Ecological Characteristics of *Digitaria sanguinalis* in Temperate Climate

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바랭이의 生態的 特性에 관한 硏究

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ABSTRACT

Growth habit, intraspecific competition of *Digitaria sanguinalis*, and interspecific competition between soybean and *D. sanguinalis* were evaluated to obtain the basic informations on establishing an effective control measure in upland corps. The earlier planting on April 1 produced approximately 3.5 times higher dry matter than that of the latest planting on July 22 and resulted in the earliest heading on July 8 and the latest heading was observed on September 4 planted on July. 22, but the interval between planting and heading dates was shortened progressively as the planting dates were delayed, showing irregularity of heading within a hill. Tiller numbers per plant were inhibited as densities increased from one to forty. One plant planted per pot produced significantly higher tiller numbers than density of 5 to 40 plants per pot. However, total tiller numbers was the highest in density of 40 plants planted per pot. Regardless of planting densities used, *D. sanguinalis* at all densities produced the similar dry matter per pot, showing severe intraspecific competition as density increased, but on each plant basis dry weight production was the highest in the lowest density such as one plant planted per pot. Competition between soybean and *D. sanguinalis* for the entire growing season decreased the total dry weight of soybean by 59.6%. Soybean required the maintenance of a weed free condition, about 3 to 4 weeks immediately after seeding, for obtaining the maximum yield, beyond which soybean crops effectively suppressed the growth of *D. sanguinalis*.

Key words: *Digitaria sanguinalis*, inter- and intraspecific competition, weed free condition.

INTRODUCTION

Digitaria sanguinalis, an annual grass is a cosmopolitan weed that is troublesome in both temperate and tropical crops (4). It is a native of Europe and has a wide range extending from latitude 50°N to 40°S. Fifty-six countries report that it is an important weed in 33 crops. Further, it was reported as one of the most serious weeds in sugarcane in Argentina, Brazil, the Philippines, and Taiwan; in peanuts in Indonesia, Taiwan, and the United Statesg in cotton in Spain, Swaziland, and Turkey; in corn in Portugal and Taiwan; and in Sorghum in Taiwan(4). However, no much informations on biological aspects of this weed are available. Knowing the ecological characteristics of weeds such as growth habit and competitive ability in terms of intraspecific and interspecific manners will be helpful in establishing the effective control method

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against *D. sanguinalis*.

John(5) suggested that in seasonal variation in growth of *Cyperus rotundus*, mean daylength during the growth period was a major factor influencing growth and development, and mean temperature appeared to be important in determining the size of new tuber and the proportion of dry matter as new tubers. *D. sanguinalis* in the Philippines at latitude of 15°N flowers all year round and in the United States remained vegetative in a 14-hour photoperiod, but it began to flower in a short day of 10 hours(9).

Williams and Ingber(11) reported that tillering of johnsongrass was delayed by medium density(4 plants per pot) and inhibited by the highest density (8 plants per pot) as the result of intraspecific competition. They indicated that johnsongrass at all densities produced about the same amount of dry matter per pot by the final harvest that was determined at 13 weeks after planting, although there were the more total dry weights per pot at the higher densities than the lower one at first harvest which was determined at 4 weeks after planting.

The yield loss of a crop is dependant on the period of weed-crop competition and the stage at which such competition initiated. Maun(6) concluded that barnyardgrass competition that was initiated at the time of soybean planting and then terminated at 5 to 9 weeks after planting was more deleterious to soybean productivity than that was initiated with 5- to 9-week old soybeans and subjected to compete until harvest. Chancellor and Peters(2) concluded that for increased productivity of crops, weeds have to be controlled before the onset of competition.

This study was conducted a) to investigate growth habit of *D. sanguinalis*, b) to evaluate intraspecific competition of *D. sanguinalis*, c) to determine competition between soybean and *D. sanguinalis*.

MATERIALS AND METHODS

The experiments were conducted between April 1 and October 18, 1982 using 1/2,000a Wagner's pots and clay pots(25-cm diameter) filled with clay loam soil. Average temperatures of experimental area were 11.6°C in April, 17.3°C in May, 22.8°C in June, 23.1°C in July, 21.8°C in August, 18.5°C in September, and 12.9°C in October. Fertilizer was applied at the recommended rate of soybean(N-P-K=3-6-4 kg/10a). *D. sanguinalis* seedlings of 2-3 leaf stage were used instead of its seeds to reduce variation due to seed weight and to avoid the risk of poor establishment. For dry weight determination, plants were dried for 48 hour in a dry oven maintained at 80°C.

Growth habit of D. Sanguinalis. The experiment was carried out between April 1 and October 14, 1982 under natural conditions. *D. sanguinalis* seedlings were transplanted into Wagner's pots at 2 week intervals from April 1 till July 22 and watered daily. The plants were harvested at 2 week intervals from seedings. At every harvest, plant height, tiller number, and dry weight of shoot and root portions were determined.

Intraspecific competition. To evaluate intraspecific competition of *D. sanguinalis*, the experiment was conducted from June 14 to October 18, 1982 under natural conditions. *D. sanguinalis* seedlings were transplanted in the density of 1, 5, 10, 20, and 40 plants per pot(1/2,000a Wagner's pot) which were approximately equivalent to 20, 100, 200, 400, and 800 plants per square meter, respectively, and maintained the optimum moisture. Plants were harvested at 2 week intervals from June 30 till October 18. The number of tillers and dry weight of shoot and root portions were determined at each harvest. The experiment was arranged in a split plot design with three replications. The main plots were harvest dates and the subplots were densities. Analysis of variance was made on all data and differences were calculated using Duncan's multiple range test at the 5% level.

Interspecific competition between soybean and D. sanguinalis. Interspecific competition between soybean and *D. sanguinalis* was evaluated under natural conditions. Soybean seeds, Danyeobkong were weighed individually and only those that weighed individually and only those that weighed 170±9 mg were used in this study. A soybean seed

per pot was planted in the center of 25cm diameter of clay pots and watered daily. Three seedlings of one-week old *D. sanguinalis* were transplanted in each pot at equal distance around the soybean plants according to scheduled competition periods. A weed free control treatment was also included for comparision.

Two series of treatments consisted of the termination and initiation of competition between soybeans and *D. sanguinalis* were used. Termination of competition means that the competition was terminated at weekly intervals by the removal of *D. sanguinalis* plants from 2- to 10-week old soybeans. Initiation of competition means that the competition was initiated by transplanting one-week old seedlings of *D. sanguinalis* into pots containing soybeans. The treatment commenced when soybeans were 1, 2, 3, 4, 5, 6, 7, 8, 9 and 10 weeks old. Harvesting was done by clipping the plants of soybeans and *D. sanguinalis* at the soil surface. The roots were then carefully washed. The above ground parts of plants were separated into leaves, stems, pods, and seeds. Each of these components was used for dry weight determination. The study was arranged in a randomized plot design with three replications.

RESULTS AND DISCUSSION

1. Growth habit.

Plant height of *D. sanguinalis* increased as the planting dates became earlier, although it was not greatly affected by planting dates(Fig. 1-1). However, the tiller numbers and total dry matter production of *D. sanguinalis* were markedly affected by the planting dates, showing that the earlier planting produced significantly higher tiller numbers and dry matter than those of later planting(Fig. 1-2 and 2-1, respectively). In accordance with each planting time, the maximum tiller numbers of *D. sanguinalis* was obtained in about the middle of August and afterwards increase of tiller number was not significant in each planting time. Total dry weight per pot which was obtained from planting at April 1

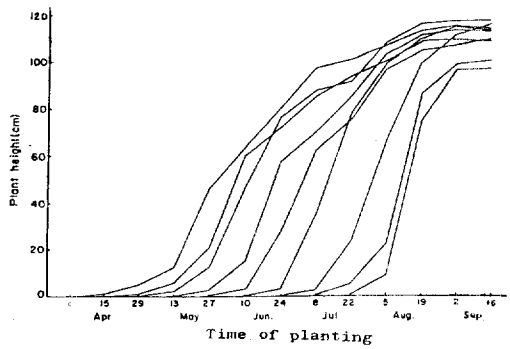

Fig. 1-1. Effect of various planting times on the plant height of *D. sanguinalis*.

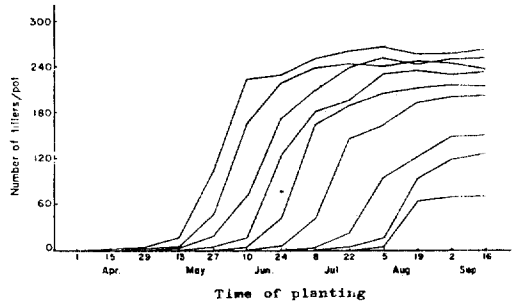

Fig. 1-2. Tiller number of *D. sanguinalis* affected by planting times.

was approximately 182g and about 53g at July 22 which showed 3.5 times higher in the earlier planting than that of the latest planting, indicating the marked difference depending upon the planting times. Shoot and root dry weights shown in Fig. 2-2 and 2-3 displayed the same trends as total dry weight shown in Fig. 2-1. Vengris(10) reported that the tallest plants of rough pigweed and yellow foxtail generally produced more total dry weight when seeded in the early spring which allowed longer growth duration.

The growth curve of *D. sanguinalis* in terms of dry matter production has been roughly divided into three phases showing sigmoid growth curve (Fig. 2-1). The first phase which is from the sowing to 3-4 weeks after planting(WAP) is characterized by relatively slow increase in dry matter. In other word, this phase is the period in which *D. sanguinalis* has been adapted to the environment. Thus, the early planting had relatively longer period of this

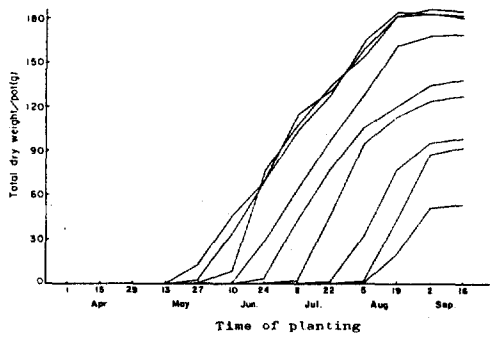

Fig. 2-1. Total dry weight of *D. sanguinalis* affected by various planting times.

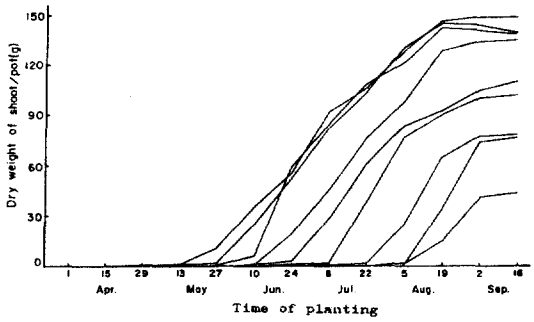

Fig. 2-2. Effect of various planting times on the shoot dry weight.

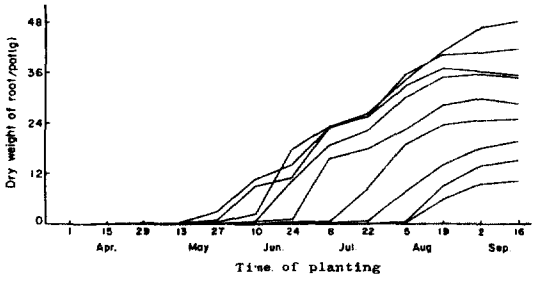

Fig. 2-3. Effect of various planting times on the root dry weight.

phase since low temperature prevails in this time. During this period, green leaves and roots mainly contributed to accumulation of total dry weight. The second phase, roughly from 4 WAP to 14 WAP, is characterized by a rapid increase in dry weight which is mainly attributed to production of new shoots and new tillers. The third phase is relatively stable in dry weight increase. This stage begins mostly in the end of August regardless of the planting times, which is belonging to the maturing stage. These results suggest that the growth habit or dry matter accumulation of *D. sanguinalis* is greatly influenced by the time of planting, and thus the earlier crop cultivation shall be reversely exposed to greater pressure caused by this weed in upland crop.

Planting of *D. sanguinalis* at April 1 required about 100 days till heading or flowering and the earlier planting resulted in the earlier heading, but the interval between planting times and heading dates was progressively shortened as the planting dates were delayed. *D. sanguinalis* seems to require to some extent the period of vegetative growth for heading or flowering(Fig. 3). Further, heading or flowering of this weed continued till the earlier headed spikes become matured, showing irregularity in behavior of heading or flowering. Furthermore, it was reported that in the Philippines at latitude 15°N, the plants flowered all year round and in the United States, remained vegetative in a 14-hour photoperiod, but in a short day of 10 hours it began to flower(9). These results show that this weed may belong to short day plant to some extent with requirement of vegetative growth period.

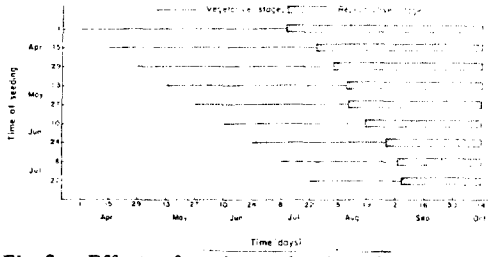

Fig. 3. Effect of various planting times on the heading of *D. sanguinalis*.

Numbers of spikes increased in proportion to increase of tiller numbers, and the earlier planting produced remarkably higher spike formation(Fig. 4), which might result in heavier infestation of this weed in the following year.

2. Effect of intraspecific competition on the growth and development of *D. sanguinalis*.

The total number of tillers per plant significantly

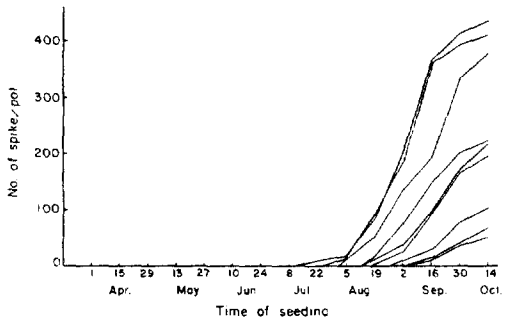

Fig. 4. Spike number of *D. sanguinalis* affected by planting times.

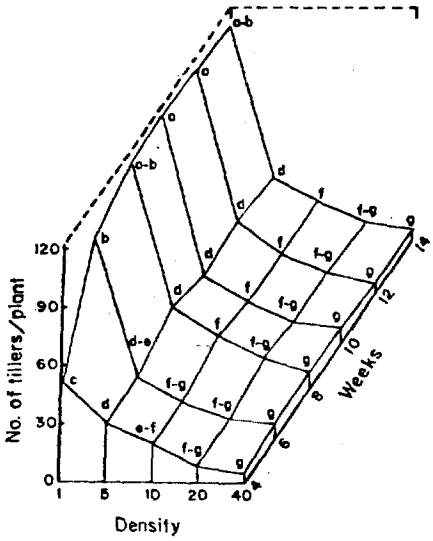

Fig. 5-1. Effect of intraspecific competition of *D. sanguinalis* on the number of tillers per plant

decreased as densities increased from 1 to 40 plants per pot. Tiller number per pot showed the similar trends as increase of total tiller number (Fig. 5-1 and 5-2). One plant planting per pot produced significantly higher tiller numbers than those of 5 to 40 plant planting per pot. The severe intraspecific competition was observed in planting number higher than 5 at 4 weeks after planting(WAP). The similar trend was observed till 14 WAP.

In terms of dry matter production, *D. sanguinalis* at all densities produced the similar amount of dry matter per pot, although dry weight accumulation per plant was the highest in the lowest density, one plant per pot(Fig. 6-1 and 6-2). This was caused by

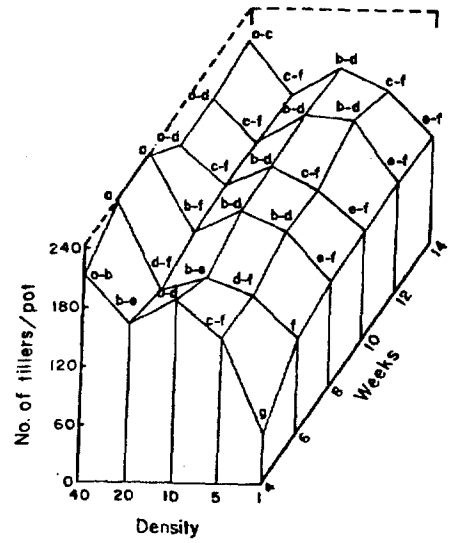

Fig. 5-2. Effect of intraspecific competition of *D. sanguinalis* on the number of tillers per pot.

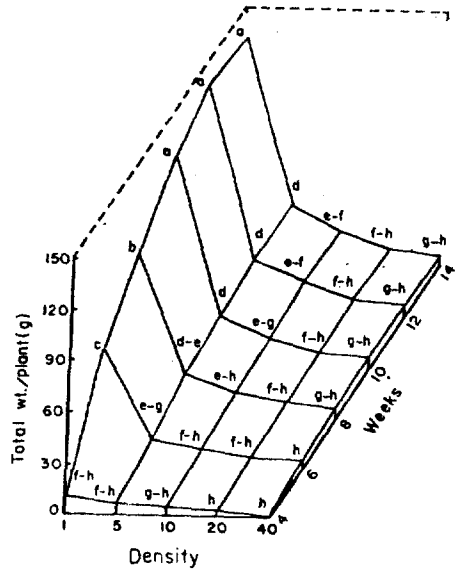

Fig. 6-1. Effect of intraspecific competition of *D. sanguinalis* on its total dry weight per plant.

inhibition of tillering with increasing density due to large individual, which resulted from greater tiller production. Similar results have been demonstrated in johnsongrass(11). Shoot and root dry weight per plant or pot displayed the similar trends as total dry weight(Fig. 7-1, 7-2, 8-1 and 8-2). Average

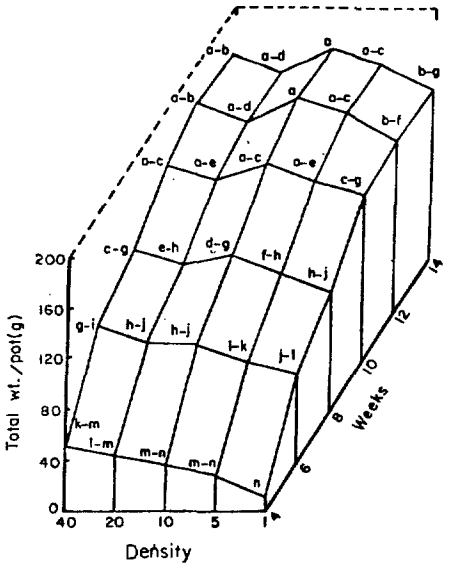

Fig. 6-2. Effect of intraspecific competition of *D. sanguinalis* on its total dry weight per pot.

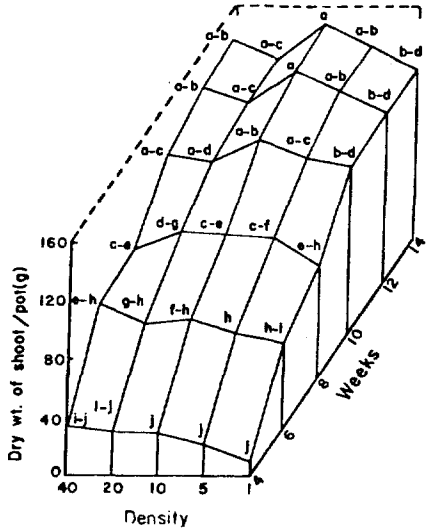

Fig. 7-2. Effect of intrspecific competition of *D. sanguinalis* on its shoot dry weight per pot.

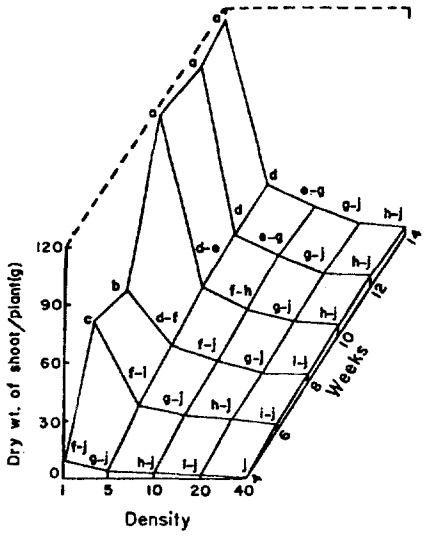

Fig. 7-1. Effect of intraspecific competition of *D. sanguinalis* on its shoot dry weight per plant.

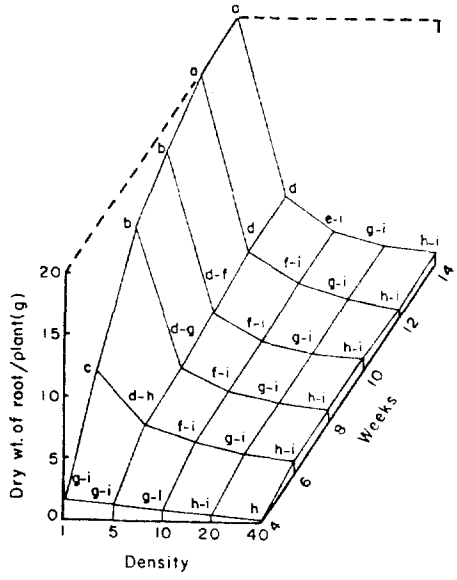

Fig. 8-1. Effect of intraspecific competition of *D. sanguinalis* on its root dry weight per plant.

individual shoot and root dry weights decreased with increasing density. The production of tillers at the lower densities was reflected in the increased individual shoot weight.

Palmblad(8) proposed that in plant populations, the three important reactions to increasing stand density are 1) mortality, which affects the number of survivors; 2) plasticity, which affects the size of the survivors and the number of seed they produce; 3) self-controlled germination, which limits the

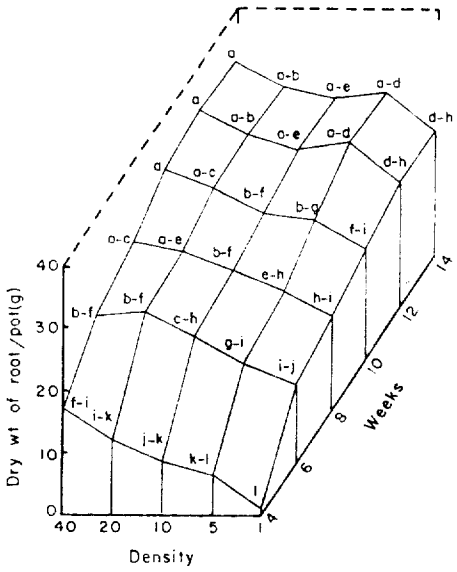

Fig. 8-2. Effect of intraspecific competition of *D. sanguinalis* on its root dry weight per pot.

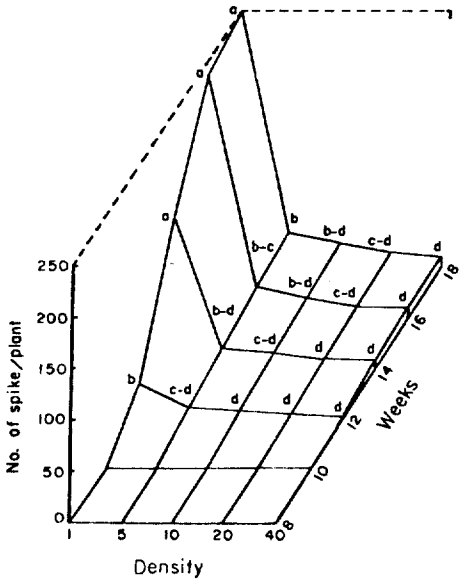

Fig. 9-1. Effect of intraspecific competition of *D. sanguinalis* on the number of spikes per plant.

number of plants per unit area. *D. sanguinalis* reacted to intraspecific competitive stress through a plastic response of dry matter production to increasing density rather than through mortality. Probably no mortality of this weed in response to increased

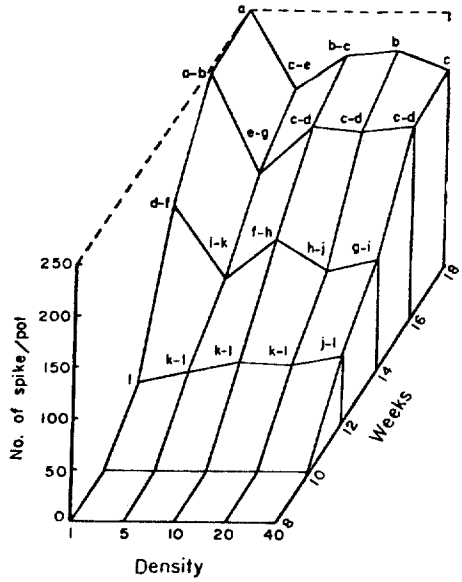

Fig. 9-2. Effect of intraspecific competition of *D. sanguinalis* on the number of spikes per pot.

density gives a competitive advantage to it.

Formation of spike per plant was the highest in density of one plant per pot and there was a severe reduction in the spike numbers with increased densities(Fig. 9-1). Total spike numbers produced was similar at all densities till the first harvest which was determined at 12 weeks after planting, but one plant per pot produced higher spike numbers than that of other densities at the final harvest which was determined at 18 weeks after planting(Fig. 9-2). Palmblad(8) observed that the percent reproduction decreased with increasing density in downy brome. These results showed that if a few plants of *D. sanguinalis* are present, regardless of occurring densities, it can produce the similar dry matter and seeds per unit area.

3. Interspecific competition of *D. sanguinalis* with soybean.

Plant height of soybean was not significantly decreased when it competed with *D. sanguinalis* for 2 to 10 weeks, or for the entire growing season (Table 1). However, Maun(6) observed a significant decrease in the height of soybeans that had been

in competition with barnyardgrass for 4, 9, or 10 weeks or the entire growing season.

Allowing *D. sanguinalis* to grow all season with soybeans significiantly decreased the total dry matter of soybeans(leaves+roots+stems+pods+seeds). Competition of *D. sanguinalis* with soybean for the first three weeks significantly reduced soybean yield as compared with the rest period of competition. Dry weight of leaves, roots, and stems showed the similar trends as the soybean yield. For maximum soybean yields, it required the maintenance of a weed free condition, about 3 to 4 weeks after seeding beyond which the plants effectively suppressed the growth of *D. sanguinalis*. There was a highly significant correlation between crop components such as roots, stems, leaves, and seeds and competition periods. A drop in soybean productivity due to competition was 59.6%. Maun(6) reported that there are 54% reduction of soybean production in competition between soybean and

Table 1. Effect of initiation and termination of competition between soybean and *D. sanguinalis* on the plant height and dry weight of soybean.

Initiation of[b] weed competition (WAS)	Period of[c] weed competition (WAS)	Plant height	Dry weight[a] Leaves	Roots	Stems	Empty pods	Seeds (Yield)
		—cm—			gram		
1		27.9b	2.71c	1.16b	2.55b	3.19c	5.89b
2		28.5ab	3.55bc	1.60b	2.86b	3.46bc	6.24b
3		29.5ab	4.03bc	2.35b	3.55b	4.55abc	8.34b
4		30.6ab	6.30a	4.51a	6.47a	5.10ab	11.40a
5		29.2ab	5.63ab	3.83a	5.83a	5.27ab	12.14a
6		30.0ab	6.37a	4.49a	6.94a	5.49a	12.74a
7		31.1a	6.73a	4.41a	6.85a	5.26ab	12.54a
8		30.7ab	6.34a	4.71a	6.45a	5.32ab	12.07a
9		31.0a	6.84a	4.52a	6.95a	5.39a	12.51a
10		31.5a[d]	6.73a	4.73a	6.84a	5.44a	12.69a
Correlation coefficient(r)		0.89**	0.88**	0.86**	0.86**	0.83**	0.85**
	2	32.0a	6.36ab	5.27a	7.29a	5.70a	12.96a
	3	32.7a	6.24ab	5.06a	6.47ab	5.52a	12.30ab
	4	32.1a	5.80abc	3.71b	5.82bc	5.75a	11.88ab
	5	31.5a	5.68abc	2.70bc	5.18cd	5.54a	12.42a
	6	31.8a	5.11abc	2.43cd	4.37de	5.45a	10.81abc
	7	31.5a	4.80bc	2.49c	4.22de	5.77a	9.50bcd
	8	31.1a	4.48c	1.84cd	3.82e	5.18a	8.58cd
	9	30.5a	4.20c	1.29d	3.39e	4.57a	7.76d
	10	30.7a	4.35c	1.60cd	3.59e	4.60a	7.85d
	Weed free full season	32.5a	6.69a	5.02a	7.49a	5.88a	13.23a
Correlation coefficient(r)		-0.91**	-0.99**	-0.95**	-0.98**	-0.82**	-0.96**

a) Means in each column for the initiation or termination treatments followed by the same letter do not differ at the 0.05 level according to Duncan's multiple range test.

b) Initiation of weed competition: 1; competed with 1-week old soybeans and allowed to compete until harvest.

c) Period of weed competition: 2; competed at the time of soybean planting and then terminated at 2 weeks after planting.

d) Significant at 0.01 level: competition between competition period and agronomic characters.

barnyardgrass. Moolani et al.(7) observed a decrease of 55% in the yield of soybeans at the heaviest stand of smooth pigweed. A highly significant negative correlation was observed between the total dry matter of soybeans and the length of *D. sanguinalis* competition (r=0.99). This means that *D. sanguinalis* has a similar competitive ability like barnyardgrass against soybean. Competition of *D. sanguinalis* terminated from 6-week old soybeans did not reduce the dry weight of soybeans as compared to weed free control(Table 1). As the weed free period after soybean emergence increased there was linear increase in the total dry weight of soybeans(Fig. 10). Shaded areas in Fig. 10 showed differences in productivity at equivalent lengths of competition between soybeans and *D. sanguinalis* in the initial stages of its life cycle(termination) and the last part of its life cycle(initiation). In terms of total dry matter production, competition of *D. sanguinalis* that was initiated at the time of soybean planting and then terminated at 5 to 9 weeks after planting was more deleterious to soybean productivity than that was initiated with 5- to 9-week old soybeans and subjected to compete until harvest. It is probably because soybeans is able to build a dense canopy. These results are in general agreement with studies by Eaton et al. (3) and Maun(6).

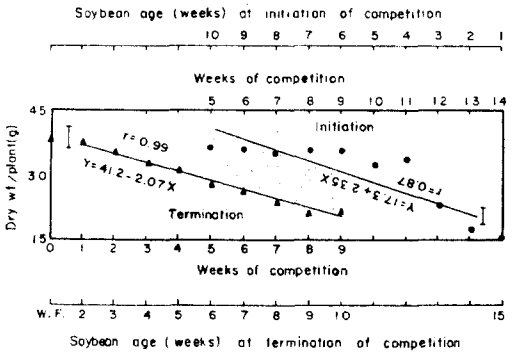

Fig. 10. Dry weight per plant of soybean as affected by the initiation and termination of competition at different stages in the life cycle of soybean. Shaded areas showed the differences in the productivity of the initiation and termination treatments at equivalent lengths of competition. Vertical bars beside each regression line are values of L.S.D. at 0.05 level of probability.

Dry weight of soybean seeds competed with *D. sanguinalis* followed a pattern similar to the total dry matter production (Table 1). These results indicate that the competition between soybeans and *D. sanguinalis* must be terminated to obtain maximum yields, as possible as age of soybean crop is young. Similar studies by Barrentine(1) showed that for maximum yields of soybeans, common cocklebur should be removed during the first 4 weeks.

The competition between soybeans and *D. sanguinalis* below the ground may be important similar to competition above ground because of their interference for water and nutrients. However, this aspect is beyond our study. Further studies along this line will shed more light on understanding of the competitive ability of *D. sanguinalis* against upland crop.

摘　　要

1. 바랭이의 分蘖數와 總乾物重은 移植時期에 따라 크게 影響을 받았는데 移植時期가 가장 빠른 4월 1일에 심은 것은 7월 22일에 移植한 것에 比해 3.5倍에 달하는 乾物重을 生産하였으며, 移植時期가 빠를 수록 分蘖數와 總乾物重이 增加하는 傾向을 보였다. 出穗는 4월 1일 移植한 것은 7월 8일에, 7월 22일 移植한 것은 9월 8일에 出穗되어서 移植時期가 이를 수록 빨라졌으며, 播種에서 出穗까지 걸리는 時間은 移植時期가 늦어짐에 따라 점차로 짧은 傾向을 나타내었으며, 共히 한포기 내에서 不規則的 出穗現狀을 보였다.

2. 바랭이의 個體當 分蘖數는 栽植密度가 增加함에 따라 顯著히 減少하였으며, Pot當 1포기 심은 것이 5~40포기 심은 것보다 크게 增加하는 傾向을 나타내었다. 그러나 Pot當 分蘖數는 40포기 심은 區에서 가장 많기는 하였으나 栽植密度에 따라 큰 差異는 없었다. 個體當 乾物重은 栽植密度가 적을 수록 增加하는 傾向이었으며, Pot當 乾物重生産은 栽植密度에 關係없이 거의 비슷하여 密度가 增加됨에 따라 심한

種內 競合 現狀을 나타내었다.

3. 바랭이와 大豆의 競合에 있어서 大豆의 全生育期間동안 競合할 境遇 大豆의 收量이 59.6%나 減少하였으며 大豆의 收量減少를 막기 위해서는 播種後 적어도 3 내지 4週, 즉 太豆의 canopy 形成이 바랭이의 發芽와 生育을 抑制시킬 수 있는 時期까지 發生하는 바랭이는 防除하여야 될 것으로 思料된다.

LITERATURE CITED

1. Barrentine, W. L. 1974. Common cocklebur competition in soybeans. Weed Sci. 22:600-603.
2. Chancellor, R. J. and N. C. B. Peters. 1974. The time of onset of competition between wild oats (*Avena fatua* L.) and spring cereals. Weed Res. 14:197-202.
3. Eaton, B. J., K. C. Feltuer, and O. G. Russ. 1973. Venice mallow competition in soybeans. Weed Sci. 21:89-94.
4. Holm, L. G., D. L. Plucknett, J. V. Pancho, and J. P. Herberger. 1977. The World's Worst Weeds. 92-97 pp.
5. John, L. H. 1975. Experiments with *Cyperus rotundus* L. III. Seasonal variations in growth. Weed Res. 15:339-348.
6. Maun, M. A. 1977. Ecological effects of barnyardgrass on soybeans in a greenhouse. Weed Sci. 25:128-131.
7. Moolani, M. K., E. L. Knake, and F. W. Slife. 1964. Competition of smooth pigweed with corn and soybeans. Weeds. 12:126-128.
8. Palmblad, I. G. 1968. Competition in experimental populations of weeds with emphasis on the regulation of population size. Ecology. 49: 26-34.
9. Peters, R. and S. Dunn. 1971. Life history studies as related to weed control in the Northeast. 6. Large and small crabgrass. Bulletin 415, a northwest regional publication of the Northeast Weed Control Conf. 5-9 pp.
10. Vengris, J. 1963. The effect of time of seeding on growth and development of rough pigweed and yellow foxtail. Weeds. 11:48-50.
11. Williams, R. D. and B. F. Ingber. 1977. The effect of intraspecific competition on the growth and development of johnsongrass under greenhouse conditions. Weed Sci. 25: 293-297.