サトウキビとハイキビの競合

Interaction Between Sugarcane and Torpedograss (*Panicum repens* L.) Densities

Md. Amzad HOSSAIN*, Ichiro NAKAMURA**, Yukio ISHIMINE**, Seiichi MURAYAMA**, Hidejiro SHIBAYAMA*** and Eiji TSUZUKI****

Key words : Sugarcane-torpedograss densities, interaction, weed biomass, sugarcane yield.

キーワード：サトウキビーハイキビ栽植密度、相互作用、雑草生育量、サトウキビ収量

Summary

Weed densities of 0, 2, 4 and 8/sugarcane/pot (experiment Ⅰ), and sugarcane densities of 0, 1, 2, 3 and 4/4 weeds/pot (expt. Ⅱ) were studied to evaluate interaction between sugarcane and torpedograss (*Panicum repens* L.). In expt. Ⅰ, sugarcane reduced total torpedograss biomass by 26-49%. Weed biomass per pot in sugarcane was increased as the weed density was increased while per weed plant biomass was decreased. The weed reduced sugarcane yield by 65-80%. Yield was decreased as the weed density was increased. Brix percentage (%) was slightly higher in weed infested sugarcane. In expt. Ⅱ, weed biomass was decreased as the sugarcane density was increased. Weed suppression ability of per sugarcane plant was decreased as the sugarcane density was increased. Higher sugarcane density increased growth and yield parameters of sugarcane per pot in weed infested treatments while the parameters per sugarcane plant were decreased. Sugarcane densities of 2, 3 and 4 recorded increased yield by 51, 81 and 87%, respectively, and they recorded decreased weed biomass by 25, 49 and 56%, accordingly compared to weed infested single (1) sugarcane. Sugarcane density of 4 showed thin culm and lower stalk length, and increased a little amount of yield than the density of 3. Effects of sugarcane densities were not observed on brix %. The experiment showed that higher density of sugarcane up to a

* United Graduate School of Agricultural Sciences, Kagoshima University, Kagoshima, 890 Japan

** Faculty of Agriculture, University of the Ryukyus, Okinawa, 903 - 0213 Japan

*** Faculty of Agriculture, Saga University, Saga, Japan

**** Faculty of Agaiculture, Miyazaki Vnirersity, Miyazaki 889−2192, Japan

certain limitation is one of the important ways to control torpedograss and to increase sugarcane yield.

Introduction

In response to environmental concerns about water contamination, soil microorganism hazards, health hazards, food risk and unknown environmental consequences of herbicide use, programs were implemented to reduce or cancel herbicide use [26,30]. To achieve this objective integrated weed management has been promoted. While herbicides are not eliminated as control options in integrated weed management, complementary methods such as increasing the relative competitive ability of the crop versus the weed are also used. Increased competitive ability may result from efficient nutrient management, or better use of crop densities and row width[26]. Non-chemical cultural methods for avoiding the environmental hazards of chemical method of weed control has to be made[17].

Studies on critical threshold of weed-crop interactions, nature of interactions and its mechanism for realizing maximum yield potential of crops are necessary to manage a particular weed in a particular crop field[15,17,20,28]. There is a need to understand better the biology of weeds and the factors that favor specific weed or weed groups in a certain crop field[1]. The impacts of weed and crop density in yield components of a crop are central to an understanding of the way weed interactions influences yield potential of a crop[2]. A number of investigators established the negative impact and correlations between increased density and seeding rates on the yield components in rice crops[2,15,28,29]. Many reporters reported that rice yield responses to weed and crop density, crop density can be a critical factor influencing rice yield losses to weeds and seedling rate has an important role in weed control[15,16,28]. Worsham[28] reported that increasing the seeding rate of rye using a cultivar that tended to produce higher biomass, and killing the cover crops as close to planting time as possible all increased weed suppression. Seedling rate higher than recommended are used to help control weeds but it should not be too low to provide open spaces for weed growth, but not too high to result in thick stand, intra specific interactions, thin culms and loading[1].

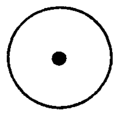
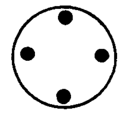
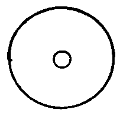
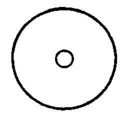
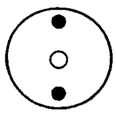
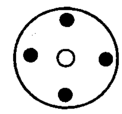
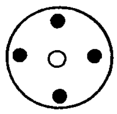
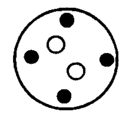
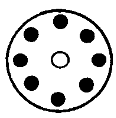
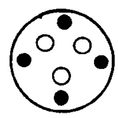
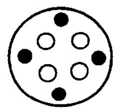
Wider row spacing, longer time for emergence, slower seedling growth and gapping in sugarcane are main factors which enhance weed growth and reduce sugarcane yield[11,19,20]. Kropff et al.[14] reported that wide row spacing enhanched the relative competitive ability of early germinating barnyardgrass but combinations of row widths and crop densities were not explored. Torpedograss (*Panicum repens* L.) is a serious rhizomatous weed in tropical and subtropical areas. Higher rhizomes and roots (7.5 ton/ha) make a loose mat-like structure into soil up to 50 cm deep and the weed also obtains higher shoot biomass (4.7 tons/ha)[6]. The weed infests the crop under and above ground. It is one of the severe weeds in sugarcane in Taiwan, Hawaii and Okinawa[5,8]. The weed reduced sugarcane yield by 70% was reported by several sinvestigators[11,23]. Higher sugarcane density may reduce weed and increase sugarcane yield [8,11]. Therefore, present study was conducted to investigate interactions between sugarcane and torpedograss densities for controlling the weed and for obtaining higher yield of sugarcane.

Materials and Methods

Experiment I

Pot experiment was conducted on reddish soil during the period of May to December, 1992 in the glasshouse of Experimental Farm of the University of the Ryukyus, Japan. The soil contained 0.89% C, 0.11% N and 134 mg P/100g soil, and exchangeable K, Ca, Mg and Na were 0.17, 10.8, 1.35 and 0.31 me/100g soil, respectively, and its pH was 5.25-6.74[13]. About 18 kg soil was taken in each wagner pot (1/2000a, a=100m^2) and recommended fertilizer N:P:K = 3.6:2.0:2.8 was mixed at 370 kg/ha. One-node cuttings of sugarcane (cv. F-160) were kept in water for 24 hours for good sprouting. Two-nodes weed-rhizome (*Panicum repens* L.) cuttings were planted in sand bed for 24 hours for good sprouting. The bed was watered as required. The experiment consisted of five treatments with five replications which

Table 1. Torpedograss and sugarcane planting design in pots.

Experiment I [a]		Experiment II [b]	
treatments	planting design	treatments	planting design
T1(1 W)		T1(4 W)	
T2(1 S)		T2(1 S)	
T3(1 S + 2 W)		T3(1 S +4 W)	
T4(1 S + 4 W)		T4(2 S + 4 W)	
T5(1 S + 8 W)		T5(3 S + 4 W)	
		T6(4 S + 4 W)	

Note : a) = Two-nodes rhizome cutting and one-node sugarcane stalk cultting were planted, b) = One-node rhizome cutting and one-node sugarcane stalk cutting were planted, ● =W=Weed, ○ =S=Sugarcane. Pot sizes in experiment I and experiment II were 0.05m^2 and 0.2m^2, respectively.

were :- T1 : Pure stand 1 weed-rhizome cutting, T2 : Pure stand 1 sugarcane cutting, T3 : 1 sugarcane cutting + 2 weed-rhizome cuttings, T4 : 1 sugarcane cutting + 4 weed-rhizome cuttings, T5 : 1 sugarcane cutting + 8 weed-rhizome cuttings. Torpedograss-rhizome cuttings and sugarcane-stalk cuttings were planted in pots according to the Table 1 (experiment I). Experiment was watered twice a day. No weed except torpedograss was allowed to grow. Two equal splits of same fertilizer in same rate was applied as top dressing at 60 and 120 day after planting (DAP). Diazinon was applied as required. Data for sugarcane and weed were recorded on stem length up to top visible dewlap (TVD) and number of tillers at 30 day intervals starting 30 DAP. Data at harvest for sugarcane were recorded on stalk length, stalk diameter, brix % and leaf area; fresh and dry weight of stalks, leaves, roots and shoots. Data for weed were recorded at harvest on dry weight of shoots and rhizomes including roots. Data were analyzed statistically by Duncan's Multiple Range Test (DMRT).

Experiment II

Pot experiment was conducted on the same reddish soil during the period of May to December, 1995 in the glasshouse of experimental farm of the University of the Ryukyus. Each wagner pot (1／1000a) was filled with 35 kg soil and fertilizer N:P:K=3.6:2.0:2.8 was mixed at 370 kg／ha. Experiment was fitted in a completely randomized design. One-node cuttings of sugarcane (cv. NCo 310) were kept in water for 24 hours for good sprouting. One-node rhizome cuttings were planted in the sand bed for 24 hours for good sprouting. The bed was watered as required. Experiment consisted of six treatments with six replications which were:- T1: Pure stand 4 weed-rhizome cuttings, T2: Pure stand 1 sugarcane cutting, T3: 1 sugarcane cutting + 4 weed-rhizome cuttings, T4: 2 sugarcane cuttings + 4 weed-rhizome cuttings, T5: 3 sugarcane cuttings + 4 weed-rhizome cuttings and T6: 4 sugarcane cuttings + 4 weed-rhizome cuttings. Torpedograss-rhizome cuttings and sugarcane-stalk cuttings were planted in pots according to the Table 1 (experiment II). Pots were watered twice a day. Equal split of above fertilizer was applied at 60 and 120 DAP. Diazinon was applied as required. Other weed species were removed by regular hand weeding. Data for sugarcane and weed were recorded on stem length up to TVD and number of tillers at 30 day intervals starting 30 DAP. Data at harvest for sugarcane were recorded on stalk length, stalk diameter, number of millable stalks, brix % and leaf area; fresh and dry weight of leaves, tops, top leaves, stalks, shoots and roots. Data for weed were recorded on dry weight of shoots and rhizomes including roots. Data were analyzed statistically by DMRT.

Results and Discussion

Experiment I

Elongation of torpedograss (*Panicum repens* L.) was rapidly increased up to 120 DAP in all treatments and thereafter it was almost constant. Pure stand weed recorded significantly higher elongation than other treatments (Fig. 1). Slightly decreased elongation was observed with higher weed density. The result was due to inter- and intra-specific competition between sugarcane and torpedograss. Number of tillers was increased rapidly up to 60 DAP, then it was increased with a medium rate may due to increasing rhizome buds[5] (Fig. 2). Number of tiller was higher per pot as weed density was higher while it was lower per weed

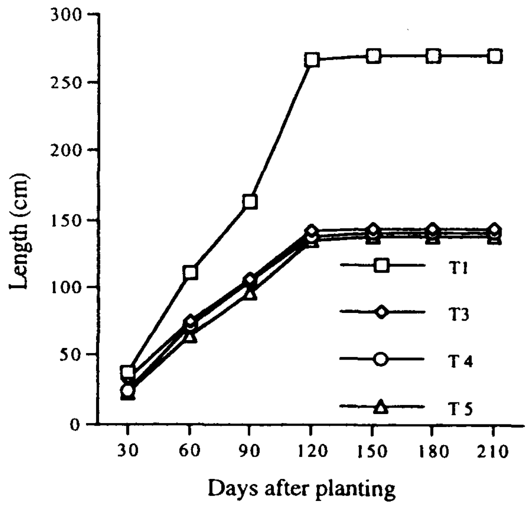


Fig. 1. Elongation of torpedograss stem under different weed densities and sugarcane. T1=1 weed, T3=2 weeds+1 sugarcane, T4=4 weeds +1 sugarcane, T5=8 weeds+1 sugarcane

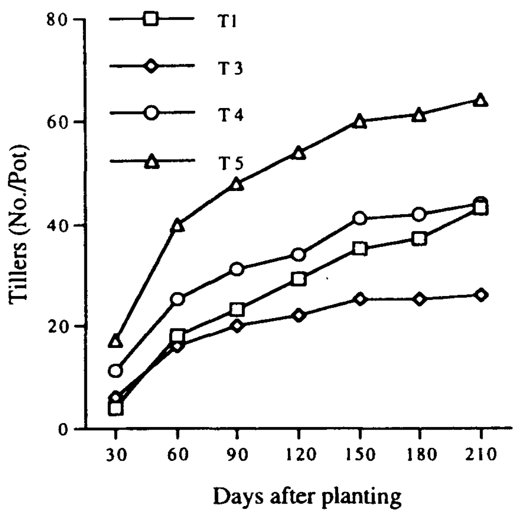


Fig. 2. Changes in number of torpedograss tillers under different weed densities and sugarcane. T1=1 weed, T3=2 weeds+1 sugarcane, T4=4 weeds+1 sugarcane, T5=8 weeds+1 sugarcane

Table 2. Torpedograss biomass production in sugarcane under different densities of torpedograss

Treatments	Shoot	Rhizome	Total
	g/pot		
T1 (1 weed)	133a (133)	106a (106)	239a (239)
T3 (1 sugarcane+2 weeds)	56c (28)	65c (33)	121c (61)
T4 (1 sugarcane+4 weeds)	74bc (19)	60c (15)	134c (34)
T5 (1 sugarcane+8 weeds)	86b (11)	88b (11)	177b (22)

Note : Means in each column not followed by the same letter are different at 5% level of significance, as determined by Duncan's Multiple Range Test. Figures in parentheses indicate the average content per plant.

plant.

Pure stand weed recorded the significant highest shoots, rhizomes and total biomass though it planted single weed compared to those of other treatments (Table 2). Weed biomass was increased in sugarcane as the weed density was increased. T5 recorded significantly higher weed biomass than that of T3 and T4. Data showed that higher shoots and rhizomes biomass may compete with crop severely for nutrients above and underground, and may result in lower yield. Weed production per weed plant was decreased as the density was increased due to inter- and intra-specific competition in T3, T4 and T5. Other investigators reported similar results[2,11].

Sugarcane stem elongation was significantly lower in weed infested treatments than that of pure stand (Fig. 3). Pure stand sugarcane recorded 3.2 tillers per pot while sugarcane with weed densities of 2, 4 and 8 recorded 1.4, 0.4 and 0.2, respectively (Fig. 4). The highest weed infested sugarcane recorded about 16 fold lower tillers than pure stand sugarcane. Stem elongation and tiller production of sugarcane was decreased as the weed density was increased. Higher rhizomes and tillers of torpedograss were causes of severe infestation both under and aboveground, and resulted in lower stem elongation and tiller production of sugarcane. Hossain et al[6]. reported that higher rhizomes and roots (7.5 ton/ha) of torpedograss make a loose mat-like structure in soil up to 50 cm deep which may compete with crop for nutrients and reduce sugarcane yield.

Leaf area and biomass of leaves and tops were significantly highest in pure stand sugarcane than that of infested treatments. The highest density of weed recorded the lowest values than other infested treatments (Table 3). Weed densities of 2 and 4 showed almost similar effects on the parameters. Higher leaf ultimately made better canopy which increased yield through photosynthesis and decreased weed by shading[11,27].

Root was significantly lower in weed infested treatments than that of pure stand sugarcane. Root of sugarcane was statistically similar among weed infested treatments (Table 4).

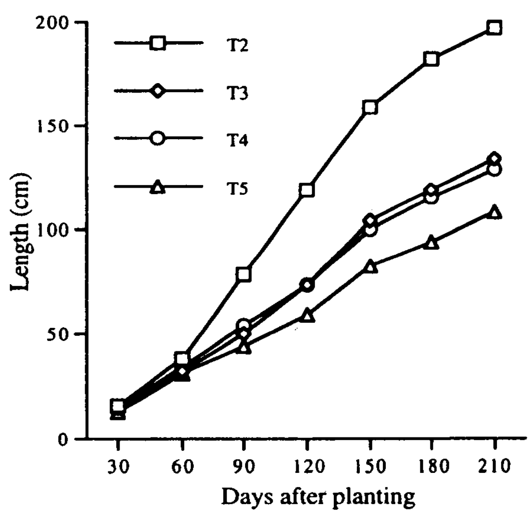


Fig. 3. Elongation of sugarcane stem under different weed densities. T2=1 sugarcane, T3=2 weeds +1 sugarcane, T4= 4 weeds+1 sugarcane, T5 =8 weeds+1 sugarcane

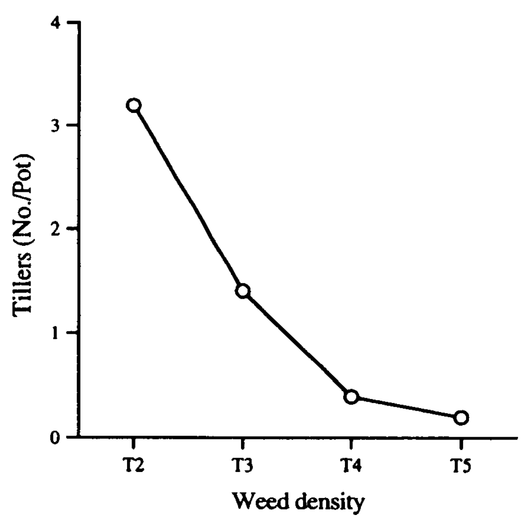


Fig. 4. Changes in number of sugarcane tillers under different torpedograss densities. T2=1 sugarcane, T3=2 weeds+1 sugarcane, T4=4 weeds +1 sugarcane, T5=8 weeds+1 sugarcane

Table 3. Leaf and top production of sugarcane under different densities of torpedograss

Treatments	Leaf area	Green leaf dry wt.	Total leaf dry wt.	Top dry wt.
	cm^2/pot	———	g/pot	———
T2 (1 sugarcane)	3727a	51a	103a	35a
T3 (1 sugarcane+2weeds)	2114b	28b	50b	21b
T4 (1 sugarcane+4weeds)	2137b	31b	47b	24b
T5 (1 sugarcane+8weeds)	1523c	24b	36c	13c

Note : Means in each column not followed by the same letter are different at 5% level of significance, as determined by Duncan's Multiple Range Test.

Table 4. Root, shoot, yield and yield contributing parameters of sugarcane under different densities of torpedograss

Treatments	Root dry wt.	Shoot dry wt.	Stalk length	Diameter	Yield	Brix
	g/pot	g/pot	cm/pot	cm/stalk	g/pot	%
T2 (1 sugarcane)	104a	317a	149a	2.22a	594a	20.2a
T3 (1 sugarcane+2 weeds)	54b	140b	82bc	1.66b	203b	22.8a
T4 (1 sugarcane+4 weeds)	58b	140b	84b	1.62b	209b	22.7a
T5 (1 sugarcane+8 weeds)	49b	84c	58c	1.50b	117c	23.0a

Note : Means in each column not followed by the same letter are different at 5% level of significance, as determined by Duncan's Multiple Range Test.

Higher roots and rhizomes of torpedograss reduced sugarcane roots. Higher roots of crop uptake higher nutrient from the surrounding soil and provide higher yield. Torpedograss reduced sugarcane shoots up to 60%. Weed density of 8 recorded significantly lower shoots than that of lower density. Higher shoots of crop make better shade and reduce weed[11]. Stalk length was significantly lower in weed infested treatments than that in pure stand sugarcane. Weed density of 8 recorded 60% lower stalk length compared to that of pure stand sugarcane. Diameter was significantly lower in weed infested treatments than that in pure one. It was statistically similar among the weed infested treatments. However, slightly reduced diameter was recorded as the weed density was increased. Higher diameter with higher stalk length increases the sugarcane yield. Baki et al.[2] reported that higher weed density reduced diameter of rice. Yield was significantly lower in weed infested sugarcanes than pure stand. Infestation of 2-4 and 8 weeds recorded about 40 and 20% of yield compared to that of pure stand sugarcane, respectively. Peng reported 60% reduced sugarcane yield caused by the same weed. Baki et al.[2] reported that path coefficient for direct effect of *I. rugosum* densities on rice yield components was remarkably higher on yield parameters. Present study showed similar tendency. Brix % was not affected by weeds might be due to inter- and intra-specific competition. Pure stand sugarcane recorded higher stalk and tillers caused intraspecific competition for nutrients, water and other elements. Brix % was increased slightly as the weed density was increased. Higher brix % causes to increase sugar yield. Weed infested sugarcane recorded a slight higher brix % while they recorded about

Table 5. Suppression effect of different densities of torpedograss on sugarcane and vice versa

Treatments	a. Sugarcane yield suppressed by torpedograss	b. Torpedograss biomass suppressed by sugarcane
	%	%
T3 (1 sugarcane+2 weeds)	66 (33)	49
T4 (1 sugarcane+4 weeds)	65 (16)	43
T5 (1 sugarcane+8 weeds)	80 (10)	26

Note : Figures in parentheses indicate the average content per plant.

$$a.\quad \frac{\text{S. stalk fresh wt. in pure pot - S. stalk fresh wt. in weed infested pot}}{\text{S. stalk fresh wt. in pure pot}} \times 100$$

$$b.\quad \frac{\text{Weed dry wt. in pure pot - Weed dry wt. in S. mixed pot}}{\text{Weed dry wt. in pure pot}} \times 100$$

Note : S.=Sugarcane, wt.=weight

Table 6. Torpedograss biomass production under different densities of sugarcane

Treatments	Shoot	Rhizome	Total
		g/pot	
T1 (4 weeds)	487a	312a	839a
T3 (1 sugarcane+4 weeds)	288b	136b	428b
T4 (2 sugarcanes+4 weeds)	217bc	95bc	295c
T5 (3 sugarcanes+4 weeds)	148c	67cd	216d
T6 (4 sugarcanes+4 weeds)	127c	63d	190d

Note : Means in each column not followed by the same letter are different at 5% level of significance, as determined by Duncan's Multiple Range Test.

60-80% lower stalk weight. So pure stand sugarcane was ultimately found to be produce higher sugar yield.

Weed densities of 2, 4 and 8 suppressed sugarcane yield by 66, 65 and 80%, respectively. Whereas sugarcane suppressed torpedograss by 49, 43 and 26%, respectively (Table 5). Weed suppression ability of sugarcane was decreased as the weed density was increased. Sugarcane yield loss for per weed infestation was decreased as the weed density was increased.

Experiment II

Stem elongation in pure stand weed was the highest in observation. Elongation was increased sharply up to 120 DAP in T1, T3 and T4. A sharp elongation was recorded in T5 and T6 up to 90 DAP, thereafter it was almost constant. Higher was the sugarcane density lower was stem elongation of torpedograss. Higher sugarcane density may resulted in better shading. Better shading and nutrient deficiency were the two major subjects to suppress elongation of torpedograss (Fig 5). Ellery[4] reported that plant production decreased with the increased shading. Tiller formation of the weed was rapid until 60 DAP then it was found to be increase in a medium rate. Pure stand weed recorded the highest tillers up to harvest than other treatments. Higher was the sugarcane density lower was the torpedograss tiller (Fig. 6). Two to four sugarcane density remarkably suppressed weed tillers compared to that of one sugarcane (T3). Weed suppression was increased with higher crop densities[16, 28, 30].

Shoots, rhizomes and total biomass of torpedograss were significantly highest in pure stand weed compared to that in sugarcane (Table 6). Single sugarcane reduced about 40% of shoots and 50% of rhizomes compared to pure stand weed. Sugarcane densities of 2-4

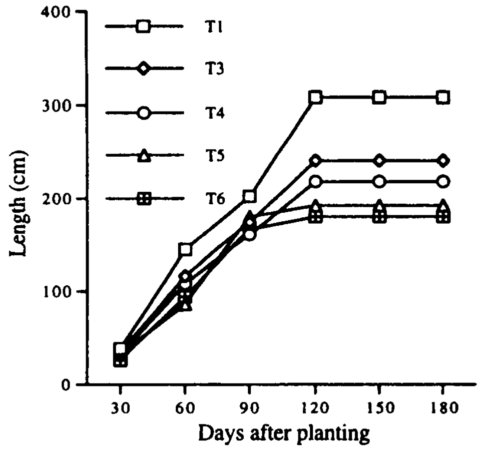


Fig. 5. Elongation of torpedograss stem under different sugarcane densities. T1=4 weeds, T3=1 sugarcane+4 weeds, T4=2 sugarcanes+weeds, T5=3 sugarcanes+4 weeds, T6=4 sugarcanes +weeds

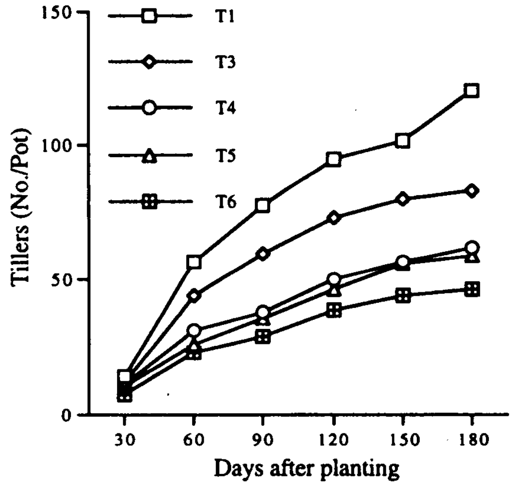


Fig. 6. Changes in number of torpedograss tillers under different sugarcane densities. T1=4 weed, T3=1 sugarcane+4 weeds, T4=2 sugarcanes+4 weeds T5=3 sugarcanes+4 weeds, T6=4 sugarcanes+4 weeds

Table 7. Leaf and top production of sugarcane under different densities of sugarcane

Treatments	Leaf area	Green leaf dry wt.	Total leaf dry wt.	Top dry wt.
	cm²/pot	g/pot		
T2 (1 sugarcane)	6078a (6078)	76a (76)	231a (231)	79a (79)
T3 (1 sugarcane+4 weeds)	1771d (1771)	21d (21)	84d (84)	30c (30)
T4 (2 sugarcanes+4 weeds)	3179c (1590)	40c (20)	143c (72)	42bc (21)
T5 (3 sugarcanes+4 weeds)	3991bc (1330)	53b (18)	193b (64)	43b (14)
T6 (4 sugarcanes+4 weeds)	4321b (1080)	57b (14)	216b (54)	50b (13)

Note : Means in each column not followed by the same letter are different at 5% level of significance, as determined by Duncan's Multiple Range Test. Figures in parentheses indicate the average content per plant.

reduced 25-56% of shoots and 30-54% of rhizomes in comparison to that of one sugarcane (T3). Sugarcane densities of 2, 3 and 4 reduced total weed biomass by 31, 50 and 56%, respectively compared to that of one sugarcane (T3). Lower density of sugarcane caused gapping that enhanced the weed growth in T3. Several investigators reported that slower emergence of sugarcane, gapping and wider row spacing are the main factors which enhance weed growth in early stages of sugarcane [11,22]. Higher rhizomes and shoots required higher nutrient which may resulted in lower yield of sugarcane. Rhizomes of torpedograss stored carbohydrate was reported by investigator [24].

Slow sugarcane stem elongation was recorded up to 60 DAP. Elongation was found to increase sharply during 60 - 120 DAP (Fig. 7), thereafter, elongation was slow. Pure stand sugarcane recorded the highest elongation throughout the observation period. T3 and T4 recorded the second highest elongation up to harvest. Detrimental intra-effect of sugarcane densities was observed in T5 and T6 from 90 DAP to harvest compared to that of other weed infested treatments. Higher was the sugarcane densities lower was the elongation. T3 and T4 recorded a slight lower elongation than pure stand sugarcane due to torpedograss infestation. Tiller was the highest in T2 due to weed free (Fig. 8). Higher was sugarcane density lower was the tiller per pot and per plant in weed infested sugarcane. Sugarcane density of 4 did not show tiller. The result was due to the intra-specific competition.

Leaf area was increased as the increased sugarcane density (Table 7). Pure stand sugarcane resulted highest leaf area due to the highest tillers and stem length in weed free environment. Higher leaf area used higher solar energy may resulted in higher yield of sugarcane and caused to lower weed by shading [11,12,27]. Murphy et al. [18] reported that leaf area increased with increasing corn density and decreasing row width, and increased leaf area is consistent with significantly reduced weed biomass. Sugarcane densities of 2-4 recorded 80-144% higher leaf area compared to that of single sugarcane in weed infested treatments. Pure stand sugarcane recorded the highest green leaves, total leaves and tops compared to

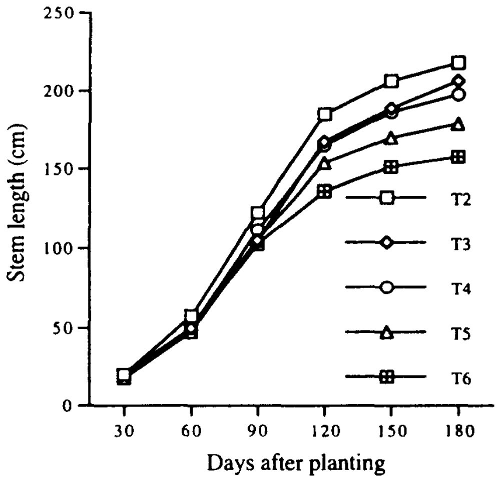


Fig. 7. Elongation of sugarcane stem under different sugarcane densities and weeds. T2=1 sugarcane, T3=1 sugarcane+4 weeds, T4=2 sugarcanes+ weeds, T5=3 sugarcanes+4 weeds, T6= 4 sugarcanes+ weeds

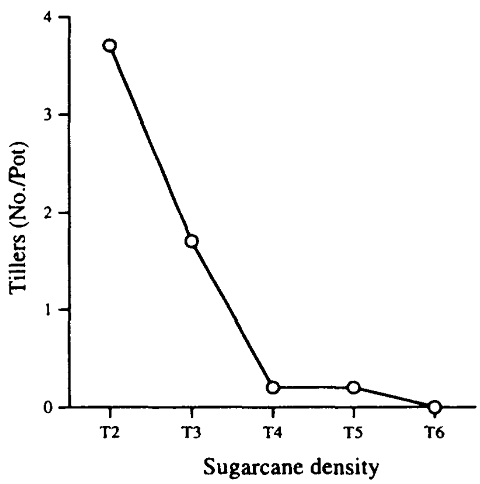


Fig. 8. Changes in number of sugarcane tillers under different sugarcane densities and weeds. T2= 1 sugarcane, T3= 1 sugarcane+4 weeds, T4= 2 sugarcanes+4 weeds T5=3 sugarcanes+4 weeds, T6=4 sugarcanes+4 weeds

that of other treatments. T6 recorded the higher dry weight of leaf compared to that of other weed infested treatments. T4, T5 and T6 recorded about 90-171% higher green leaves compared to that of T3. T5 and T6 recorded significantly higher total leaves compared to that of other infested treatments. T4, T5, and T6 recorded 70-157% higher total leaves and 40-66% higher top in comparison to that of T3. Ishimine et al.[11] reported that higher leaves of sugarcane made better shade which caused to lower weed biomass. Higher top usually determine better growth and development[8,10].

Roots and shoots of sugarcane were significantly highest in T2 compared to that of other treatments. Sugarcane densities of 2-4 recorded about 40-50% higher roots and 48-96% higher shoots than T3. Higher sugarcane density recorded higher roots in weed infested treatments which caused lowest weed. Higher roots of crops uptake higher nutrient resulting in higher growth and development[31]. Sugarcane in T2, T5 and T6 recorded significantly higher stalk length than other treatments (Table 8). Higher sugarcane density recorded higher stalk length. T4 recorded about 63% higher stalk length compared to that of T3. Pure stand sugarcane recorded higher stalk length due to higher number of tillers than T3 and T4. Higher millable stalks was recorded in T2, T5 and T6 than other treatments. Weed infested sugarcane recorded millable stalks only from mother plant. Pure stand sugarcane re-

Table 8. Root, shoot, yield and yield contributing parameters of sugarcane under different densities of sugarcane

Treatments	Root dry wt.	Shoot dry wt.	Stalk length	Millable stalk	Diameter	Yield	Brix
	g/pot	g/pot	cm/pot	no./pot	cm/stalk	g/pot	%
T2 (1 sugarcane)	299a (299)	719a (719)	456a (456)	3.2 (3.2)	1.97ab	1535a (1535)	17.9a
T3 (1 sugarcane+4 weeds)	150c (150)	277d (277)	181c (181)	1.3 (1.3)	2.00a	625c (625)	18.4a
T4 (2 sugarcanes+4 weeds)	210bc (105)	409c (204)	296b (148)	2.0 (1.0)	1.84bc	945b (473)	18.4a
T5 (3 sugarcanes+4 weeds)	225b (75)	514bc (171)	423a (141)	3.0 (1.0)	1.75c	1130b (377)	18.2a
T6 (4 sugarcanes+4 weeds)	214b (54)	453b (113)	498a (125)	4.0 (1.0)	1.72c	1168b (292)	18.0a

Note : Means in each column not followed by the same letter are different at 5% level of significance, as determined by Duncan's Multiple Range Test. Figures in parentheses indicate the average content per plant.

corded millable stalks from tillers and mother plant. Higher sugarcane density recorded higher millable stalks in weed infested treatments. T2, T3, and T4 recorded the higher diameters than other treatments. Diameter was decreased with increased sugarcane density in weed infested treatments. Higher diameter with stalk length resulted in higher yield of sugarcane were reported by several investigators[3, 10, 11, 27]. T4 recorded non-significant different in diameter compared to that of the pure stand sugarcane. The highest yield was recorded in pure stand sugarcane. Severe reduction of sugarcane yield was observed in T3 compared to that of other treatments. Higher sugarcane density resulted in higher yield in weed infested treatments. Other reporters reported that higher density of crop up to a limitation resulted in higher yield and lower weed[2, 25]. In this study, sugarcane densities of 2, 3 and recorded 51, 81 and 87% higher yield, respectively than that of weed infested single sugarcane. Brix % was not affected by the weed and sugarcane densities. Because, pure stand sugarcane recorded higher tillers caused intra-specific competition and weed infested treatments caused

Table 9. Suppression effect of different densities of sugarcane on torpedograss and vice versa

Treatments	a. Sugarcane yield suppressed by torpedograss	b. Torpedograss biomass suppressed by sugarcane
	%	%
T3 (1 sugarcane+4 weeds)	59	49 (49)
T4 (2 sugarcanes+4 weeds)	38	64 (32)
T5 (3 sugarcanes+4 weeds)	26	74 (25)
T6 (4 sugarcanes+4 weeds)	24	77 (19)

Note : Figures in parentheses indicate the average content per plant.

$$\text{a.}\quad \frac{\text{S. stalk fresh wt. in pure pot - S. stalk fresh wt. in weed infested pot}}{\text{S. stalk fresh wt. in pure pot}} \times 100$$

$$\text{b.}\quad \frac{\text{Weed dry wt. in pure pot - Weed dry wt. in S. mixed pot}}{\text{Weed dry wt. in pure pot}} \times 100$$

Note : S.=Sugarcane, wt.=weight

intra and interspecific competition.

Treatments T3, T4, T5, and T6 obtained 59, 38, 26 and 24% reduced sugarcane yield compared to that of the pure stand, respectively (Table 9). Yield increasing ability per sugarcane plant was decreased as the sugarcane density was increased. Sugarcane suppressed 49, 64, 74 and 77% of weed in T4, T5 and T6, respectively. Weed suppression ability of sugarcane densities was decreased as the sugarcane density was increased.

The results of the experiments demonstrated that sugarcane reduced stem elongation, shoots and rhizomes of torpdograss significantly. Weed biomass in sugarcane was increased as the weed density was increased while per weed plant biomass was decreased. Sugarcane reduced torpedograss biomass by 26-49%. Torpedograss densities of 2-8 per sugarcane plant reduced stem length, tillers, leaves, tops, roots, shoots, stalk length and stalk diameter of sugarcane significantly. Yield and yield parameters of sugarcane were decreased as the weed density was increased. On the contrary, brix % of sugarcane was increased slightly as weed density was increased. The weed reduced sugarcane yield by 65-80%. In another experiment, weed biomass was decreased as the sugarcane density was increased. Weed suppression ability of per sugarcane plant was decreased as the sugarcane density was increased. Higher sugarcane density increased total stalk length, millable stalks, roots, shoots and yield in weed infested treatments while the parameters per sugarcane plant were decreased. Effects of sugarcane densities were not observed on brix production. Higher sugarcane density of 2, 3 and 4 recorded an increase in yield by 51, 81 and 87% and lower weed biomass by 25, 49 and 56% than that of weed infested single sugarcane. Sugarcane density of 4 showed thin culm and lower stalk length, and increased a little amount of yield than the density of 3. The experiment showed that higher density of sugarcane up to a certain limitation is one of the important way to control torpedograss and to increase sugarcane yield.

References

1. Aurora, M. B. 1995. Weed management in wet-seeded in Asia. Proc. 15th APWSS conf. Tsukuba, Japan **1(B)**: 656-662.
2. Baki, B. B., S. Suhaimi and J. A. Munir 1995. Path analysis of two sympatric gramonoids (*Echonochlo crus-galli* s pp. *crus-galli* L. Beauv. and *Ischaemum rugosum* salisb.) in competition with rice (*Oryza sativa* L. Var. MR. 84). Proc. 15th APWSS conf. Tsukuba, Japan 1(A): 546-556.
3. Ehara, H., M. Tsuchiya and T. Takamura 1994. Growth and dry matter production of sugarcane in warm temperature zone of Japan. 3. Type of sugarcane suitable for forage production. Jpn. J. Trop. Agr. **38(1)**: 51-58.
4. Ellery L. K. 1972. Effect of shade on Giant Foxtail. Weed Sci. vol. 2:588-592.
5. Holm, L. G., D. L. Plucknett, J. V. Pancho, James P. Herberger 1977. The world's worst weeds, Distribution and Biology. Univ. press , Hawai, Honolulu, pp. 353-357.
6. Hossain, M. A., Y. Ishimine, H. Akamine and S. Murayama 1996. Growth and development characteristics of torpedograss (*Panicum repens* L.) in Okinawa Island, Southern Japan. Weed Res. Japan **41(4)**, 323-331.
7. Ishimine, Y., K. Miyazato and S. Matsumoto 1985. Effect of nitrogen level on growth and

seed production of *Paspalum urvillei* Steud. Weed Res. Japan 30(2): 143-147.
8. Ishimine, Y., K. Miyazato and S. Matsumoto 1986. Competition between sugarcane and *Bidens pilosa* L. Var. *radiata* Scherff. at earlier stages of sugarcane growth. Weed Res. Japan 31(4): 287-293.
9. Ishimine, Y., S. Murayama and S. Matsumoto 1988. Effect of shade on growth and seed production of *Rottboellia exaltata* L.f. and *Solanum alatum* Moench. Weed Res. Japan 33(2): 114-121.
10. Ishimine, Y., S. Murayama and S. Matsumoto 1988. Competition between sugarcane and *Rottboellia exaltata* L. f. at earlier stage of cane growth. Weed Res. Japan 33(2), 122-128.
11. Ishimine, Y., M. A. Hossain, K. Motomura, H. Akamine, S. Murayama and S. M. M. Uddin 1994. Comparative study of sett planting and settling transplanting system of sugarcane. Sci Bull. Coll. Agr. Univ. Ryukyus, Japan 41: 319-326.
12. Kawamoto, Y., Y. Masuda and I. Goto 1988. Sorghum-legume mixed cropping for high yields of high quality forage. JARQ. 22 (2): 114-120.
13. Kuba, M. 1993. Actual conditions and soil management of farm lands in Okinawa-soil, Chemical properties and management of fertilization in sugarcane fields. Pedologist (Published by the group of Japanese Pedologists) 37(2): 126-137.
14. Kropff, M. J., F. J. H. Vorssen, C. J. T. Spetters and W. de Groot 1984. Competition between a maize crop and a natural population of *Echinochloa crus-galli* (L.)Beauv. Neth. J. Agric. Sci., 32, 324-327.
15. Moody, K. 1995. Sustainability in rice weed management. Proc. 15th APWSS conf. Tsukuba, Japan 1(A): 93-103.
16. Moody, K. 1992. Weed management in wet-seeded rice in tropical Asia. Int. Symposium, Biological control and Integrated Management of Paddy and Aquatic Weeds in Asia. Tsukuba, Japan, pp. 1-20.
17. Mukhopadhayay, S. K. 1995. Current scenario and future lines of weed management in rice crop with particular references to India. Proc. 15th APWSS, conf. Tsukuba, Japan 1(A): 28-41.
18. Murphy, S. D., Y. Yakubu, S. F. Weise and C. J. Swanton 1996. Effect of planting patterns and interrow cultivation on competition between corn (*Zea mays*) and late emerging weeds, Weed Sci., 44(4) 865-870.
19. Nada, G., B. S., E. Lokeshwarapa, C. Dwarakanata, N. A. Chammiah, J. Gouda. Problematic dicot weeds and control in sugarcane, Ind. J. Weed Sci. pp. 129-136.
20. Noguchi, K., K. Nakayama and M. Takabayashi 1977. Studies on competition between upland crops and weeds. Effect of different cropping systems on the weed community. Japan. J. Crop. Sci. 46(4): 504-509.
21. Olofsdotter M. and D. Navarez 1995. Approaches in rice allelopathy research. Proc. 15th APWSS conf. Tsukuba, Japan, 1(A) 315-320.
22. Patel, M. P., P. L. Naik, N. J. Mehta, H. S. Patel and B. C. Naik 1991. Herbicidal control of weeds in sugarcane. Indian sugar 41(5): 309-312.
23. Peng, S. Y. and L. T. Twu 1974. Effect of competition by *panicum repens* L. on sugarcane and eradication by herbicides. 15th conf. ISSCT (South Africa). Vol. 2. Agron.,

pp. 794-808.

24. Peng, S. Y., 1984. Developments in crop science (4). The biology and control of weeds in sugarcane , pp. 26-79.
25. Singh, N. and M. K. Moolani 1975. A review of chemical weed control in sugarcane proc. Third all India weed control, Seminar, Hissar pp. 41-42.
26. Swanton, C. S. and S. F. Weise 1991. Integrated weed management: The rationale and approach. Weed Technol. 5, 657-663.
27. Uddin, S. M. M., 1996. Effect of mixture of charcoal with pyroligneous acid on growth, yield and quality of sugarcane (*Saccharum officinarum* L.). Ph. D. thesis. The United Graduate School of Agricultural Sciences, Kagoshima University. Kagoshima, Japan pp. 1-198
28. Vangsaroj, P. 1995. Implementation of integrated weed management fo sustainable rice production. Proc. 15th APWSS conf. Tsukuba, Japan 1(A): 81- 92.
29. Watanabe, H. 1995. Weedy rice problems in Southeast Asia and control strategy. Proc. 15th APWSS conf. Tsukuba Japan 1(A): 68-80
30. Worsham, A. D., G. G. Nagabhushana and J. P. Yenish 1995. The contribution of no-tillage crop production to sustainable agriculture. Proc. 15th APWSS conf. Tsukuba, Japan 1(A): 104-111.
31. Yamaguchi, M. 1983. World vegetables. Published by Van Nostrond, Rainhold. PP. 66-89.

サトウキビとハイキビの競合

Md.アムザド・ホサイン*、仲村一郎**、石嶺行男**
村山盛一**、芝山秀次郎***、續　栄治****

サトウキビとハイキビの混植条件下における、それぞれの栽植密度の違いによる相互の影響を検討するために以下の実験を行った。実験Ⅰでは、サトウキビ1節苗に対しハイキビ地下茎0、2、4及び8本をポットに混植、更に実験Ⅱでは、ハイキビ地下茎4本植えにそれぞれサトウキビ苗0、1、2、3及び4本をポットに混植し、サトウキビとハイキビの生育調査を行った。

実験Ⅰの結果、ハイキビの主茎伸長、地上部及び地下茎の生育量はサトウキビの影響で有意に減少した（Fig.1,Table 1)。サトウキビ混植条件下におけるハイキビの生産量は、ハイキビの密度が高くなるに従い、ポット当たりでは増加したが、栽植本数当たりでは減少した（Table 1)。このときのサトウキビによる抑制率は26～49%であった（Table 4)。また、サトウキビ密度が高くなるに連れ有意に減少し（Table 2, 3)、抑制率は65～80%であった。

実験Ⅱの結果、サトウキビの密度が高くなると、ハイキビの生産量は減少し、ハイキビによるサトウキビ1株当たりの抑制率も減少した（Table 5)。また、サトウキビの茎長、原料茎数、根重、地上部重、収量は、サトウキビの密度が高くなるに連れ、株当たりでは減少したが、ポット当たりでは増加した。しかしながらブリックスへの影響は見られなかった（Table 7)。

ハイキビ混植条件下におけるサトウキビ1節苗に対し、2ないし3倍植えでは、サトウキビ収量が51～81%増加し、ハイキビの生産量を25～49%に抑える事ができた事から、ある限界までのサトウキビ高密度植えは、ハイキビの生育を抑え、サトウキビ収量を増加させる作付け方法の1つになると思われた。

* 鹿児島大学大学院連合農学研究科生物生産科学専攻
** 琉球大学農学部
*** 佐賀大学農学部
**** 宮崎大学農学部