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SOYBEAN (*GLYCINE MAX*(L.) MERR.) RESPONSE TO POSTEMERGENCE DURATION OF NATURAL WEED INFESTATION

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Introduction

Production potential of a given field is shared between crop plants and weeds. Competitive ability of growing cultivars and weeds may be vital to yield production, because the stronger competitor can gain more from limited resources of a shared area.

Soybean may compete directly with accompanying weeds for various resources indispensable for their growth. Seed yield of soybean may be inversely proportional to the amount of water, minerals, and light used by weeds at the expense of soybean[2,22]. Moreover, weeds may interfere with soybean development indirectly through the production and release of allelopathic compounds that inhibit crop growth[12].

Substantial development in chemical weed technology provides considerable selection of highly specific and effective but costly postemergence herbicides. High costs of applying herbicides force farmers to answer the questions 'to spray or not to spray?' and, since weed elimination in improper time of weed and soybean development may not prevent yield losses, 'when to spray?'. The time of weed elimination may also be as vital as the weed elimination itself. Considerable research efforts have been devoted to determine the optimum time for eliminating particular weed species from a soybean field[3,4,14,17,21,23]. Weed competitiveness with soybean in most cases was studied with one planted species of weed[4,5,6,9,11,17,23]. Only a few reports dealt with naturally occurring weeds, which was usually a single species left after eliminating other weeds from the competition[3,14]. BURNSIDE[1] investigated the duration effect of natural weed populations with some additionally seeded weed species on yield of soybean. SHURTLEFF and COBLE[20] used five broadleaf weed species seeded with soybean in pots to

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determine the competitive effects of weeds planted at different times relative to soybean planting time, and found that soybean dry weight was always reduced when grown in competition with a weed. JACKSON *et al.*[10] observed that the effects of weed infestation on soybean yield depended on the density and duration of weed, and on moisture conditions.

The objective of this study was to establish the influence of duration of multispecies weeds naturally occurred after soybean emergence on phenological and morphological characteristics, on above ground vegetative biomass and seed yield (including their components) of some soybean genotypes classified into early maturity group.

Materials and methods

Experiments were carried out on the field of Experimental Farm, Faculty of Agriculture, Hokkaido University, Sapporo.

Split-plot experimental design with 3 replications was applied. Conventional cultural practices with chemical insect and disease controls were utilized. Sowing was done manually on the depth of about 2.5 cm. The hand weedings were done at the conclusion of each period of weed infestation, and after that plots were kept weed free until harvest. All weight measurings were done on air dry plant material.

Experiment 1987

Three soybean cultivars 'Himeyutaka' ('HYU'), 'Kitamusume' ('KMU'), and 'Suzuhime' ('SHI') were used. Cultivars were assigned to main plots. The six durations of natural weed infestation (0-control, 10, 20, 25, 30, and 35 days after soybean emerging) were assigned to subplots.

Plots were arranged in four row 1.3 m long units. Interrows were 50 cm wide, and interplant spaces were 10 cm. Five plants from the center of every plot were sampled for recording of quantitative characteristics.

Experiment 1988

Four genotypes, including three Polish breeding lines selected in Academy of Agriculture, Poznan : 'I02', 'I04', 'I12', and one Japanese cultivar : 'Wasekogane' ('WKO'), were used. The three durations of weed infestation (0-control, 25, and 40 days after soybean emerging) were assigned to main plots. The genotypes were subjected to subplots. Plots were arranged in three row 2.0 m long units. Interrows were 50 cm wide and interplant spaces were 15 cm. Ten plants from the center of every plot were sampled for recording of quantitative characteristics.

Results

In both years of experiment there was no substantial variation of phenological characteristics among various durations of natural weed infestation. Morphological characteristics with the tested differences among duration of weed infestation and its interactions with cultivars are presented in Table 1. Plant height increased along with increase of duration of weed infestation. The weak reactions to duration of weed infestation was found in 'Suzuhime' in 1987 and in 'I12' in 1988 (Fig. 1).

TABLE 1. Morphological characteristics variation and interaction (weed duration × genotype) in various duration of postemergence weed intestation in 1987 and 1988

Characteristics	1987		1988	
	Weed duration	Weed duration × genotype	Weed duration	Weed duration × genotype
Plant height	** #3	**	**	*
Branch number	**	ns	**	**
Stem diameter	**	ns	**	**
Lodging score	**	ns	**	**
Basal pod height	**	*	ns	ns
ratio to plant height	**	ns	ns	ns
Pod no. below 10 cm #1	**	**	**	**
ratio #2	**	**	**	**
Pod no. below 15 cm #1	**	**	ns	**
ratio #2	**	**	**	**
Pod no. below half #1	**	ns	**	**
ratio #2	**	**	*	**

#1 – of plant height

#2 – % of total pod number/plant

#3 – *, ** significant at the 5 % and 1 % levels, respectively; ns – not significant

Branch number, stem diameter, and lodging score decreased along with an increase in duration of weed infestation. The interactions between cultivars and durations of weed infestation were observed in 1988 and not in 1987.

In 1987, basal pod height and its proportion to canopy height tended to increase when weeds interfered with soybean plants longer. In 1988, response of genotypes to weed duration was less spectacular.

Pod number in the space below 15 cm of plant height decreased along with increase of duration of weed interference. The strongest response (decrease) to weed duration was observed in 'Suzuhime' in 1987 and in 'I12' in 1988 (Fig. 2, a and

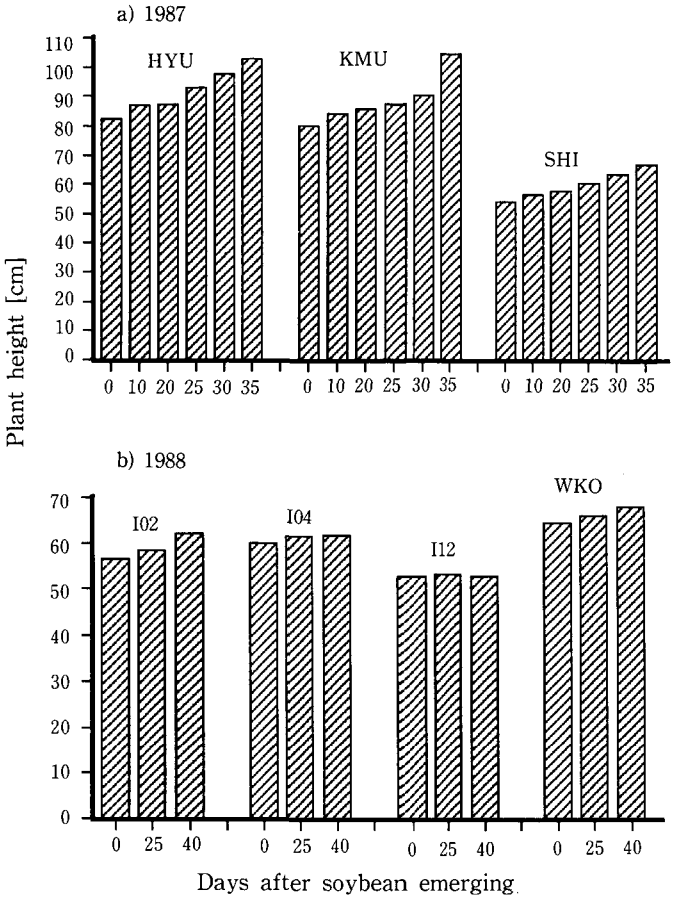

Fig. 1. Differential responses in plant height among soybean genotypes to postemergence duration of natural weed infestation.

b). In both years, in ratio of pods below 15 cm to all pods per plant the genotypes responded very individually (Fig. 2, c and d). Pod number below 10 cm and below half of canopy and their ratios had similar tendencies to the ones pod number below 15 cm of canopy and its ratio showed.

Responses and interactions in above ground biomass components to weed interference periods are shown in Table 2. Total above ground weight decreased along with increase in duration of weed infestation (Fig. 3). Stem weight decreased, but its proportion to combined stem and branch weight increased, as duration of weed interference got longer. Branch weight and its proportion to combined stem and branch weight decreased markedly along with increase of duration of weed infestation. In 1987, 'Kitamusume' reacted more strongly to duration of weed interference than other genotypes.

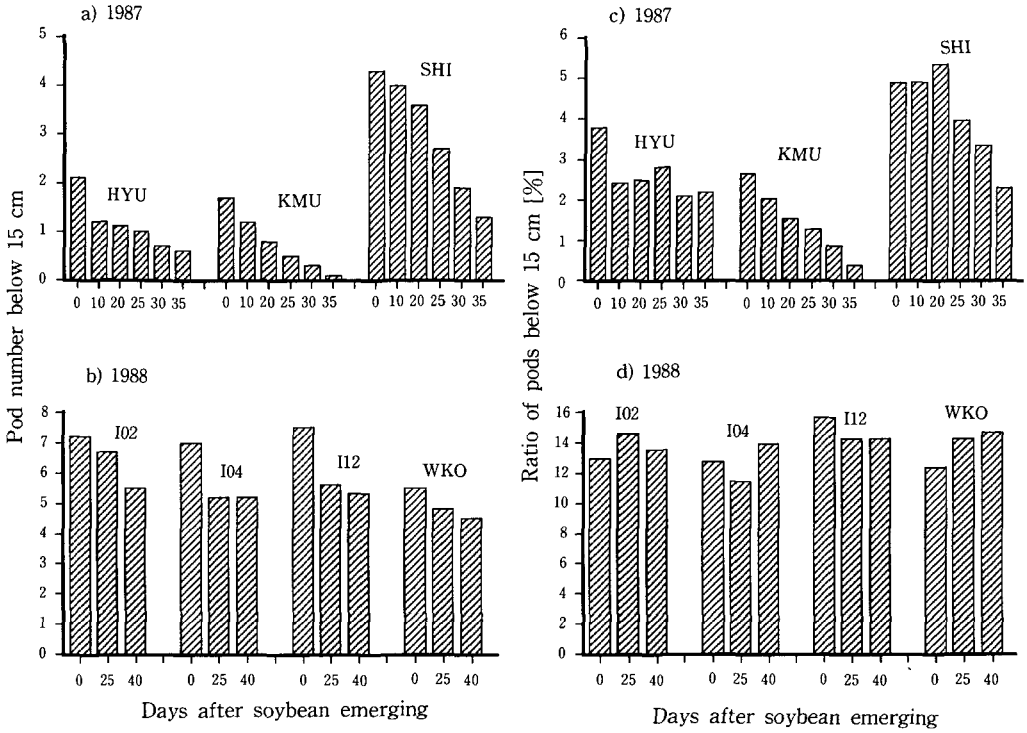

Fig. 2. Differential responses in pod number below 15 cm of plant height (a and b) and its ratio to total pod number per plant (c and d) among soybean genotypes to postemergence duration of natural weed infestation.

The increase of duration of weed interference caused a decrease in the weight of threshed and sterile pods (Fig. 4). In 1987, the smallest decrease in the stem fertile pod weight was observed in 'Himeyutaka'. The strongest reaction (decrease) in branch fertile pod weight was observed in 'Kitamusume'. In sterile pod weight, in 1987 'Himeyutaka' and in 1988 'I02' showed the weakest response to weed duration.

Seed yield and its components responded significantly to weed interference as shown in Table 3, but harvest index did not show any clear tendency in both years. The specific response to weed duration in seed yield was observed in 'Wasekogane' in 1988.

Stem, branch, and sterile pod number per plant in all cultivars tended to decrease when weed duration increased, but 'Suzuhime' and 'I12' showed little response of stem pod number to duration of weed infestation (Fig. 5). The proportion of stem pods to all fertile pod number per plant increased along with increase of duration of weed interference. Thus opposite tendency to the stem pod number was found in stem pod ratio. In the proportion of sterile pod number to total pod number per plant particular genotypes showed highly specific re-

TABLE 2. Above ground biomass characteristics variation and interaction (weed duration × genotype) in various durations of postemergence weed infestation in 1987 and 1988.

Characteristics	1987		1988	
	Weed duration	Weed duration × genotype	Weed duration	Weed duration × genotype
Total plant weight #1	** #3	**	**	**
Stem weight	**	ns	ns	ns
stem ratio #2	**	**	**	*
Branch weight	**	**	**	*
branch ratio #2	**	**	**	*
Stem plus branches	**	**	**	**
Total pod weight	**	**	*	ns
Stem pod weight	**	**	ns	ns
Branch pod weight	**	*	**	ns
Sterile pod weight	**	**	**	**
Weight/pod	*	**	**	*

#1 – above ground yield without leaves and petioles taken after harvesting maturity

#2 – to combined stem and branch weight

#3 – *, ** significant at the 5 % and 1 % levels, respectively; ns – not significant

TABLE 3. Seed yield components variation and interaction (weed duration × genotype) in various durations of postemergence weed infestation in 1987 and 1988

Characteristics	1987		1988	
	Weed duration	Weed duration × genotype	Weed duration	Weed duration × genotype
Yield per plant	** #1	ns	**	**
Harvest index	ns	**	ns	ns
Total pod number/plant	**	**	**	**
stem pod number	**	**	ns	**
ratio to fertile pods	**	**	**	**
branch pod number	**	**	**	**
ratio to fertile pods	**	**	**	**
sterile pod number	**	**	**	**
ratio to total pod no.	**	**	**	**
Seed number per plant	**	**	**	**
100 seed weight	*	**	ns	**
Seed number/pod	**	**	**	**

#1 – *, ** significant at the 5 % and 1 % level, respectively; ns – not significant

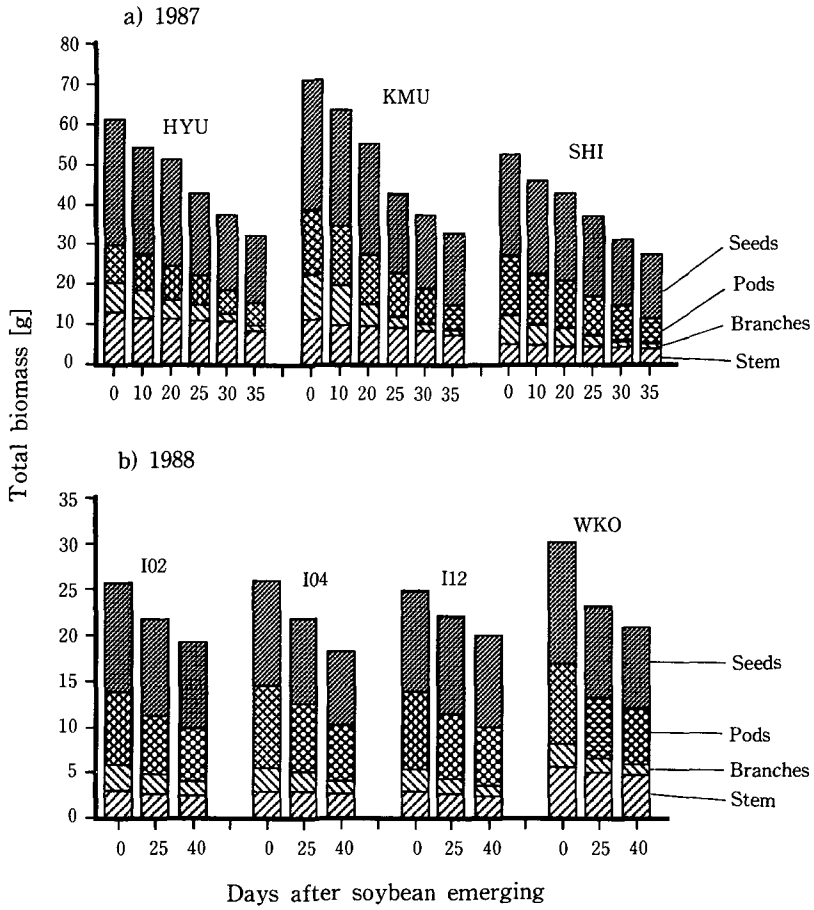

Fig. 3. Differential responses in total above ground biomass (stem, branches, pods, and seeds) among soybean genotypes to postemergence duration of natural weed infestation.

sponse to weed duration.

Seed number per plant decreased along with increase of duration of weed interference. Response of genotypes was very specific. Small seed cultivars 'Suzuhime' and 'I12' showed the strongest decrease in number of seeds per plant (Fig. 6).

Discussion

Relatively short periods of weed infestation applied in experiments did not affect any of the recorded phenological characteristics. STANIFORTH and WEBER[21] reported that even all-season presence of weeds delayed maturity only about one day.

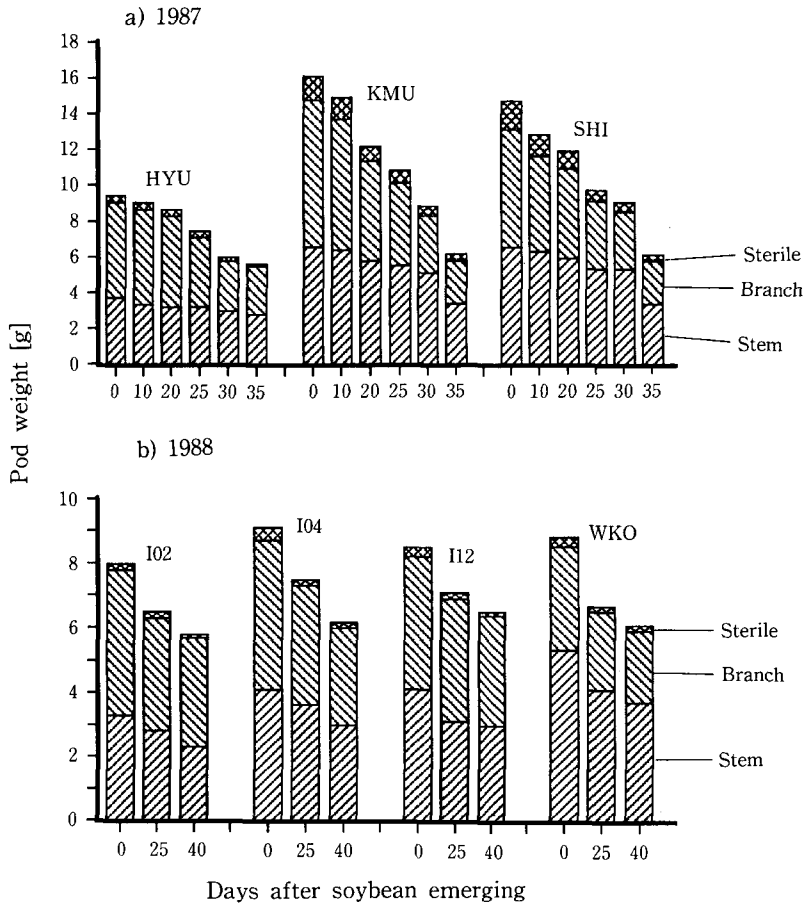

Fig. 4. Differential responses in threshed stem and branch, and sterile pod weight among soybean genotypes to postemergence duration of natural weed infestation.

Increasing plant height along with increasing duration of weed infestation in early stages of plant development indicated the applied genotypes' strong competitiveness with weeds for light. Some previous studies found that single species weed competition caused the soybean to grow shorter than noncompetitive stands did[16,21]. In other studies (ORWICK and SCHREIBER[18] ; SHURTLEFF and COBLE[19]) interference of some weed species caused plants to grow shorter but other species grew taller. It seems that when weeds were seeded or planted in uniform density and spacing, they influenced soybean development in a different way from naturally occurring multispecies and more dense weed populations.

The decrease of vegetative above ground biomass along with increase in weed duration of our experiments was in general agreement with findings reported by ORWICK and SCHREIBER[18], LEGERE and SCHREIBER[11], and MONKS and

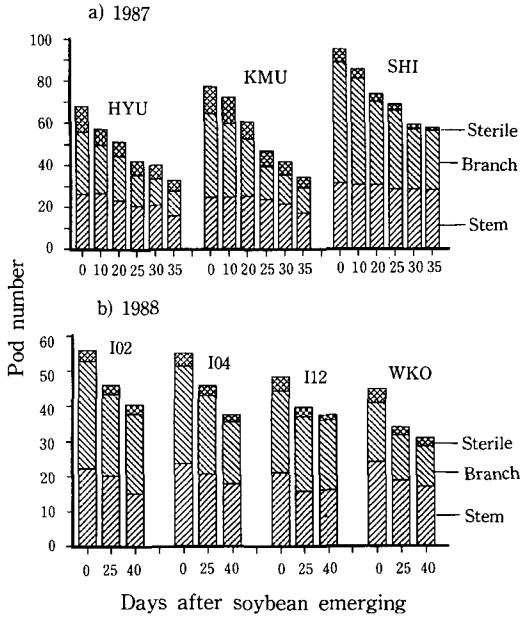

Fig. 5. Differential responses in stem, branch and sterile pod number per plant among soybean genotypes to postemergence duration of natural weed infestation.

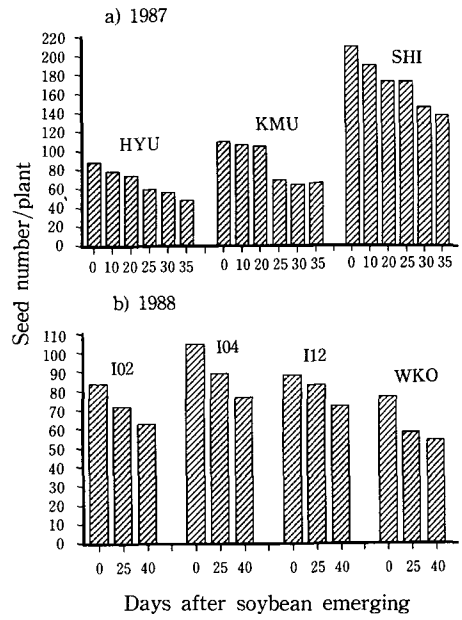

Fig. 6. Differential responses in seed number per plant among soybean genotypes to postemergence duration of natural weed infestation.

OLIVER[15]. Decreased branch number seems to be related to reduction of canopy width reported by MORTENSEN and COBLE[16] in the presence of weed interference. ORWICK and SCHREIBER[18] reported similar tendency in reducing branch number of soybean in the presence of weeds. STANIFORTH and WEBER[21] reported some increases in lodging when weeds interfered all-season. This is contrary to the results of our experiments which showed a small decrease in lodging with duration of postemergence weed infestation. Such lodging reaction of soybean to postemergence weed interference may be associated with reduced stem diameter, branching, and total above ground plant biomass. In response to weed infestation, if stem diameter becomes significantly thinner, lodging may increase, and strong reduction of branch and above ground biomass may decrease lodging.

Characteristics like basal pod height, number of pods below 15 cm, and pod number on lower half of plant height are connected to potential losses during mechanical harvesting. For this reason they have economical importance. Growth habit and sequence of flower development along canopy are closely associated with pod number on lower part of canopy. Our experiments showed significant decrease in pod number produced in lower parts of canopy when weeds were allowed to compete with soybean longer. It seems that densely growing

weeds can reduce the photosynthesis in the lower part of soybean canopy and also may reduce the amount of photomorphogenic light indispensable for developing buds, flowers, and pods. This could be the reason for pod abscission and yield reduction on shadowed parts of canopy[7,8,13].

Generally, the seed yield and its components showed similar decreasing tendency with increase in duration of weed interference, as it was found in numerous reports dealing with single weed species interfering with soybean[1,15,19,21]. Moreover, BURNSIDE[1] found that soybean varieties showed differences in competitiveness with both early and late emerging weeds and concluded that weed control in the first month after planting is the most critical in obtaining high soybean yields. Our experiments showed that any period of postemergence weed interference with soybean may be harmful for seed yield production. However, the extent of losses may depend greatly on genotypes and growing conditions.

Summary

To test the response of soybean to natural postemergence-weed interference, the experiments with three replication (split-plot) were conducted in 1987 and 1988 at Sapporo. Except phenological and a few other characteristics, most of the traits examined decreased along with duration of weed infestation. Decrease in seed yield was caused by reduction of seed number per plant in prolonged weed infestation. Any duration of weed infestation affected soybean development and yield. Weed control in the early time after soybean emergence is the most critical in obtaining high soybean seed yields.

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References

1. BURNSIDE O. C. : Soybean (*Glycine max*) growth as affected by weed removal, cultivar, and row spacing. Weed Sci. **27** : 562-565. 1979
2. BURNSIDE O. C. and G. A. WICKS : Influence of weed competition on sorghum growth. Weed Sci. **1** : 332-334. 1969
3. COBLE H. D., F. M. WILLIAMS and R. L. RITTER : Common ragweed (*Ambrosia artemisiifolia*) interference in soybeans. Weed Sci. **29** : 339-342. 1981
4. CORDES R. C. and T. T. BAUMAN : Field competition between ivyleaf morningglory (*Ipomoea hederacea*) and soybeans (*Glycine max*). Weed Sci. **32** : 364-370. 1984
5. GEDDES R. D., H. D. SCOTT and L. R. OLIVER : Growth and water use by common cocklebur (*Xanthium pensylvanicum*) and soybeans (*Glycine max*) under field conditions. Weed Sci. **27** : 206-212. 1979

6. HAGOOD E. S., Jr., T. T. BAUMAN, J. L. WILLIAMS Jr, and M. M. SCHREIBER : Growth analysis of soybeans (*Glycine max*) in competition with jimsonweed (*Datura stramonium*). Weed Sci. **29** : 500-504. 1981
7. HARDMANN L. L. and W. A. BRUN : Effect of atmospheric carbon dioxide enrichment at different developmental stages on growth and yield components of soybean. Crop Sci. **11** : 886-888. 1971
8. HEINDL J. C. and W. A. BRUN : Patterns of reproductive abscission, seed yield and yield components in soybean. Crop Sci. **24** : 542-545. 1984
9. HOWE O. W. III, and L. R. OLIVER : Influence of soybean (*Glycine max*) row spacing on pitted morningglory (*Ipomoea lacunosa*) interference. Weed Sci. **35** : 185-193. 1987
10. JACKSON L. A., G. KAPUSTA, and D. J. SCHUTTE MASON : Effect of duration and type of natural weed infestation on soybean yield. Agron. J. **77** : 725-729. 1985
11. LEGERE A. and M. M. SCHREIBER : Competition and canopy architecture as affected by soybean (*Glycine max*) row width and density of redroot pigweed (*Amaranthus retroflexus*). Weed Sci. **37** : 84-92. 1989
12. LOLAS P. C. and H. D. COBLE : Noncompetitive effects of johnsongrass (*Sorghum halepense*) on soybean (*Glycine max*). Weed Sci. **30** : 588-593. 1982
13. MANN J. D. and E. G. JAWORSKI : Comparison of stresses which may limit soybean yields. Crop Sci. **10** : 620-624. 1970
14. MCWHORTER C. G. and J. M. ANDERSON : Hemp sesbania (*Sesbania exaltata*) competition in soybeans (*Glycine max*). Weed Sci. **27** : 58-64. 1979
15. MONKS D. W. and L. R. OLIVER : Interactions between soybean (*Glycine max*) cultivars and selected weeds. Weed Sci. **36** : 770-774. 1988
16. MORTENSEN D. A. and H. D. COBLE : The influence of soil water content on common cocklebur (*Xanthium strumarium*) interference in soybean (*Glycine max*). Weed Sci. **37** : 76-83. 1989
17. OLIVER L. R. : Influence of soybean (*Glycine max*) planting date on velvetleaf (*Abutilon theophrasti*) competition. Weed Sci. **27** : 183-188. 1979
18. ORWICK P. L. and M. M. SCHREIBER : Interference of red root pigweed (*Amaranthus retroflexus*) and robust foxtail (*Setaria viridis* var. *robusta-alba* or var. *robusta-purpurea*) in soybeans (*Glycine max*). Weed Sci. **27** : 665-674. 1979
19. SHURTLEFF J. L. and H. D. COBLE : Interference of certain broadleaf weed species in soybeans (*Glycine max*). Weed Sci. **33** : 654-657. 1985a
20. SHURTLEFF J. L. and H. D. COBLE : The interaction of soybean (*Glycine max*) and five species in the greenhouse. Crop Sci. **33** : 669-672. 1985b
21. STANIFORTH D. W. and C. R. WEBER : Effects of annual weeds on the growth and yield of soybeans. Agron. J. **48** : 467-471. 1956
22. WEBER C. R. and D. W. STANIFORTH : Competitive relationships in variable weed and soybean stands. Agron J. **49** : 440-444. 1957
23. WILLIAMS C. S. and R. M. HAYES : Johnsongrass (*Sorghum halepense*) competition in soybeans (*Glycine max*). Weed Sci. **32** : 498-501. 1984