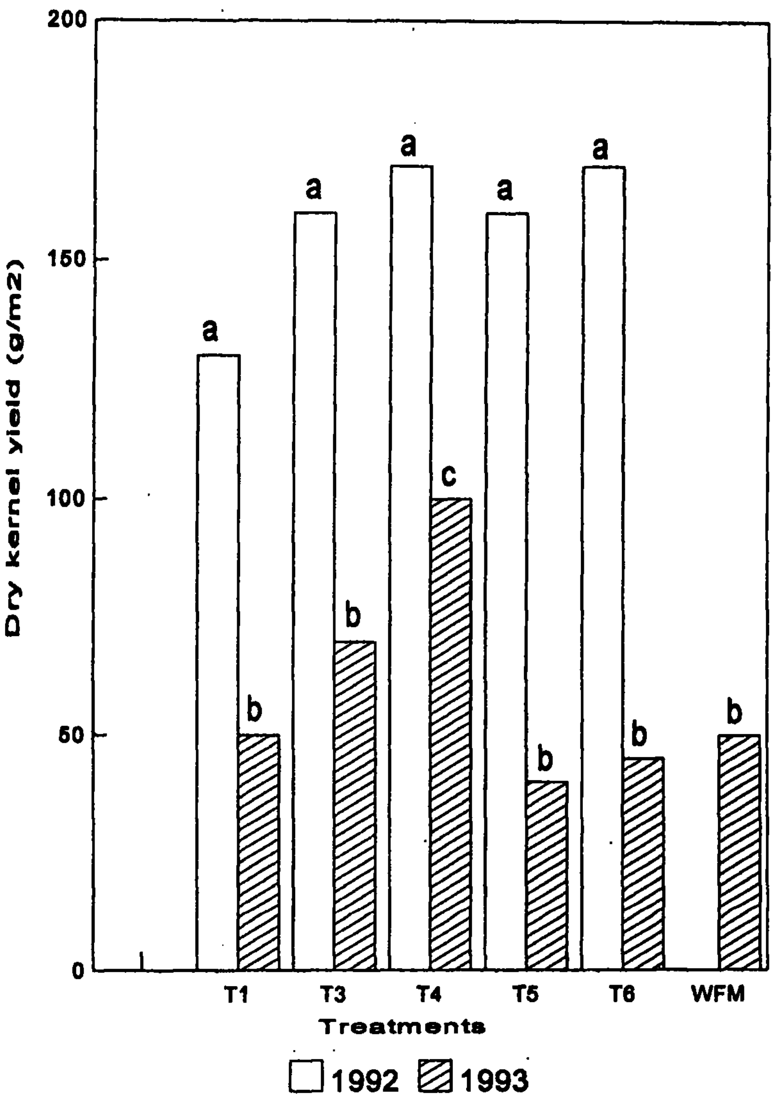
Treatment	Number of ears/m²		1000 Dry kernel weight (g)	
	1992	1993	1992	1993
T1	6.66	3.66	75.25	60.50
WFM	-	4.50	-	83.00
T3	6.66	4.17	84.00	79.50
T4	6.66	4.83	74.50	85.50
T5	6.66	3.00	81.00	74.25
T6	6.66	4.00	81.25	65.25
LSD $p<0.05$	0.00	1.02	22.68	15.49

All yield components (dry kernel yield, number of kernel rows/ear, number of kernels/row and number of kernels/ear) were affected by the adverse climate of 1993 (Figures 3 and 4). Thus greater yield components were observed in 1992, the season with a warmer climate, suitable for maize.

The variations among the treatments were similar in all yield components, irrespective of the year. However, the differences among the treatments were more prominent in 1993. This treatment differences under adverse climatic conditions are due to the poor growth of maize.

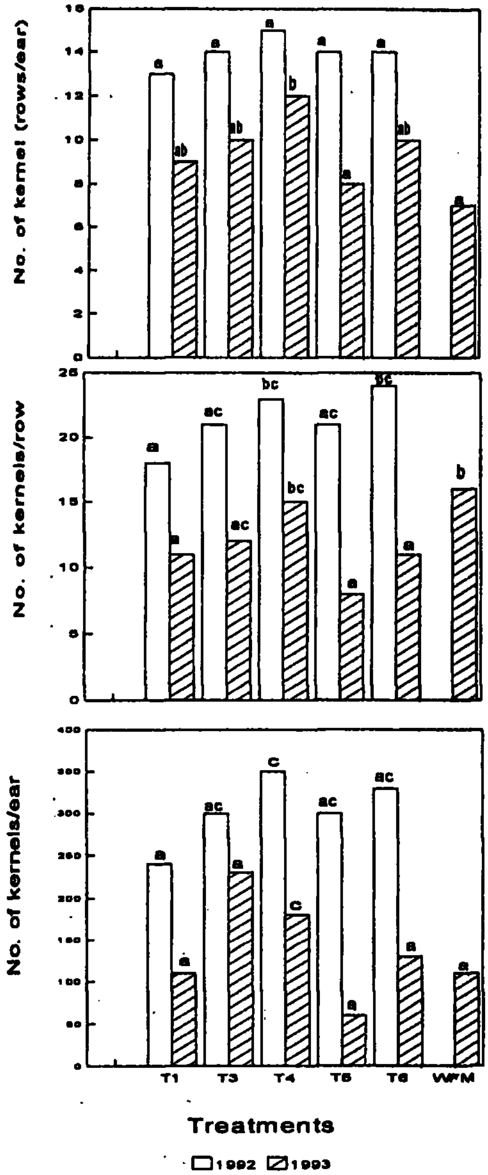
Analysis of individual yield components illustrated that dry kernel weight was not significantly influenced by the adopted method of treatment, except in the treatment which had three soybean rows in between coupled maize rows in 1993. This treatment had the highest kernel dry weight, which was significantly greater than in the others. A similar phenomenon was not observed in 1992, although all intercropped plots had greater dry weights of kernel, when compared with monoculture treatment. However, the low corn yield in the weed-free monoculture plots was an interesting observation, which indicated the benefits of intercropping.

The soybean yield and yield components were also higher in the treatment having three soybean rows in between two coupled maize rows. This was more prominent in 1993, under adverse climatic conditions.



* values without a common letter within a year are significantly different according to Least Significant Difference test (p,0.05).
WFM - complete Weed Free Maize sole crop; see Figure 1. for details of other treatments.

Figure 3. Effect of planting arrangement on kernel yield in 1992 and 1993.



* values without a common letter within a year are significantly different according to Least Significant Difference test (p,0.05).
WFM - complete weed free maize sole crops; see Figure 1. for details of other treatments.

Figure 4. Effect of mixture pattern on the no. of kernel rows/ear, no. of kernels/row and number of kernels /ear of maize in 1992 and 1993.

Number of kernel rows/ear in both experiments followed a similar pattern. However, mono-cropping did not depress this parameter. Similarly, the number of kernel/rows was not significantly affected by mono-cropping; although intercropping with soybean marginally increased this yield components. In contrast, the number of kernels per ear was depressed to a greater extent. On all occasions, intercropping with three rows of soybean produced the highest yield components. This accounted for the greater yields of corn by intercropping. Thus, intercropping of corn with soybean, which could occupy the niche of weeds, promoted growth and yield of corn; due to the multitude of benefits (Andrew and Kassam, 1976; Weil and McFadden, 1991) added by the legume.

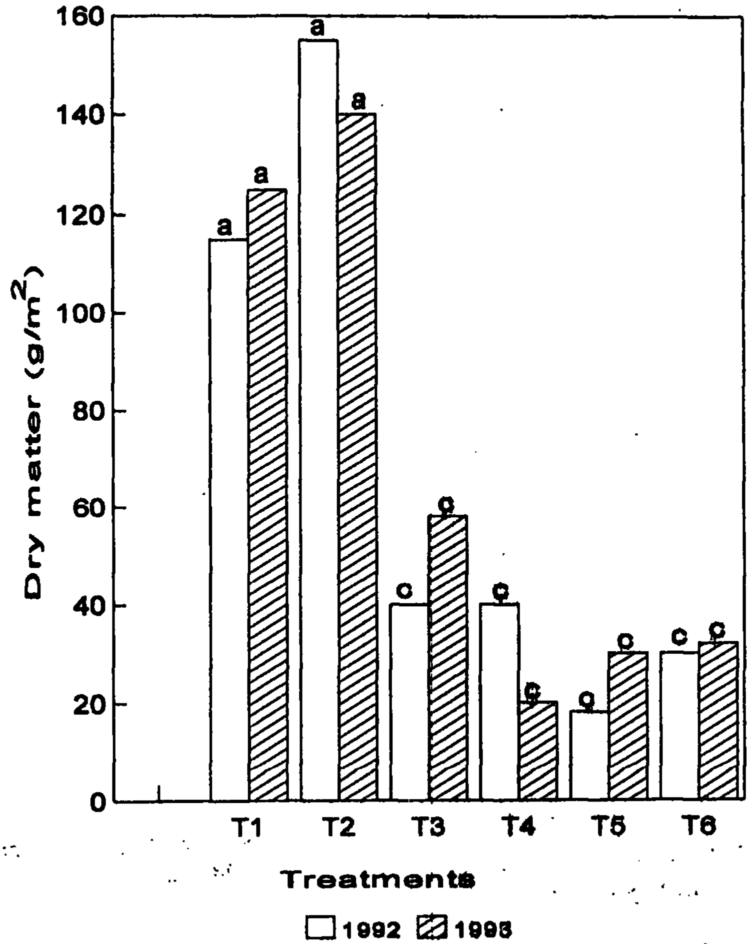
Weed dry matter (Figure 5) illustrates the proliferation of unwanted species in the monoculture plots. Intercropping reduced weed population, confirming earlier reports (Ayeny *et. al.*, 1984; Weil and McFadden, 1991). The reduced weed dry matter in the intercropped plots clearly illustrates this phenomenon. Thus, the greater yields of the intercropped plots could also be attributed to reduced competition from weeds, which is not present in well managed soybean intercrops.

CONCLUSIONS

The niche occupied by weeds could successfully be used to intercrop a legume, which not only increases maize yield, but also enhances the productivity of the system.

The impact of including a grain legume as an intercrop may be more evident under stress conditions, when the environment is not conducive for the growth of corn. In such seasons, depressed yield of corn will also be offset by the productivity of soybean, and weeds will also be controlled by the process.

This study illustrates that the inclusion of three rows of soybean produced the highest beneficial impact. Thus, a plant arrangement to include the maximum possible number of legume plants, would enhance the benefits and reduce cost of weed control.



* Values without a common letter within a year are significantly different according to Least Significant Difference test (p<0.05).

Figure 5. **Effect of mixture pattern on weed dry matter accumulation at the time of crop harvest in 1992 and 1993.**

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