Analysis of Intensive Cultivation Techniques in Small Land Agriculture : Growth and yields of soybeans intercropped in alternative planting with taro or maize

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Analysis of Intensive Cultivation Techniques in Small Land Agriculture

—— Growth and yields of soybeans intercropped in alternative planting with taro or maize ——

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SUMMARY

Two experiments on alternative intercropping with soybean and taro (Expt. I) or maize (Expt. II) were conducted in 1983 and 1982, respectively.

Expt. I. One-row alternative planting (1R) and three-rows alternative planting (3R) with soybean and taro were examined in the field condition. In the first half of growth period, taro grew more vigorously than soybean because of early planting (May 19) of taro tubers compared to soybean seeding (Jun. 16). But after July there was a drought spell which might have inhibited the growth of taro which is susceptible to dryness. As to light distribution in the plant community, relative light intensity was the lowest at the b point between soybean plants in 3R compared it with the points a (1R) and c (3R) between soybean and taro in 1R and 3R, respectively, in the latter half of the growth period. Seed yield from the plant GGG (3R) was the lowest significantly among the plants in the different planting positions, and the main reason for this poor yield was the small number of filled seeds. But there was no difference between CGC (1R) and ÇGG (3R). Therefore, yield per area tended to become lower in 3R. In the case of taro, there was no statistical difference in tuber yield per plant or per area among the plants in the different planting positions, though both yields tended to be higher in 3R than 1R. Light intensity was higher at the point of d (3R) in the latter half of the growth period.

Expt. II. In the combination of soybean and maize, the seed yields of soybeans in the different planting positions were estimated in the minimum unit fields of alternative intercropping. Soybean tended to produce higher yield in GGZ than ZGZ and GGG unit, and this was due to the higher number of pods and the higher percentage of perfect seeds. This tendency toward a higher yield in GGZ unit might be attributed to the rational and efficient light distribution around the soybean plant in the plant community after terminal leaf expansion stage of soybean growth.

As a result, the suitable planting position to obtain good yield of intercropped soybean will be found in GGZ or GGC unit. Therefore, the favorable planting patterns may be two rows of soybean followed by one row of another crop in alternating cropping.

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INTRODUCTION

In the previous replacement trial by pot arrangement on the growth of soybeans intercropped with taro or maize under the condition of pot culture, soybean produced higher seed yield in the combination with taro than with maize. This resulted from the slow growth of taro plant compared to soybean growth in the early experimental period. On the other hand, the poor yield of soybean in the combination with maize was caused by shading due to the taller plant height of maize which resulted in spindle elongation of soybean stems during that growth period.

The present planting experiments were done with the same combination of soybean and taro or maize to ascertain growth response of soybean intercropped in the different planting postitions under the field condition.

MATERIALS AND METHODS

Expt. I. Used varieties of soybean and taro were Chuteppou and Gifu Wase, respectively. Experimental plots were composed of two planting patterns with two replications, that is,

1R : One row of taro was alternated with one row of soybeans

3R : Three rows of taro were alternated with three rows of soybeans.

The main cultivation practices were as follows : Sowing or planting date, soybean (Jun. 16), taro (May 19) ; planting density, 57cm in row space for both crops, 50cm in hill space for taro and 27cm for soybean. Harvesting date : soybean (Nov. 14), taro (Nov. 17). Fertilizer application : soybean (3.0, 15. 0, 6.0kg/10 a), taro (23.0, 15.0, 6.0kg/10 a) as elements of N, P_2O_5, K_2O by using ammonium sulphate, superphosphate and potassium chloride, respectively. This experiment was done in the farmer's field at Kakamigahara City in 1983. Relative light intensity in plant community was measured at the different points as seen in Fig. 1. Yield survey was done with 10 replications of plants per plot in each crop.

Expt. II. Effects of the planting position of crops on soybean growth in alternative intercropping were examined. Variety was Chuteppou in soybean and Honey Bantam in maize. Minimum planting unit fields for maize-soybean intercropping were prepared to evaluate the growth of each plant and its yield at the different planting positions. Planting methods of experimental plots were shown in Fig. 1 and each plot has 8 replications. Main cultivation methods were as follows : Sowing was May 24 in maize and June 24 in soybean. Maize seedlings were transplanted at the fourth leaf emergence stage. Planting density was 60cm in row space and 30cm in hill space. Fertilizer application was the same as in Expt. I. Relative light intensity at several points around soybean plants were measured vertically at every 10cm above ground and also at every 10cm distance from the base point plant to the neighboring plant. Yield analysis was also accomplished.

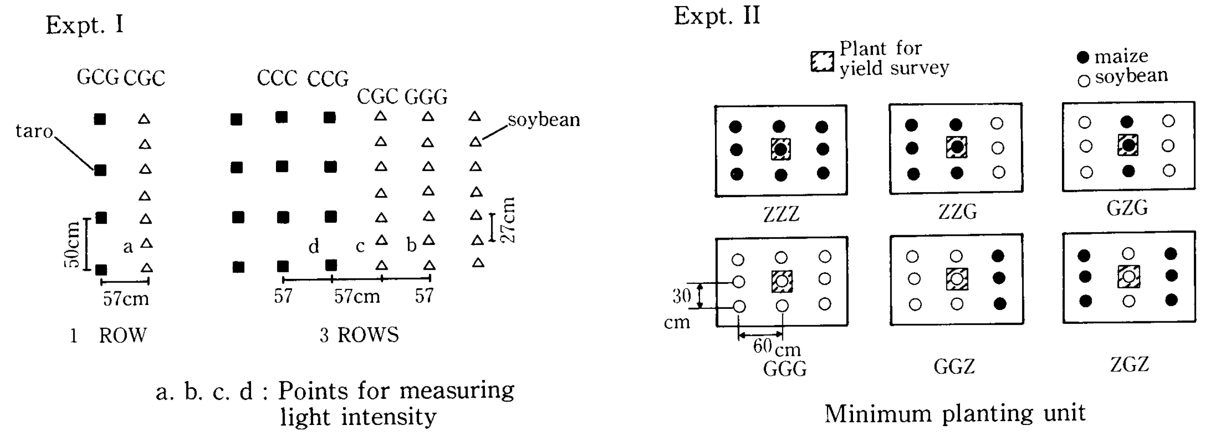

Fig. 1. Experimental plots and planting positions of soybean and taro (Expt. I and Expt. II).

RESULTS AND DISCUSSION

Expt. I. Growth : Plant height was greater in taro than soybean in their early growth stages because taro was planted about one month earlier than soybean (Fig. 2). But this tendency was reversed at the end of September due to severe dryness after July and soybeans became taller than taro. Taro became rather shorter than before on Oct. 13. This would be due to susceptibility to dryness in taro as its own characteristics. With developing plant growth, light transmission patterns in the plant community were also changed. Thus, there was no difference among the measured points at the time on July 28 as seen in Fig. 3, but on Sept. 29 the light intensity at the point of d(3R) became apparently higher. On the other hand, the value of b(3R) was the lowest of all the points for measuring intensity at the time when the soybeans became higher than taro. And this tendency was more remarkable in the middle of October with the order of d>a>c>b. Johnson and Pendleton[1] and Shaw and Weber[2] reported that the effects of higher light transmission into the lower parts just above the ground surface on plant growth resulted in increasing its yield. This result coincides with the present experimental result. From the standpoint of plant type, Sakamoto and Shaw[3], Sivakumer et al[4]., Kokubu and Watanabe[5] and our previous paper[6,7] indicated that the plant type was one of the most important factors in producing a good yield. This was corroborated by the present study.

Yield : So far, it is pointed out that one of the suitable partner crops for soybeans is taro in alternative intercropping, but there is little information on the plant growth at each different planting position in intercropping. From Table 1, soybean yields per plant were significantly higher in the following order ; CGC (1R)>GGC(3R)>GGG(3R). These yields were not attributed to 100 seed weight but the number of perfect seeds per plant. Total number of seeds and also pods were the lowest at

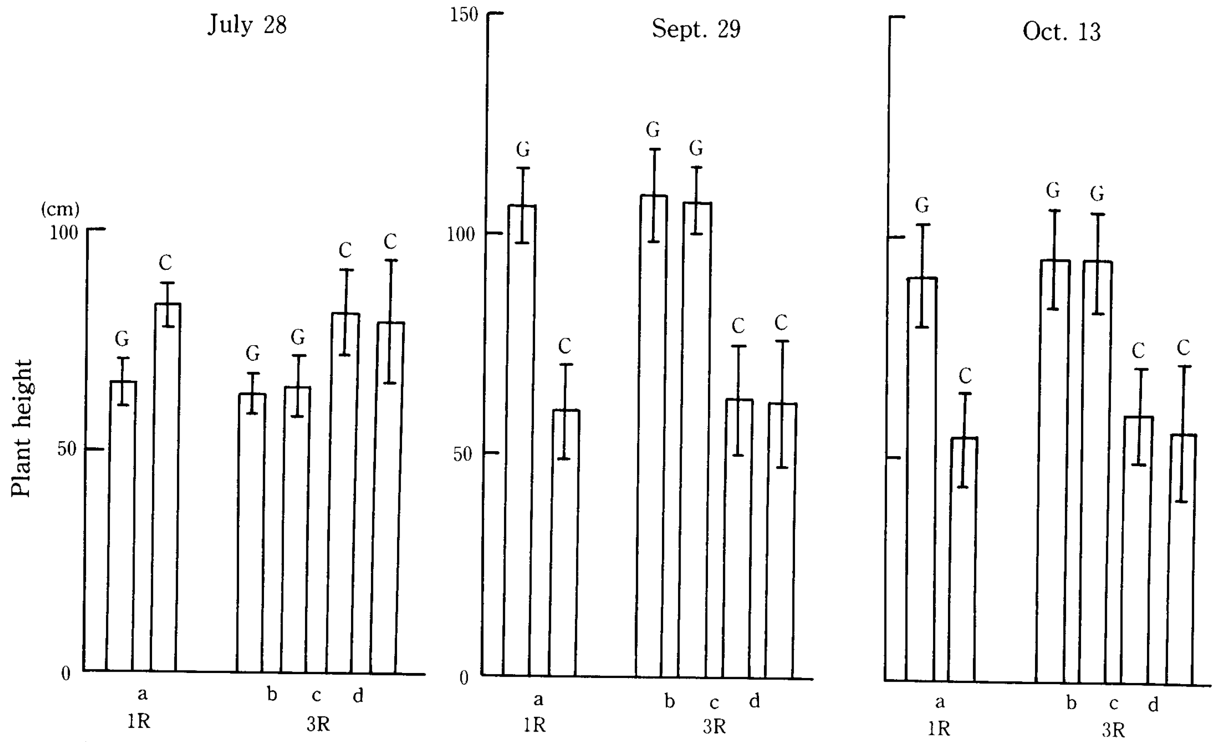

Fig. 2. Plant height at the different growing time.
Note) G : soybean, C : taro

1R : One row alternative planting
3R : Three rows alternative planting
a-d : Measuring points of light intensity

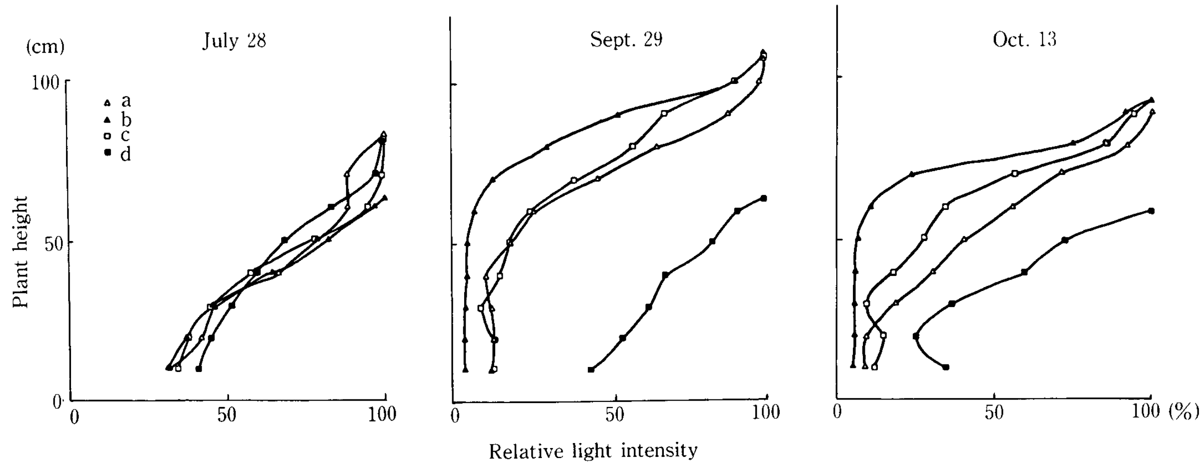

Fig. 3. Light transmission patterns at the different planting positions during growth period.
Note) a−d : see Fig. 2.

GGG (3R), while yields per area tended to be lower in 3R than 1R. Thus, in the present experiment there was no remarkable difference between 1R and 3R on planting patterns. On the other hand, taro tuber weight per plant and per area showed no significant difference among the planting patterns and the planting positions in rows (Fig. 4).

Expt. II. All types of alternative row intercropping will be included in the combination of these planting units in connection with maize-soybean intercropping. Plant height and the number of branches per plant of both crops were shown in Fig. 5. Soybean plant height was greater in ZGZ and GGZ than in GGG plant, but the number of branches tended to show a reverse tendency with a high value of GGG. While, maize tended to be high in plant height at ZZZ. Each planting unit with different planting position showed its own distribution in the plant community. As shown in Fig. 6. the interval between isoline of light intensity was wide in ZGZ and GGZ but narrow in GGG unit. Shading by maize plant would make soybean growth spindle in plant height. The light distribution pattern of GGZ plant was in the midway between ZGZ and GGG in terms of behavior. These characteristic isoline patterns of light intensity would be based on their own plant types, especially disposition of leaves. Most leaves of GGG plant gathered into the central upper parts of the plant status, while those of ZGZ disposed widely.

Table 1. Yield and yield components of soybean in taro-soybean intercropping.

Planting position	Perfect seed weight/hill	No. of perfect seeds	100 seed weight(g)
CGC(1R)	44.1 a	115.6 a	38.3 a
GGC(3R)	38.6 a	100.7 a	38.4 a
GGG(3R)	30.5 b	78.3 b	39.1 a

Note) In each column, means followed by a common letter are not significantly different at the 5% level by Duncan's New Multiple Range Test.
CGC : soybean plants between taros
GGC : soybean plants between soybean and taro
GGG : soybean plants between soybeans

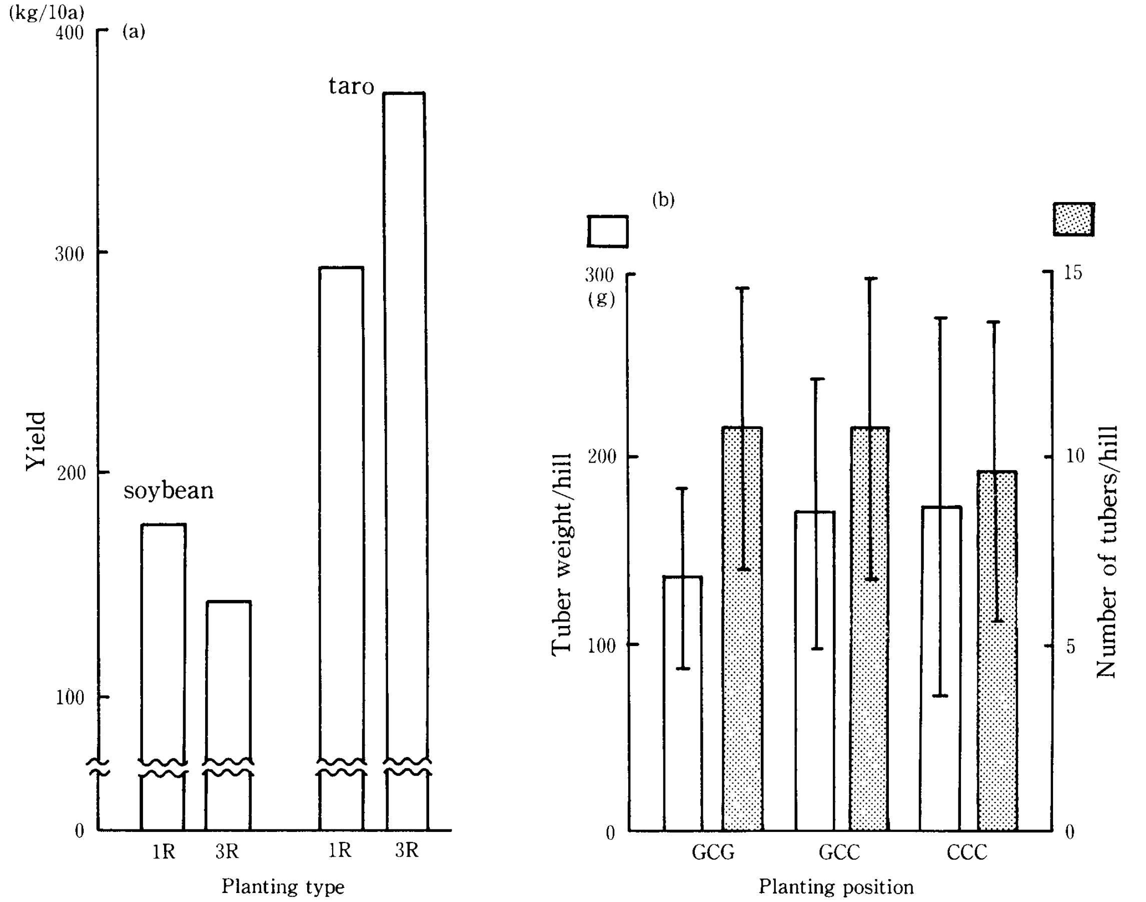

Fig. 4. Yields of soybean and taro (a), and tuber weight and the number of tubers per plant (b).

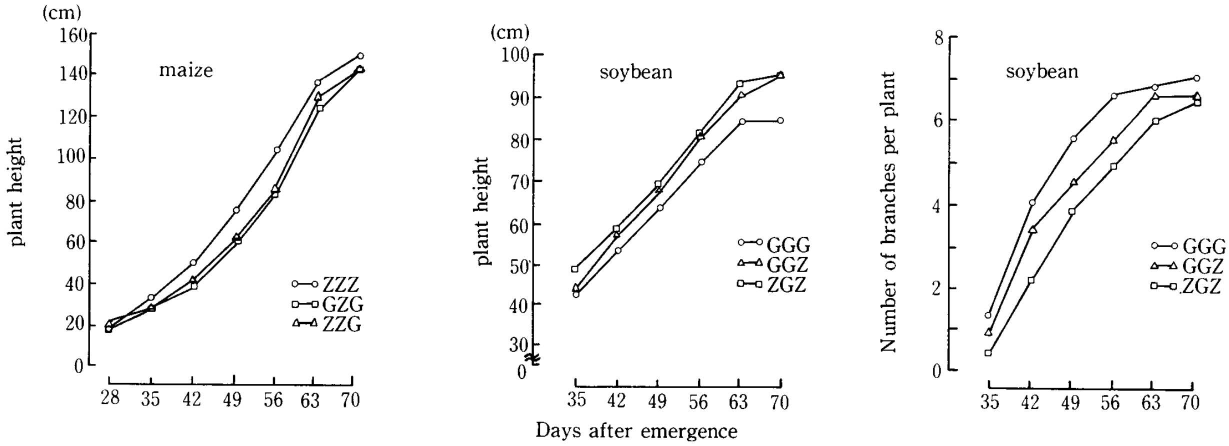

Fig. 5. Changes of plant height and the number of branches after seedling emergence.

Yield of soybean tended to be higher in GGZ, and there was no difference between ZGZ and GGG (Table 2). This tendency resulted from the higher number of pods and the high percentage of perfect seeds. The rational and efficient light transmission after terminal leaf expansion stage in GGZ will be able to contribute to the relatively higher seed production, so its suitable lightening pattern might be seen around the soybean plant accompanied with the maize plant on one side. On the other hand, there was no difference among the maize units as far as seed yield was concerned (Table 3).

Pendleton et al[8]. showed that the major advantages of this system (alternative intercropping) was

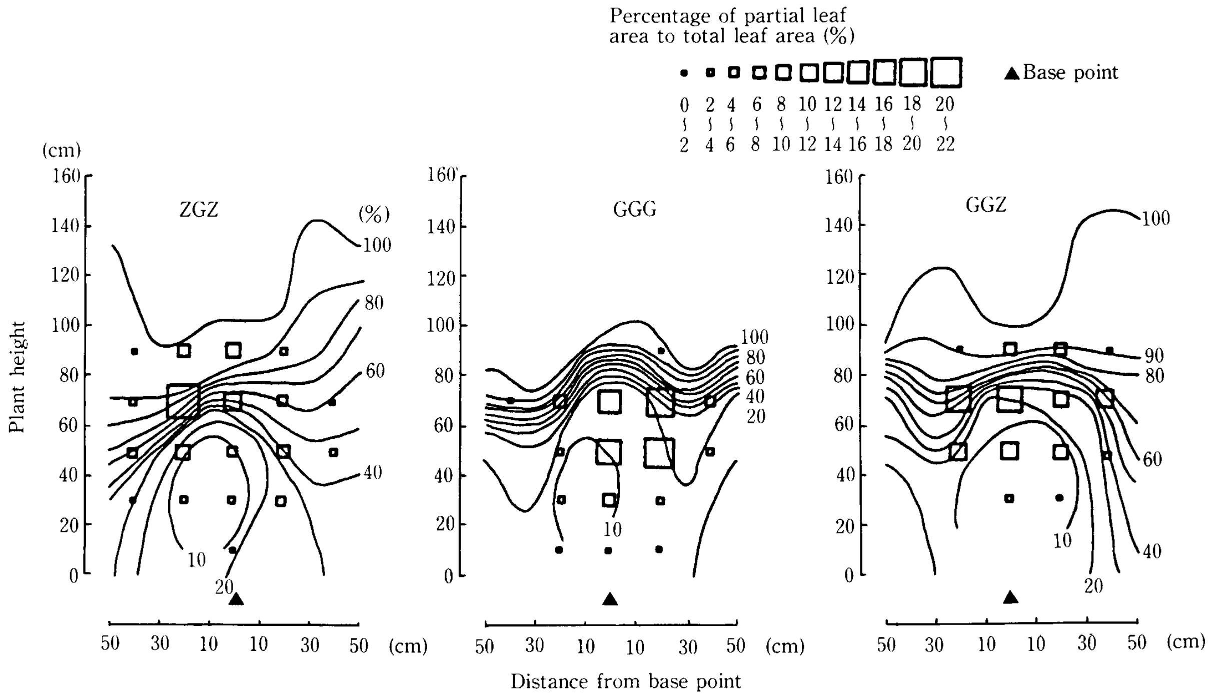

Fig. 6. Light distribution and leaf disposition around soybean plants at the different planting units.

Table 2. Yield and yield components of soybean in maize-soybean intercropping (Means±S.D.).

Planting position	Seed weight per hill (g)	No. of seeds per pod	No. of pods per hill	100 seed weight (g)
ZGZ	44.2± 8.1	1.1±0.2	135.3±33.8	32.9±3.8
GGG	44.4±18.2	1.3±0.2	135.3±32.1	31.9±2.4
GGZ	62.1±14.2	1.4±0.2	146.0±23.1	32.4±2.5

Table 3. Yield and yield components of maize in maize-soybean intercropping (Means±S.D.).

Planting position	Seed weight per ear (g)	No. of rows per ear	No. of seeds per row of ear	100 seed weight (g)
ZZZ	35.2±3.7	13.7±1.8	33.8±5.5	9.5±1.2
ZZG	33.0±5.1	13.1±1.5	33.8±5.2	9.5±1.1
GZG	34.2±7.6	13.4±0.8	28.3±4.8	10.1±1.3

the fact that the border rows of the tall crop yielded 20 to 40 percent more than rows within the field ; and in the USA cornbelt, in which all maize rows in alternative planting had a higher yield than the monoculture check while all soybean rows displayed a lower yield. Our previous paper showed low yield of intercropped soybean caused by low light intensity over the soybean canopy due to shading by greater plant height of the neighboring maize. And in the combination with taro, each soybean yield by different planting positions was not clarified here.

From the above experimental results and related references to this study, it seemed that the growth and yield of soybean intercropped was dependent upon the growth behavior of neighboring crops like taro and maize in this study. Willem[9] pointed out the efficiency of alternating intercropping (strips) which should be wide enough to facilitate the use of machinery, and in mixed cropping, species were intimately mixed in strip cropping, only the plants on the edge of strip affect the other. The width of the strips also depends on the competitive yield advantage of the one crop and the yield disadvantage of the other crop. The authors can agree with Willem's suggestions and some other factors such as water stress, plant type and variety and so on should be taken into consideration for determination of the planting space and also for finding suitable and reasonable planting patterns in this intercropping systems. The competitions for water, nutrients and oxygen etc. in the soil will be also closely related to plant growth and yield in the intercropping as mentioned by Radke and Burrous[10] and Gomezz[11]. This dimension will also be discussed in future experiment.

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小規模耕地における集約栽培技術の解析

—— サトイモ並びにトウモロコシとの交互作における間作ダイズの生育と栽植位置 ——

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要　　約

前報のダイズ―トウモロコシ間作とダイズ―サトイモ間作のポット実験結果に基づき，本報では同様の組み合わせによる圃場条件下での間作ダイズの収量を知るため実験Ｉ（ダイズ―サトイモ間作）と実験II（ダイズ―トウモロコシ間作）を実施し，以下の結果を得た。栽植様式はいずれの実験区とも１列交互作区１R）と３列交互作区（３R）を設定した。

〔結果〕

実験Ｉ：生育前半はサトイモの方がダイズより生育速度が速く，生育も相対的に旺盛であった。後半は乾燥気象となったためサトイモの生育が抑制され，群落内相対照度は１Ｒのａ及び３Ｒのｃ地点に比較して３Ｒのｂ地点で最低となった(図１)。ダイズ収量は株当たりでは栽植位置からみてGGG(３R)がCGC(１R)やCGG(３R)よりも有意に低かった。この直接な理由としてGGG個体の完全粒数の低下があげられた。面積当たり収量には有意差はなかった。一方，サトイモ収量については株当たり、面積当たりとも栽植区間に統計的差異は認められなかった。

実験II：ダイズ，トウモロコシ交互作の最小単位としての栽植区画圃を設定し，栽植位置ごとの両作物の生育と収量を検討した。その結果，ダイズではGGZ（３R）がZGZ（１R）やGGG（３R）よりも生育良好で収量も高い傾向にあった。これには群落内の受光状態からみて最頂葉展開期以後の光環境がGGZの栽植位置で最も合理的であったことがわかった。なお，両実験を通してダイズのpartner cropとしてはサトイモよりもトウモロコシの方が栽植区間で収量差異が小さかった。

即ち，間作ダイズの生育を対象とした場合，交互作の栽植位置からみて，高収量を得るには両側ともダイズを組み合わせたGGGと，草高の高いトウモロコシとのZGZ栽植は避けて，受光体制の好しいダイズ―ダイズ―partner cropの栽植形態が良いと考えられる。