

Weed suppression under the maize-soybean intercropping system

K. P. S. Bandula PREMALAR¹, Takuma GEMMA¹, and Hideho MIURA¹

(Received : April 30, 1993)

Abstract

A field study was conducted to determine the ability of soybean (*Glycine max* cv. Otofuke Ohsode) to occupy the weed's niche under maize (*Zea mays* cv. Honey buntam) crop by the means of intercropping. Keeping the planting density of maize constant, six types of plant arrangements with different soybean planting densities were tested (Fig. 1). Treatments were arranged in the split plot design with four replicates, in which the main plots included weeding treatments and the subplots received plant arrangements. Dry matter production at 20 day intervals and grain yield at harvest were determined. Of the total of 225 weed plants/m² at 60 days after planting, 60% was belongs to *Rorippa palustris*, *Stellaria media*, *Chenopodium album*, and *Poligonum* spp. (Table 1). At this stage both crops showed severe dry matter reductions in unweeded treatment. On the other hand, in weeded treatments, significant dry matter increases of both maize and soybean over sole crops were observed under all intercropping treatments except T 3. Weed growth was clearly suppressed by intercrops (Fig. 2). Yields of maize in all plant arrangements were similar to sole crop yield with a 20% yield increment in T 4. In this arrangement, soybean seed yield was not reduced. These results suggest that there is a possibility to get higher yield advantages by intercropping with less weeds, if crops are arranged properly.

Key words : dry matter production, maize-soybean intercropping, weed, yield.

Introduction

Intercropping is the space dependent multiple cropping system which is simply defined as growing of two or more crops simultaneously on the same field (Willey, 1979). Here the intensification is in both time and space dimensions. There are many reasons for intercropping such as increased the productivity or yield advantage, better use of available resources, reduction of

damages caused by weeds, insects and diseases and many other socioeconomic advantages. These advantages are gained without the use of high level of inputs as the plants in such systems use the natural environmental resources efficiently (Willey 1979 ; Francis 1986). Intercropping, therefore, could be applied to the organic farming systems.

Most of the farmers in the tropical and sub-tropical countries are in small scale and they

¹Laboratory of Forage Crops, Obihiro University of Agriculture and Veterinary Medicine, Obihiro, Hokkaido 080, Japan.

are seriously constrained by low productivity and limited land resources. Intercropping would be the possible means of increasing the productivity of these farmers (Evans 1960 ; Enyi 1973 ; Andrews and Kassam 1975 ; Cordero and McCollum 1979). Weeds are one of the most important cost creators in farmlands. Intercropping can be used as an efficient means of weed control. Steiner (1984) observed that the intercropping maize with mung bean (*Vigna radiata* L.), sweet potato (*Ipomoea batatas* L. Lam.) or ground nut (*Arachis hypogaea*) reduced weed growth, yield losses and time required for weeding. Weed control in maize depends on many factors including the use of herbicides and cultivation. When the maize plants are growing, herbicide application becomes more and more difficult and the location of maize roots should determine the depth and placement of cultivator shovels limiting the use of cultivators. Use of cultivators will tend to root pruning. When maize is about 75 cm tall, cultivation within 15 cm from the stem to a depth of 15 cm will cut off much of the root system (Klingman and Aston 1982). In dry weather, such plants may seriously wilt after cultivation and could not tolerate even slight wind. Therefore, use of a companion crop to suppress weeds in later stages of the crop is also important aspect of intercropping. In organic crop husbandry, which is becoming more and more popular, intercropping can play a major role. Bulson and Snaydan (1990) reported that the wheat and field beans under organic crop husbandry as intercrops, resulted not only the yield advantages but also greater suppression of weed growth.

Under farmers condition especially in developing countries, the crops are grown as monocultures without adequate weeding. Weeds also occupy their own niche in such conditions in the crop growing field and steal the growth resources available for the crop plants and ultimately lead to interspecific competition for various growth

factors. Therefore, this study was aimed to evaluate the role of soybean as a weed suppressor under maize and soybean intercropping system.

Materials and Methods

A field experiment was conducted in the 1992 growing season at the research field of Obihiro University of Agriculture and Veterinary Medicine in Obihiro, Hokkaido, on volcanic ash soils (andosols). Treatments were arranged in the split plot design with four replicates. Unweeded (w_0) and weeded (w_1) were established on 18 m by 4 m whole plots as the main plots. The plots received w_0 were kept with weeds throughout the season, whereas w_1 plots were kept weed free until the maize plants reach about 75 cm in height at which it is hard to apply any mechanical method of weed control without damage to the plant roots. Sub plots were 4 m by 3 m and consisted of six different plant arrangements including the sole crop of maize (T1) and soybean (T2) as controls (Fig. 1). The other four treatments were maize and soybean additive type of mixtures. The planting density of maize was kept constant to 66,666 plants/ha, which is the standard in Hokkaido.

A soybean row with same plant spacing (T3), with half of the plant spacing (T5) as the control ; and two soybean rows with the same plant spacing as the sole soybean (T6) in between two maize rows spaced as the control and three soybean rows spaced 30 cm placed in between two coupled maize rows having 30 cm spacing and 20 cm away from the maize rows (T4) were the mixtures used (Fig. 1).

A sweet corn cultivar, Honey buntum was intercropped with soybean cultivar, Otofuke ohsode. These are well adapted to Hokkaido. Maize was planted on May 19 and soybean was planted just after maize emerged on May 18 in 1992. Fertilizers were added as recommended amounts for respective maize and soybean in Tokachi area, at the same rates as sole crop plots

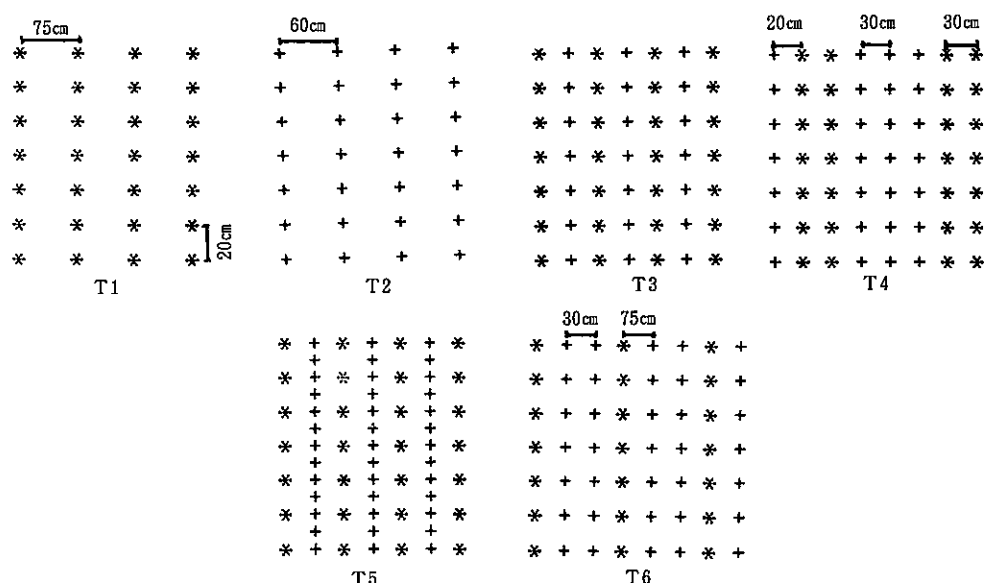


Fig. 1. Plant arrangements used in the experiment. * maize; + soybean; T 1 sole crop maize; T 2 sole crop soybean; T 3 alternative rows with the same plant spacing as sole crops; T 4 three soybean rows in between two couples maize rows; T 5 soybean alternative rows with half of the plant spacing as sole crop; T 6 two soybean rows with the same plant spacing as the sole crop.

to the all arrangements.

Starting 20 days after soybean planting, five plants of both maize and soybean were randomly taken from each plot at 20 day interval until final harvest for dry matter determination. Plants were sampled from an area bordering the net harvest plots. Weeds were also sampled on the same dates from 0.25 m² quadrats in three places from the plots with weeds, those were also from outside the net harvest plot. At maturity, pods of soybean and ears of maize were hand harvested only in the weeded plots from the entire net harvest plots. All above ground weed tissue was also hand harvested from an area of 0.25 m² in three locations of each plot. Weed counts were taken at 8 weeks after planting from randomly selected places of the unweeded plots. For total dry matter determination, whole crop plants and weeds sampled were dried at 70 °C for 2 to 4 days depending on the age and the amount of the sample.

Results

Weed counts

Total number of 225 plants/m² of weeds were recorded in the experimental field. Of these, approximately 60% was occupied by four major species. Those were *Rorippa palustris* Bess., *Stellaria media* Villars, *Chenopodium album* L. and *Polygonum spp.* (*lapathifolium/japonicum*)

(Table 1). *Rorippa palustris* commonly found in Hokkaido (Numata and Yoshizawa 1977) was the most troublesome weed due to the ability to reproduce rapidly by underground runners and hard to control even by deep hoeing.

The weed counts of different species were not significant between plant arrangements. Weeds grew very rapidly in unweeded plots without showing any difference among plant arrangements at any growth stage.

Table 1. Major weeds observed in the experimental site and their densities

NAME	DENSITY Plants / m ²	PERCENTAGE %
Marshcress (<i>Rorippa palustris</i> Bess)	38.00	17.00
Chickweed (<i>Stellaria media</i> Villars)	29.75	13.00
Lambsquarters (<i>Chenopodium album</i> L.)	31.07	14.00
Smartweed (<i>Polygonum spp.</i> , <i>japonicum</i> and <i>lapathifolium</i>)	36.00	16.00
Pale persicaria (<i>Polygonum nodosum</i> Pess.)	1.67	0.74
Field cress (<i>Rorippa atrovirens</i>)	1.25	0.55
Wild amaranth (<i>Amaranthus lividus</i> Loisel)	17.42	7.74
Sowthistle (<i>Sonchus oleraceus</i> L.)	15.67	6.96
— (<i>Polygonum nepalense</i> Meisn)	12.25	5.40
Quackgrass (<i>Agropyron repens</i> L.)	2.83	1.25
Others	39.00	17.33

Crop growth

Dry matter production of maize was higher in weeded plots compared to unweeded plots in all growth stages. At 40 days after planting there were significant increases in dry matter production by T 4, T 5 and T 6 arrangements than sole maize (Table 2). Soybean dry matter increase was observed in all mixtures at all growth stages except T 3 in which the planting

density was less than the sole crop. Until 40 days after planting, effects of weeding on soybean did not appeared, indicating that weeds did not affect on dry matter production at the early seedling stages. Thereafter, however, obstacle of soybean growth by weeds became obvious. Table 3 shows that there were effects of weeds on dry matter production of soybean in all treatments. At 40 days after planting in weeded plots,

Table 2. Effect of plant arrangement and weeds on dry matter production of maize at 40 days after planting

Plant arrangement	Weeding treatment		Mean	SE. for plant arrangement	SE. for plant arrangement at the same weed treatments
	Unweeded	Weeded			
	-g/m ² -				
Sole maize (T 1)	6.05	9.66	7.85	±1.26 ¹⁾	±1.78
T 3 ²⁾	5.05	9.38	7.21		
T 4	6.12	12.32	9.21		
T 5	5.77	12.25	9.01		
T 6	10.38	11.45	10.91		
Mean	6.67	11.01			
SE. for weeding treatment		±1.20			
SE. for weeding treatment at the same plant arrangement		±2.68			

¹⁾ SE ; Standard error.

²⁾ See Fig. 1.

Table 3. Effect of plant arrangement and weeds on dry matter production of soybean at 40 days after planting

Plant arrangement	Weeding treatment		Mean	SE. for plant arrangement	SE. for plant arrangement at the same weed treatments
	Unweeded	Weeded			
	-g/m ² -				
Sole soybean (T 2)	40.75	79.62	60.18	±7.68 ¹⁾	±10.87
T 3 ²⁾	39.51	63.60	51.56		
T 4	57.99	104.82	81.40		
T 5	66.32	188.17	127.25		
T 6	68.43	163.63	116.03		
Mean	54.60	119.97			
SE. for weeding treatment			±4.11		
SE. for weeding treatment at the same plant arrangement			±9.20		

¹⁾ SE ; Standard error.²⁾ See Fig. 1.

T 4, T 5 and T 6 produced significantly higher dry matter over sole soybean because of high planting density.

Weed dry matter

At the early growth stages of no weeding treatment, weed growth could not be suppressed by soybean in this intercropping systems.

At the harvest, weed dry weight in the plots

kept weed free was significantly different among plant arrangements. T 4, T 5 and T 6 gave significantly less weeds over the sole crop (Fig. 2). Average weed dry weights recorded were 6.05, 54.73, 79.53 and 107.93 g / m² in 20, 40, 60 and 80 days after planting, respectively.

Crop yield

In unweeded plots, maize and soybean were

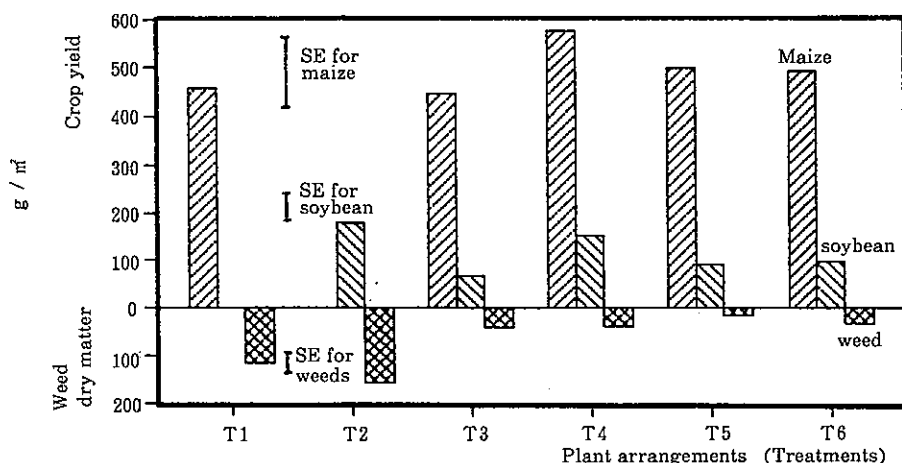


Fig. 2. Maize and soybean yields and weed dry matter at the time of harvest. T 1 . sole crop maize ; T 2 sole crop soybean ; T 3 alternative rows with the same plant spacing as sole crops ; T 4 three soybean rows in between two coupled maize rows ; T 5 soybean alternative rows with half of the plant spacing as sole crop ; T 6 two soybean rows with the same plant spacing as the sole crop.

severely suppressed by the huge weed growth resulting in no yield. On the other hand, in weed free plots both sole crops show the highest weed dry matter production, while showing very low weed dry matter production in all intercropping situations (Fig. 2). There were 36.6%, 49.99%, 49.66% and 66.16% of weed dry matter reduction by T 3, T 4, T 5 and T 6 treatments, respectively.

T 4 showed a 20% yield increment over sole crop of maize, but no significant fresh seed yield differences were observed. Yield increments of soybean compared to sole crop were observed. But T 4, which consisted of three soybean rows in between two coupled maize rows, gave a good soybean yield similar to sole soybean (T 2) and same maize yield as sole crop of maize (T 1) with low weed dry weight.

Discussion

All the mixtures used were additive type mixtures. Maize grain yield in all systems were not different from sole crop situation. In sole crop situation, high amount of weed was recorded and these weeds seemed to utilize the growth resources available for maize plants. In the mixtures, soybean could be utilized the same or less growth resources to produce the same yield as in sole crop. Even if soybean has been utilized much resources than weeds did it in sole crop situation, it is believed that as a legume, soybean may contribute for some growth factors to be favorable for the maize growth by the ability of microbial association. In complete weed interference condition, the yield was almost zero without considering plant arrangement. The initial slow growth of soybean and maize could not smother weeds. Okibo (1979) reported that the extent of weed infestation was related to the amount of soil cover and crop canopy development. Ayeni et al. (1984) also reported the same type of relationship under maize and cowpea (*Vigna unguiculata* L. Walp) intercrop-

ping system. There is crop-weed competition till the crop canopy cover the soil surface. In contrast, the population of common lambsquarters (*Chenopodium album* L.) could be suppressed by maize-soybean intercrop (Moss and Hartwig 1980).

The seed yield of soybean was significantly depressed in all arrangements except T 4 owing to the effect of the shade by maize and possibly other interspecific competition. T 4, which consisted of three soybean rows in between two coupled maize rows, gave a similar yield to sole soybean. In this arrangement, soybean could get enough light with low interspecific competition and also by high planting density. The weed biomass also significantly lower in T 4 arrangement. Therefore, T 4 plant arrangement gave not only higher yield advantages but also greater suppression of weed growth. A similar study was conducted by Moody and Shetty (1981). They reported that weed suppression was greatest when the density of the intercrop was higher than that of the sole crop.

This experiment probably reflects that there is a possibility of occupying weed's niche by another crop to increase crop production, when crops are arranged in proper way to utilize the growth resources efficiently and with only initial weed control.

References

- AKOBUNDO, I. O. 1979. Weed control in Nigeria. Pesticide Article and News Summaries, (PANS) 25 : 287-299.
- AUDREWS, D. J. and A. H. KASSAM 1975. The importance of multiple cropping in world food supplies. In Multiple cropping, R. I. PAPONDICK, P. A. Sanchez and G. B. Triplett (eds). Am. Soc. of Agron. spec. pub. No 27, Madison, Wis, pp 1-10.
- AYENI, A. O., W. B. DUKE and I. O. AKOBUNDO 1984. Weed interference in maize, cowpea and maize / cowpea intercrop in a sub humid

- tropical environment. I. Influence of cropping season. *Weed Research*, 24 : 269-279
- BULSON, H. A. J., R. W. SNAYDON and C. E. STOPES 1990. Intercropping Autumn sown field beans and wheat; effect on weeds under organic farming conditions. *In* BCPC Mono. 45 ; Crop organic and low input agriculture. R. Unwin (ed.) British Crop Protection Council pp 55-62
- CORDERO, A. and R. E. MCCOLLUMS 1979. Yield potential of interplanted annual food crops in south-eastern US. *Agron. J.* 71 : 834-842.
- ENYI, B. A. C. 1973. Effect of intercrop maize or sorghum with cowpeas, pigeon peas or beans. *Expt. Agric.* 9 : 83-90.
- EVANS, A. C. 1960. Studies in intercrop ping. 1. Maize or sorghum with ground nuts. *In* Yield of corn, cowpea and soy bean under different intercropping systems R. A. James and R. O. Robert (eds.) *Agron. J.* 75 : 1005-1009.
- FRANCIS, C. A. 1986. Multiple cropping ; Practice and potentials. Macmillan, New York.
- KLINGMAN, C. G. and F. M. ASHTON. 1982. Weed science ; principle and practice. John Wiley and Sons, Inc. USA.
- MOSS, P. A. and N. L. HARTWIG 1980. Competitive control of common lambs quarter in a corn-soybean intercrop. *Proc. Northeast Weed Sci. Soc.* 34 : 21-28.
- NUMATA, M. and N. TOSHIZAWA 1977. *Weed Flora of Japan*. Zenkoku Noson Kyoiku Kyokai.
- OKIBO, B. N. 1979. Evaluation of plant interactions and productivity in complex mixtures as a basis for improved cropping system design. *In* Proceedings of the international workshop on intercropping. R. W. Willey (ed) ICRISAT, India. pp 155-179.
- MOODY, K. and S. V. R. SHETTY 1982. Weed control in intercropping systems. *In* Proceedings of the international workshop on intercropping. R. W. WILLEY (ed) ICRISAT India. pp 229-237.
- STEINER, K. G. 1984. Intercropping in tropical small holder agriculture with special reference to West Africa. Gesellschaft fur Technische Zusammenarbeit (GTZ), Eschborna Germany.
- WEIL, R. R. and M. E. McFADDEN 1991. Fertility and weed stress effects in performances of maize-soybean intercrop. *Agron. J.* 83 : 717-721.
- WILLEY, R. W. 1979. Intercropping - Its importance and research needs, part 1. Competition and yield advantage. *Field Crop Abstract*, 32 : 1-10.

トウモロコシ・ダイズ間作条件下での 雑草抑制

K. P. S. バンドゥラ プレマラル・
源馬 琢磨・三浦 秀穂

帯広畜産大学飼料作物科学講座
(北海道帯広市稲田町西2線11番地)

和 文 摘 要

トウモロコシ・ダイズ間作条件下で、雑草の生育抑制のためのダイズの適切な配置と栽植密度を検討した。トウモロコシの栽植密度を一定にし、ダイズの密度をかえた6種類の個体配置 (Fig. 1) を試験した。処理は分割区法4反復で行った。主区として雑草処理、副区は個体配置とした。20日おきに作物と雑草の乾物重を計り、収穫後作物収量を計った。播種60日後の1㎡当たり平均225雑草のうち約60%はスカンタゴボウ (*Rorippa palustris*)、ハコベ (*Stellaria media*)、シロザ (*Chenopodium album*)、およびタデ (*Poligonum* spp.) が占めていた (Table 1)。このステージで無除草区のトウモロコシとダイズの乾物重は大きく減少した。逆に除草区での乾物生産は、単作区に対し、T3を除く全ての間作処理区で増加がみられた。雑草の生育が抑えられたT4では、トウモロコシ収量が20%増加し、ダイズ収量の減少もみられな

かった (Fig. 2)。以上の結果から、作物を適当な組合せで間作することにより、雑草の生育を抑制し、高収量が望める可能性がある。