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Cultural Control Systems of Naturalized Weeds in Forage Crop Fields

Seturo SATO[*1], Koji TATENO[*2], Ryoji KOBAYASHI[*3] and Kuniaki SAKAMOTO[*4]

[*1,2,3] Grassland Division, Kyushu National Agricultural Experiment Station (Nishigoshi, Kumamoto, 861-1192 Japan)
[*4] Department of Research Planning and Coordination, Kyushu National Agricultural Experiment Station (Nishigoshi, Kumamoto, 861-1192 Japan)

Abstract

Experiments were conducted to control spiny amaranth (*Amaranthus spinosus* L.) and velvetleaf (Abutilon theophrasti Medic.) in a field of forage corn sown in early, mid-and late spring by using an Italian ryegrass (*Lolium multiflorum* Lam.) living mulch, and to control swinecress (*Coronopus didymus* (L.) J. E. Smith) in an Italian ryegrass sward by dense sowing at the Kyushu National Agricultural Experiment Station, Nishigoshi, Kumamoto. Growth spiny amaranth in the corn field depended on weed control treatments. The living mulch adequately controlled the weed in the field of corn sown in early spring, but the weed-controlling effect was reduced with the delay in the sowing date, and the living mulch did not control the weed in the late spring sowing plot. Although the living mulch substantially reduced the fodder yield of corn in the early spring sowing plot, it only slightly reduced the corn yield in the mid-spring sowing plot. Pre-emergence application of atrazine + alachlor adequately controlled the weed irrespective of the sowing dates. Neither living mulch nor pre-emergence herbicide mixture adequately controlled velvetleaf, but the growth of velvetleaf in the field of forage corn depended on the sowing date of corn. At the time of corn harvest, growth in the late spring sowing plot was more reduced than that in the plot sown in mid-spring, which indicates that a shift of the corn sowing date to late spring could be effective for avoiding damage by velvetleaf. Sowing of Italian ryegrass at twice as much as the standard density adequately suppressed the growth of existing swinecress in the ryegrass sward, and dense sowing markedly reduced the amount of the weed both in the first and second croppings of ryegrass without reduction of the crop yield. Cropping systems of forage crops that could effectively avoid the damage caused by velvetleaf, spiny amaranth and swinecress were examined based on the experimental results.

Discipline: Weed control
Additional key words: dense sowing, living mulch, spiny amaranth, swinecress, velvetleaf

Introduction

In recent decades, various alien weeds have been detected in forage crop fields throughout Japan. It is considered that these species were introduced through imported concentrates[10)], and some of them are recalcitrant. Our previous questionnaire revealed that the most serious naturalized weeds in the Kyushu district were spiny amaranth (*Amaranthus spinosus* L.) and velvetleaf (*Abutilon theophrasti* Medic.) in forage corn fields and swinecress (*Coronopus didymus* (L.) J. E. Smith) in Italian ryegrass swards[3)].

Spiny amaranth and velvetleaf compete with corn during the growing season, and their mature lignified plants, which reach 2 m or more in height, mechanically disturb the harvest. Spiny amaranth often occurs in fields treated with the conventional pre-emergence herbicides, *i.e.*, atrazine, alachlor and their combination, and velvetleaf is considered to be resistant to the pre-emergence herbicides[3,6,12)]. Although swinecress reaches a height of only 20 to 30 cm and has no adverse effect on Italian ryegrass growth, cows tend to produce milk with a strong odor of swinecress when the weed contaminated their feed[9)]. Swinecress plants are often overlooked because they slip into the ryegrass sward, and thus, chemical con-

Present address:
[*1] Department of Animal Production, Chugoku National Agricultural Experiment Station (Oda, Shimane, 694–0013 Japan)
[*2] Department of Research, Planning and Coordination, National Grassland Research Institute (Nishinasuno, Tochigi, 329–2793 Japan)
Corresponding author: S. Sato (uhyouhyo@anim.affrc.go.jp, fax +81–8548–2–2280)

trol of this weed is frequently unsuccessful.

For these reasons, it is important to develop cultural methods to replace chemical applications for the control of spiny amaranth, velvetleaf and swinecress.

Living mulch (cover crop) is considered to be a suitable cultural method to control weeds in row crops in the United States[5] and Sato et al.[9] reported that the growth of swinecress observed in Italian ryegrass swards was affected by the sowing density of ryegrass.

The objectives of this study were 1) to implement the cultural control of spiny amaranth and velvetleaf in forage corn fields by the use of an Italian ryegrass living mulch, 2) to control swinecress in Italian ryegrass swards by dense sowing, and 3) to analyze the cultural systems applied to control these weed species in forage crop fields.

Materials and methods

All the experiments were conducted at the Kyushu National Agricultural Experiment Station in Nishigoshi, Kumamoto. The soil type was a thick high humic Andosol (Melanudands). Plots were arranged in a randomized complete block design with 2 or 3 replications, and data were subject to an analysis of variance ($P < 0.05$).

1) Control of spiny amaranth and velvetleaf in forage corn field

Experiments were conducted to control spiny amaranth and velvetleaf in a forage corn yield using a cultural method in 1995 and 1996. The experimental design is shown in Table 1. Corn (*Zea mays* L. cv. Pioneer 3352) was sown 20 cm apart in rows 0.75 m apart in 3 m long plots. Velvetleaf seeds were treated with water at 70°C for 15 min to promote their germination[2]. After sowing of spiny amaranth or velvetleaf seeds, plots were treated with either a living mulch or a pre-emergence herbicide mixture to control the weeds. Italian ryegrass (*Lolium multiflorum* Lam. cv. Tachiwase) was sown at a density of 0.3 and/or 0.6 kg/a in the living mulch plots, and pre-emergence application of atrazine + alachlor at a rate of 10.0 + 10.8 g/a was performed in the herbicide-treated plots. For each weed, a single plot was left untreated as a check plot. In all the experiments, both the sowing of the weeds and the weed control treatments were carried out on the same day as the sowing of corn.

To monitor the growth of weeds and corn, vegetation from either a 0.4 × 0.75 or a 0.6 × 0.75 m area with 2 or 3 corn plants in the center was cut periodically, and leaf area and dry weight of weeds and corn were determined. At harvest time, 5 corn plants from a 1 m section of a central row in each plot, and vegetation in a 1 m sec-

Table 1. Experimental design of spiny amaranth and velvetleaf control[a)]

Cultural details	Corn sowing time		
	Early spring	Mid-spring	Late spring
Date of corn sowing	April 5, 1995	April 28, 1996	May 24, 1996
Amount of fertilizer applied (N–P_2O_5–K_2O)(kg/a)	3.0–3.0–3.0	2.5–2.5–2.5	2.5–2.5–2.5
Sowing rate (g/a) and sowing depth of spiny amaranth seeds (cm)	17.8 0	26.7 0–8	26.7 0–8
Sowing rate (g/a) and sowing depth of velvetleaf seeds (cm)	46.0 0	46.0 0–10	46.0 0–10
Plot size of one treatment (m) and no. of rows in a plot (rows/plot)	3.0 × 6.75 9	3.0 × 6.0 8	3.0 × 6.0 8
Weed control method[b)]	L3, L6, HB	L3, HB	L3, HB
Date of sampling to determine growth parameters in spiny amaranth control experiment (weeks after sowing)	7, 9, 11	5.5, 6.5, 7.5, 8.5	5.5, 6.5, 7.5
Date of sampling to determine growth parameters in velvetleaf control experiment (weeks after sowing)	6, 8, 10	5, 6, 7, 8	5, 6, 7
Harvest date	July 19, 1995	July 29, 1996	August 13, 1996

a): Each experiment was carried out in different fields.
b): L3 and L6: Italian ryegrass living mulch treatment sown at a density of 0.3 and 0.6 kg/a, respectively.
HB: Pre-emergence application of atrazine + alachlor at a rate of 10.0 + 10.8 a. i. g/a.

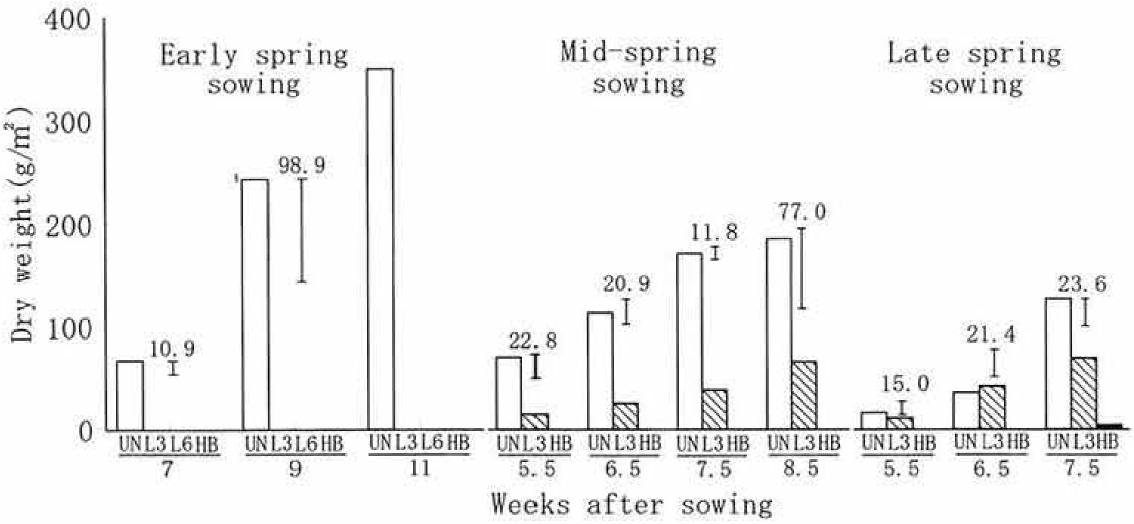

Fig. 1. Changes in dry weight of spiny amaranth during corn growth
UN (□): Untreated.
L3 (▧) and L6 (▩): Italian ryegrass living mulch treatement sown at a density of 0.3 and 0.6kg/a, respectively.
HB (■) : Pre-emergence application of atrazine + alachlor at a rate of 10.0 + 10.8 a. i. g/a.
Vertical lines indicate LSD ($P<0.05$).

tion of interrow adjacent to the central row were cut to determine the dry weight.

2) Control of swinecress in Italian ryegrass sward

On October 18, 1995, Italian ryegrass was sown in three 3 × 6 m plots infested with swinecress seeds previously sown at a density of 50 g/a. In one of the plots, ryegrass was sown at a density of 250 g/a with post-emergence application of thifensulfron-methyl (Harmony) at a rate of 0.375 g/a 6 weeks after sowing (herbicide-treated plot). In the 2 remaining plots, ryegrass was sown at the density of 250 g/a (check plot) and 500 g/a (dense-sowing plot) without herbicide application. Samples of crops from the first and second croppings (hereafter referred to as "first and second crops") from two 0.5 × 0.5 m quadrates in each plot were harvested on April 15 and May 2, 1996, respectively. All the samples were assorted into the ryegrass and swinecress (no other species were found), and the growth of the weed and yield of ryegrass were determined. Prior to the sowing, swinecress seeds were treated by the method of Kobayashi[3] to promote their germination. Plots were fertilized at a rate of 0.5–0.5–0.5 kg/a with a 16–16–16 N–P_2O_5–K_2O compound fertilizer before sowing.

Results and discussion

1) Control of spiny amaranth and velvetleaf in forage corn field

(1) Spiny amaranth control

Changes in the weight of spiny amaranth during corn growth are shown in Fig. 1. Italian ryegrass living mulch completely controlled spiny amaranth during the growing season of corn in the early spring sowing plot. Adequate weed control was achieved because Italian ryegrass grew vigorously enough to compete with the weed under cool temperatures during the growing season. The effect of the living mulch on weed control was less pronounced with the delay in corn sowing, and the mulch of the late spring sowing plot failed to control the weed because the ryegrass seedlings withered at high temperatures after emergence. The effect of the mulch on the control of spiny amaranth in the mid-spring sowing plot was intermediate between that of the early and late spring sowing plots.

Pre-emergence application of atrazine + alachlor adequately controlled spiny amaranth in every sowing. Weed seeds were present in the surface soil in the early spring sowing plot, and in soils at a depth of 0–8 cm in the mid- and late spring sowing plots. The herbicide mixture completely controlled the weed when the weed seeds were in and under the herbicide-treated layer. Since spiny amaranth is sensitive to atrazine + alachlor, these herbicides may be absorbed both through the roots and the hypocotyls exposed to the treated soil[1].

Changes in the dry weight and leaf area of corn and spiny amaranth during corn growth are shown in Table 2 and Fig. 2, respectively. In the early spring sowing plot, the living mulch suppressed the growth of corn. The dry weight and LAI (leaf area index) of corn in the living mulch plots were found to be significantly smaller than those in the untreated and herbicide-treated plots during

Table 2. Changes in dry weight of corn during growth in the spiny amaranth control experiment[a)]

(g/m^2)

Sowing time	Early spring			Mid-spring				Late spring		
Weeks after sowing	7	9	11	5.5	6.5	7.5	8.5	5.5	6.5	7.5
Untreated check	36.8A	191.6A	451.5A	53.0A	121.7A	182.5A	329.5A	75.5A	221.0A	498.2A
Living mulch plot (L3)[b)]	14.4B	47.7B	199.7B	56.9A	90.1B	201.5A	336.5A	79.6A	188.7A	560.9A
Living mulch plot (L6)[b)]	16.4B	69.7C	127.8C	–	–	–	–	–	–	–
Pre-emergence application[c)]	38.8A	158.0D	586.2D	62.1A	113.4A	253.4A	422.4A	73.8A	266.8A	574.5A

a): Values followed by the same letters within the same columns are not significantly different (P<0.05).
b): Living mulch plots were treated with Italian ryegrass sown at a density of 0.3 or 0.6 kg/a.
c): Mixture of atrazine+alachlor was applied at a rate of 10.0+10.8 a.i. g/a before corn seedling emergence.

growth in the early spring sowing plot. In the mid-spring sowing plot, although the dry weight of corn in the living mulch plot was smaller than that in the untreated and herbicide-treated plots 6.5 weeks after sowing, and although the LAI of corn in the living mulch plot was smaller than that in the herbicide-treated plot 7.5 weeks after sowing, the living mulch suppressed the growth of corn less in the mid-spring sowing plot than in the early spring sowing plot. In the late spring sowing plot, the living mulch did not suppress the corn growth, and there was no difference in the growth parameters among the weed control treatments.

Dry weight of spiny amaranth at the corn harvest time and corn yield are shown in Fig. 3. Spiny amaranth plants were not detected in the living mulch plots sown in early spring. In the mid-spring sowing plot, the dry weight of the weeds in the living mulch plots was smaller than that in the untreated plots, while in the late spring sowing plot, the dry weight of the weeds was similar. In the herbicide-treated plots, few spiny amaranth plants were observed, and the dry weight of the weeds was significantly smaller than that in the untreated plots in every sowing. In the early spring sowing plot, corn fodder yield in the living mulch plots was reduced to 60–66% of that in the untreated plot. In the mid-spring sowing plot, a slightly lower corn yield was observed in the living mulch plot. No significant difference was observed in the yield between the living mulch and the untreated plots in the late spring sowing plot. Corn fodder yield in the herbicide-treated plots was approximately similar to that

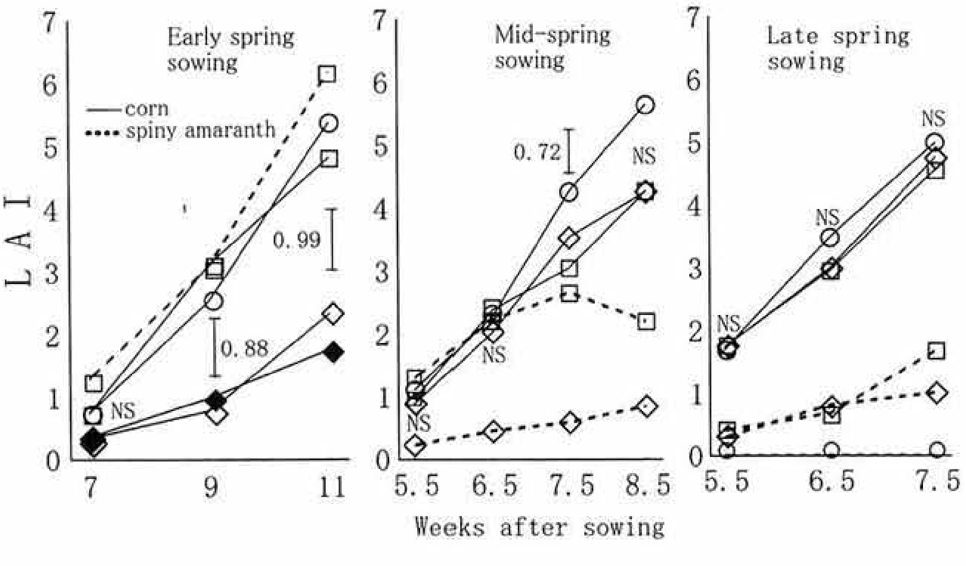

Fig. 2. Changes in leaf area of corn and spiny amaranth during corn growth
□ :Untreated.
◇ and ◆ : Italian ryegrass living mulch treatment sown at a density of 0.3 and 0.6 kg/a, respectively.
○ : Pre-emergence application of atrazine + alachlor at a rate of 10.0 + 10.8 a. i. g/a.
Spiny amaranth plants were not observed in the living mulch plots nor in the herbicide-treated plots in the early spring sowing.
Vertical lines indicate LSD (P<0.05) of corn. NS: Not significant (P<0.05).

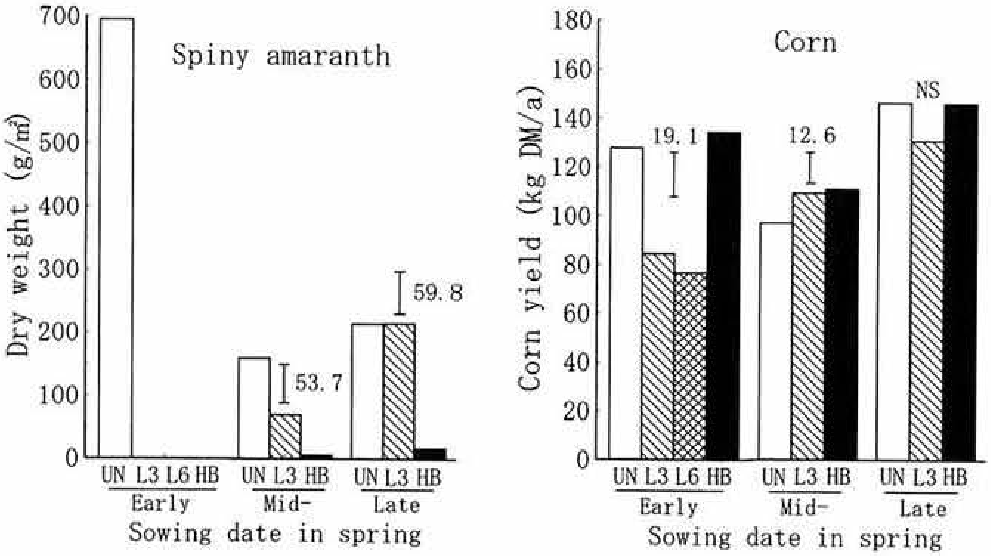

Fig. 3. Dry weight of spiny amaranth at corn harvest time and corn yield

UN (□): Untreated.

L3 (▧) and L6 (▨): Italian ryegrass living mulch treatement sown at a density of 0.3 and 0.6 kg/a, respectively.

HB (■) : Pre-emergence application of atrazine + alachlor at a rate of 10.0 + 10.8 a. i. g/a.

Vertical lines indicate LSD ($P<0.05$). NS: Not significant ($P<0.05$).

in the untreated plots irrespective of the sowing dates. In the untreated and herbicide-treated plots, corn yield in the late spring sowing plot was lower than that in the early and mid-spring sowing plots, because harvest was earlier than the maturation time of corn to avoid damage by typhoons.

Meanwhile, pre-emergence application of atrazine + alachlor successfully controlled spiny amaranth irrespective of the sowing dates without any reduction in corn yield, although this herbicide mixture has often been reported to be ineffective in corn fields[8, 11]. Failure to control the weed using pre-emergence herbicides is often observed in fields in which slurry and/or immature compost had been continuously applied. It is assumed that a change in soil adsorption resulting from continuous application of organic fertilizer might be responsible for the ineffectiveness of the pre-emergence herbicides[13].

The results revealed that the Italian ryegrass living mulch 1) strongly suppressed corn growth in the early spring sowing although it could control the weed, 2) could not control the weed in the late spring sowing, and 3) could adequately control the weed in the mid-spring sowing without severe reduction of the corn yield. The use of the living mulch could be a suitable method of control of spiny amaranth in fields of forage corn sown in mid-spring if a slight reduction of corn yield and slight infestation with the weed were acceptable to the farmers. Moreover, it is definitely an effective method of control in the fields where application of slurry and/or immature compost as fertilizer had reduced the effectiveness of pre-emergence herbicides.

(2) Velvetleaf control

Changes in the dry weight of corn and leaf area of corn and velvetleaf during corn growth are shown in Table 3 and Figs. 4 and 5, respectively. Data on mid-and late spring sowings are presented and analyzed because

Table 3. Changes in dry weight of corn during growth in the velvetleaf control experiment[a)]

(g/m^2)

Sowing date	Mid-spring				Late spring		
Weeks after sowing	5	6	7	8	5	6	7
Untreated check	26.9A	71.4A	146.8A	212.2A	86.1A	137.2A	296.1A
Living mulch plot (L3)[b)]	25.4A	68.9A	145.6A	191.1A	83.9A	152.8A	328.0A
Pre-emergence application[c)]	36.3B	121.8B	195.8B	238.4A	82.4A	184.3A	332.6A

a): Values followed by the same letters within same columns are not significantly different ($P<0.05$).

b): Living mulch plot was treated with Italian ryegrass sown at a density of 0.3 kg/a.

c): Mixture of atrazine+alachlor was applied at a rate of 10.0+10.8 a.i. g/a before corn seedling emergence.

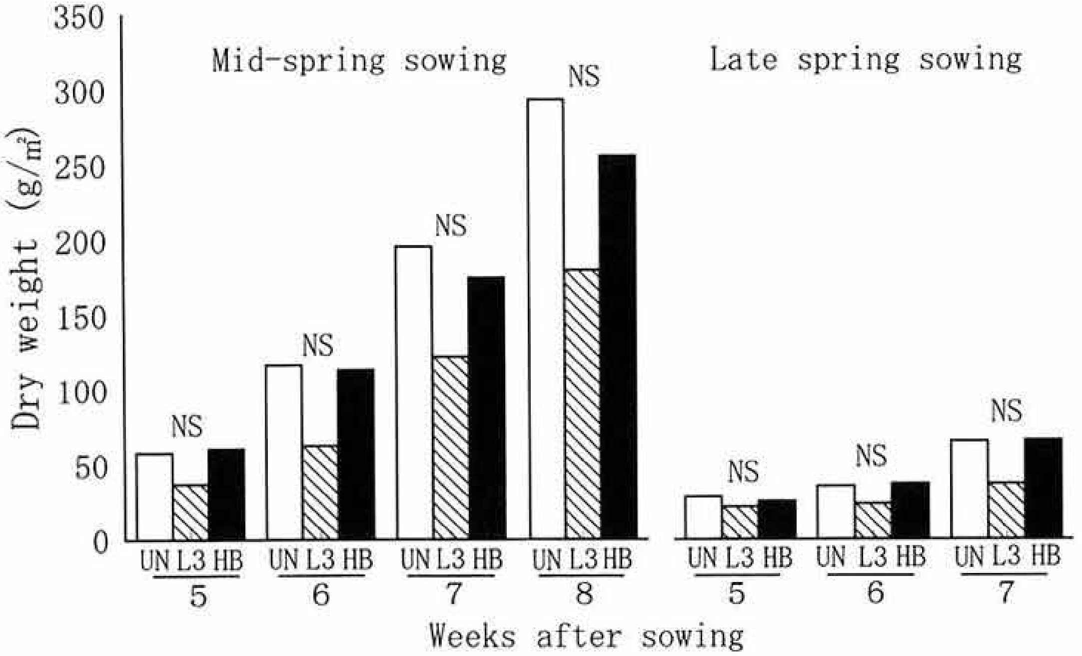

Fig. 4. Changes in dry weight of velvetleaf during corn growth
UN (□) : Untreated. L3 (▨) : Italian ryegrass living mulch treatement sown at a density of 0.3 kg/a.
HB (■) : Pre-emergence application of atrazine + alachlor at a rate of 10.0 + 10.8 a. i. g/a.
NS: Not significant ($P<0.05$).

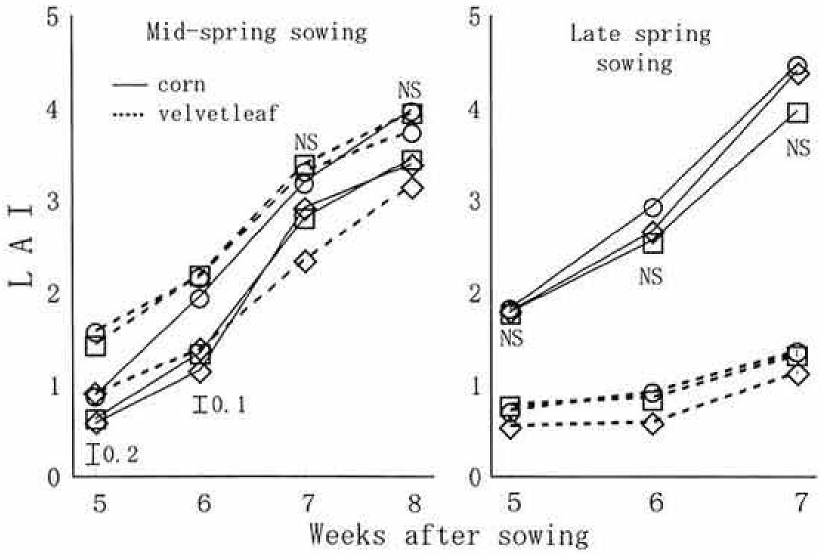

Fig. 5. Changes in leaf area of corn and velvetleaf during corn growth
□ : Untreated.
◇ : Italian ryegrass living mulch treatment sown at a density of 0.3 kg/a.
○ : Pre-emergence application of atrazine + alachlor at a rate of 10.0 + 10.8 a. i. g/a.
Vertical lines indicate the magnitude of LSD ($P<0.05$) of corn.
NS: Not significant ($P<0.05$).

velvetleaf seeds used in the early spring sowing were less vigorous and the percentage of emergence was too low to obtain the data.

Neither the Italian ryegrass living mulch nor pre-emergence herbicide mixture controlled velvetleaf during the growing season of corn irrespective of the sowing dates. There were no differences among the weed control treatments in terms of the growth of the weed for both

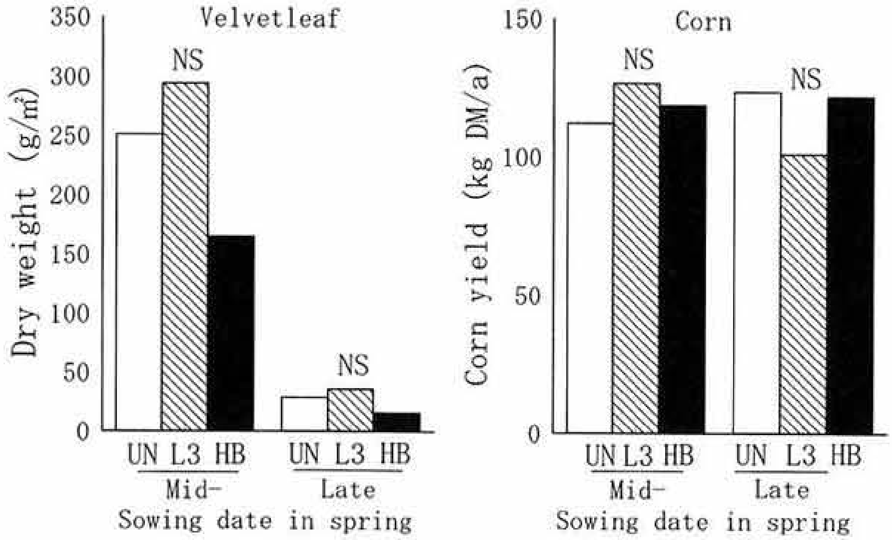

Fig. 6. Dry weight of velvetleaf at corn harvest time and corn yield
UN (□) : Untreated.
L3 (▨) : Italian ryegrass living mulch treatment sown at a rate of 0.3 kg/a.
HB (■) : Pre-emergence application of atrazine + alachlor at a rate of 10 + 10.8 a. i. g/a.
NS: Not significant ($P<0.05$).

sowing dates. Although the living mulch had no effect on weed growth because ryegrass seedlings withered at high temperatures, the dry weight of the weed in the late spring sowing plot was smaller than that in the mid-spring sowing plot for all of the investigation dates during corn growth.

In the mid-spring sowing plot, there were no significant differences in the change in the dry weight of corn between the plots treated with living mulch and untreated plots, and the dry weight of the herbicide-treated plots was largest among the weed control treatments. Although the LAI of corn in the mid-spring sowing plots was smaller in the living mulch and untreated plots than that in the herbicide-treated plots 5 and 6 weeks after sowing, no significant differences were observed among the weed control treatments subsequently.

In the late spring sowing plot, the living mulch did not suppress corn growth, and there were no differences in the growth parameters among the weed control treatments.

Dry weight of velvetleaf at corn harvest time and corn yield are shown in Fig. 6. No significant differences were observed in the dry weight of velvetleaf among the weed control treatments in either the mid-or late spring

Table 4. Growth of swinecress and Italian ryegrass yield at harvest time[a)]

Weed control treatment (sowing density of ryegrass)		First cropping[b)]				Second cropping[b)]			
		Swinecress[c)]			Italian ryegrass yield	Swinecress[c)]			Italian ryegrass yield
		No.of plants	Dry weight	No. of flowering plants		No. of plants	Dry weight	No. of flowering plants	
	(kg/a)	(/m²)	(g/m²)	(/m²)	(kg DM/a)	(/m²)	(g/m²)	(/m²)	(kg DM/a)
Untreated	(0.25)	28.3A	2.56A	0	113.6A	18.7A	1.74A	17.7A	38.8A
Dense sowing	(0.50)	3.3B	0.05B	0	99.4A	2.7B	0.20B	2.3B	40.4A
Herbicide[d)]	(0.25)	5.0B	0.03B	0	71.3B	1.0B	0.02C	1.0B	27.8B

a): Values followed by the same letters within same columns are not significantly different ($P<0.05$).
b): First and second crops were harvested on April 15 and May 18, 1996, respectively.
c): Swinecress was sown at a density of 0.05 kg/a prior to the ryegrass sowing.
d): Post-emergence application of thifensulfron-methyl (Harmony) was made at a rate of 0.375 g/a 42 days after ryegrass sowing.

Table 5. **Cropping systems for the control of spiny amaranth, velvetleaf and swinecress in forage crop fields**

Cropping System	Weed control treatment (▲)	Weed species	Pre-emergence herbicide effectiveness	Forage crops and their growing season (Jan.–Dec.)
System 1	Pre-emergence application (▲ 1)	General	effective	Jan.–Mar.: Italian ryegrass ×; Apr.: ○ corn (▲ 1) × (Aug.); Oct.: ○ Italian ryegrass
System 2	Living mulch (▲ 2)	Spiny amaranth	ineffective	Jan.–Mar.: Italian ryegrass ×; Apr.: ○ corn (▲ 2) × (Aug.); Oct.: ○ Italian ryegrass
System 3	Shift of sowing date (▲ 3)	Velvetleaf	effective or ineffective	Jan.–Mar.: Italian ryegrass ×; May: ○ corn (▲ 3) × (Sep.); Oct.: ○ Italian ryegrass
System 4	Pre-emergence application (▲ 1) Dense sowing (▲ 4)	General Swinecress	effective	Jan.–Mar.: Italian ryegrass ×; Apr.: ○ corn (▲ 1) × (Aug.); Oct.: ○ (▲ 4) Italian ryegrass
System 5	Living mulch (▲ 2) Dense sowing (▲ 4)	Spiny amaranth Swinecress	ineffective	Jan.–Mar.: Italian ryegrass ×; Apr.: ○ corn (▲ 2) × (Aug.); Oct.: ○ (▲ 4) Italian ryegrass
System 6	Shift of sowing date (▲ 3) Dense sowing (▲ 4)	Velvetleaf Swinecress	effective ineffective	Jan.–Mar.: Italian ryegrass × × (Apr.); May: ○ corn (▲ 3) × (Sep.); Oct.: ○ (▲ 4) Italian ryegrass

▲ 1–4: Weed control treatment. ○ : Sowing of forage crops. × : Harvest of forage crops.

sowing plot. However, the growth of the weed in the late spring sowing plot was much more reduced than that in the mid-spring sowing plot, and the difference corresponded to the weed growth during the corn growing season. The reduced growth of velvetleaf in the late spring sowing plot may have been caused, partly, by competition with vigorous corn growth during the growing season, and, partly, by the short photoperiodic response of the weed[4,7]. There were no significant differences in the corn yield among the weed control treatments in either the mid- or late spring sowing plot.

In the current experiment, neither the Italian ryegrass living mulch nor the pre-emergence herbicide mixture could control velvetleaf in the forage corn field. However, shifting the sowing date to late spring should be recommended as a useful cultural method for avoiding damage by this weed.

2) Control of swinecress in Italian ryegrass sward

Growth of swinecress and yield of Italian ryegrass at harvest time are shown in Table 4. At the first crop harvest, the plant density and weight of swinecress in both the dense sowing and herbicide-treated plots were smaller than those in the untreated plot. No flowering plants of the weed were observed in the first crop. At the second crop harvest, the plant density and weight of swinecress in both the dense sowing and herbicide-treated plots were much smaller than those in the untreated plot. After the first crop harvest, most of the swinecress plants in each plot resumed growth and flowered by the second crop harvest. The number of flowering plants in both the dense sowing and herbicide-treated plots was significantly smaller than that in the untreated plot.

Ryegrass yield in the dense-sowing plot was almost similar to that in the untreated plot, but was higher than that in the herbicide-treated plot at each harvest. The decrease of the ryegrass yield in the herbicide-treated plot was ascribed to injury by the herbicide during the growing season (Table 4).

It is concluded that dense sowing of Italian ryegrass should be a promising method not only for the suppression of the growth of swinecress plants present in the Italian ryegrass swards but also for the prevention of future infestation through the inhibition of seed production.

3) Cropping systems of forage crops for weed control

Forage corn production followed by the planting of Italian ryegrass is a major cropping system in the Kyushu district, where pre-emergence application of atrazine + alachlor is performed for weed control in forage corn field (System 1 in Table 5). Spiny amaranth and velvetleaf in the corn fields and swinecress in the ryegrass swards are the most serious weeds in this cropping system. The present study revealed that 1) ryegrass living mulch could be applied to control spiny amaranth in corn sown in mid-spring, 2) damage to corn caused by velvetleaf should be less serious in the late spring sowing than that in the mid-spring sowing, and 3) the growth of swinecress in the Italian ryegrass sward could be suppressed when the ryegrass is sown at a high density. Based on these results, Table 5 presents 5 modified cropping systems in the forage crop fields infested by these weed species.

Spiny amaranth could be controlled with the pre-emergence herbicide mixture irrespective of the sowing date. However, in the fields where fertilization with immature compost has reduced the effectiveness of the herbicide mixture owing to the changes in soil adsorption, Italian ryegrass living mulch should be applied for controlling the weed and corn must be sown in mid-spring in this case (System 2). Although neither the pre-emergence herbicides nor the living mulch could control velvetleaf, weed damage to corn was less appreciable in the late spring sowing. In the Kyushu district, when Italian ryegrass is harvested twice using a bale machine specialized for grass harvesting, the second crop is often harvested in mid-spring. Therefore, it is recommended to sow corn in late spring after the second harvest of Italian ryegrass to avoid the damage by velvetleaf and to use efficiently the bale machine (System 3).

As herbicide application is not useful to control swinecress in an Italian ryegrass sward, dense sowing may be the only effective method of weed control. In the case of the ryegrass sward already infested with swinecress, dense sowing might be combined with System 1, 2 or 3, depending on the weed species in corn, and Systems 4, 5 and 6 could be recommended.

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