Title	琉球列島のサトウキビ畑における雑草の生理・生態 : 第11報 土壌水分がツノアイアシとテリミノイヌホウズキの生育と種子生産に及ぼす影響(農学部附属農場)
Author(s)	仲間, 操; 石嶺, 行男; 村山, 盛一
Citation	琉球大学農学部学術報告 = The Science Bulletin of the Faculty of Agriculture. University of the Ryukyus(35): 105-112
Issue Date	1988-12-05
URL	http://hdl.handle.net/20.500.12000/3898
Rights	

Physiological and Ecological Characteristics of Weeds of Sugarcane Fields in the Ryukyu Islands

11. Effects of Soil Moisture on the Growth and Seed Production of *Rottboellia exaltata* L. f. and *Solanum alatum* Moench.

Misao NAKAMA*, Yukio ISHIMINE* and Seiichi MURAYAMA**

Summary

Seeds of two important sugarcane field weed species, *Rottboellia exaltata* L. f. and *Solanum alatum* Moench. were sown and grown in Wagner pots of 1/5000a under different soil moisture intensities, namely, pF2.0, 2.5, 3.0, 3.5 and saturation, in order to determine what effect soil moisture will exert on the growth and seed production of these weeds.

1. The plant height and plant length increased with increasing soil moisture intensity and reached maximums at pF2.0. The figures were smallest at pF3.5 (Fig. 1.).
2. The number of tillers per plant and number of branches per plant increased in a similar manner and were largest at pF2.0. The number of tillers per plant was smallest at saturation and the number of branches per plant was smallest at pF3.5 (Fig. 2).
3. The leaf area per plant increased as the soil moisture intensity was increased, the value being largest at pF2.0 for both *Rottboellia* and *Solanum*. The smallest value was seen at pF3.5 for *Rottboellia* and at saturation for *Solanum* (Fig. 3.).
4. Lower soil moisture intensities reduced the T/R ratio in both *Rottboellia* and *Solanum* (Table 1).
5. The total dry weight increased at larger pF, the value being largest at pF2.0. At pF3.5 the total dry weight was reduced so severely that practically no seeds were produced in *Rottboellia* and no fruits formed in *Solanum,* indicating that both of the weeds can not survive under excessively dry conditions (Fig. 4.).
6. The longest delay in heading and flowering took place at saturation or under excessively moist conditions. The seed production characters (number of spikes per plant, weight of spike, length of spike, number of fruits per plant, weight of fruit) increased with increasing soil moisture intensity, values being largest at pF2.0 and smallest at pF3.5 (Table 2).

* Agricultural Experiment Station, College of Agriculture, University of the Ryukyus
** Department of Agriculture, College of Agriculture, University of the Ryukyus
Sci. Bull. Coll. Agric. Univ. Ryukyus **35** : 105~112 (1988)

Introduction

The increasing extensive application of irrigation water in the cultivation of sugarcane in Okinawa Prefecture is coupled with simultaneous occurence and vigorous growth of weeds in the irrigated fields, while the high temperature that prevails in this part of the subtropics contributes in part to this situation. In a report dealing with the problem of weed infestation encountered in the efforts toward increasing upland field crop yields in Southern kyushu, Japan, through utilization of irrigation water, Yamamoto and Ohba[10] pointed out that irrigating the fields increases weed growth and therefore care should be exercised in irrigation along with the control of weeds in the fields. Nishida and Kasahara[7] indicated that temperature and soil are the enviromental stresses that exert the greatest physiological and ecological effects on the growth of weeds.

In this study the effects of soil moisture on the growth and seed production were assessed for *Rottboellia exaltata* L. f. and *Solanum alatum* Moench., annual weed species most abundant in sugarcane fields, hereafter referred to as *Rottboellia* and *Solanum*, respectively.

Materials and Methods

The experiment was conducted from 20 March throuh 18 July 1987 in the glasshouse at the Experimental Farm of the Faculty of Agriculture, using 60 Wagner pots of 1/5000a. The seeds used in the experiment were collected from 1 plant in the field at the Experimental Farm and air-dried indoors and kept in the desiccator at room temperature for 9 months. The soil type was the typical dark-red (pF 6) . On 20 March the pots were filled with 4.5kg/pot of the soil and fertilized with 5g/pot of compound systhetic fertilizer (N : 4, P : 3, K : 8). Each of the pots was then broadcast with 10 seeds and 17 days later hand-thinned to a uniform stand of 1 plant per pot.

Five plots for this study, namely, pF2.0, pF2.5, pF3.0, pF3.5 and saturation, were established. The pF curve was determined by the centrifugation method. Losses of water caused by evaporation were weighed using the gravimetric method[11] and supplemented at 15 : 00 every day starting 17 days after seeding in order to maintain soil moisture as constant as practicable. The pF values, 2.0, 2.5, 3.0 and 3.5 immediately before watering were $\pm$0.3, $\pm$0.4, $\pm$0.4 and $\pm$0.3, respectively.

For sampling 3 pots were randomized daily after seeding and top dry weight, root dry weight, number of branches per plant, leaf area per plant, number of spikes per plant and number of fruits per plant were recorded. For measurement of root dry weight, roots were washed free of debris, care being taken to prevent breaking. Plant height, plant length, number of tillers per plant were recorded at 10-day intervals after seeding. Data were also taken on number of days before heading and number of days before flowering. Dry weight was measured for the root, stem, leaf and seed which were dried in the electric drying oven at 95°C for 48 hours. Leaf area was measured with the aid of Hayashidenko Model AAM-5 leaf area meter.

Results

Plant height and plant length data are presented in Fig. 1. In *Rottboellia* the plant height increased at smaller pF or with increasing soil moisture intensity and a quick increase took place at pF2.0 and 2.5 at 20 days after seedsng. In *Solanum* the plant length similarly increased at smaller pF and a quick increase occured as late as at 40 days after seeding. The plant height and length values were largest at 90 days after seeding, the plant height being 120cm at pF2.0 and 100cm at pF2.5. The plant length was 76cm at pF2.0 and 60cm at pF2.5. Values at pF 3.0 and 3.5 were small from the beginning of treatment and markedly small compared with pF 2.0 and 2.5 figures. At saturation a considerable difference in increase was noted between plant height and plant length ; the plant height at the last sampling (at 120 days after seeding) being 95cm, while the plant length was no more than 10cm.

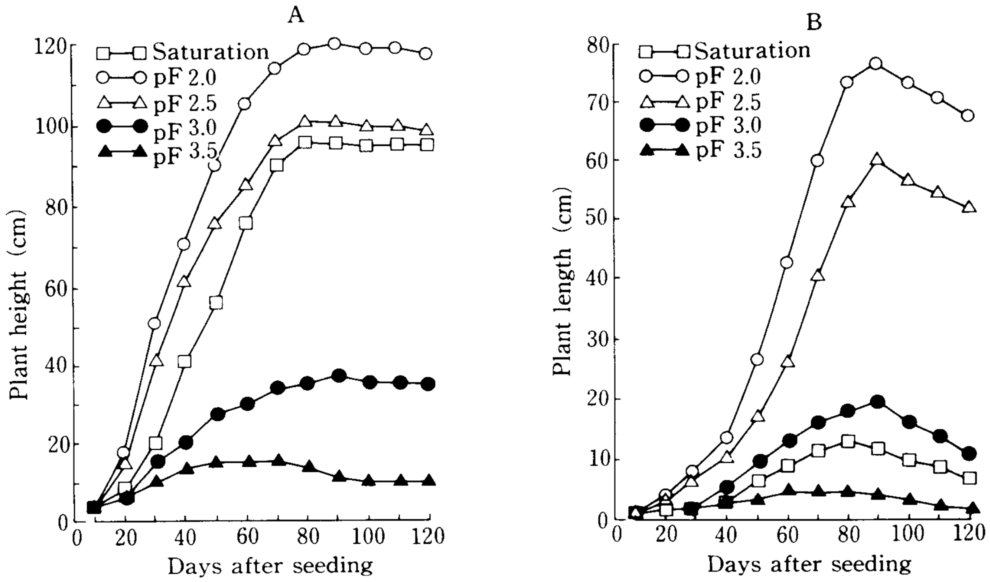

Fig. 1. Changes in plant height of *Rottboellia exaltata* L. f. (A) and plant length of *Solanum alatum* Moench. (B) with soil moisture intensity

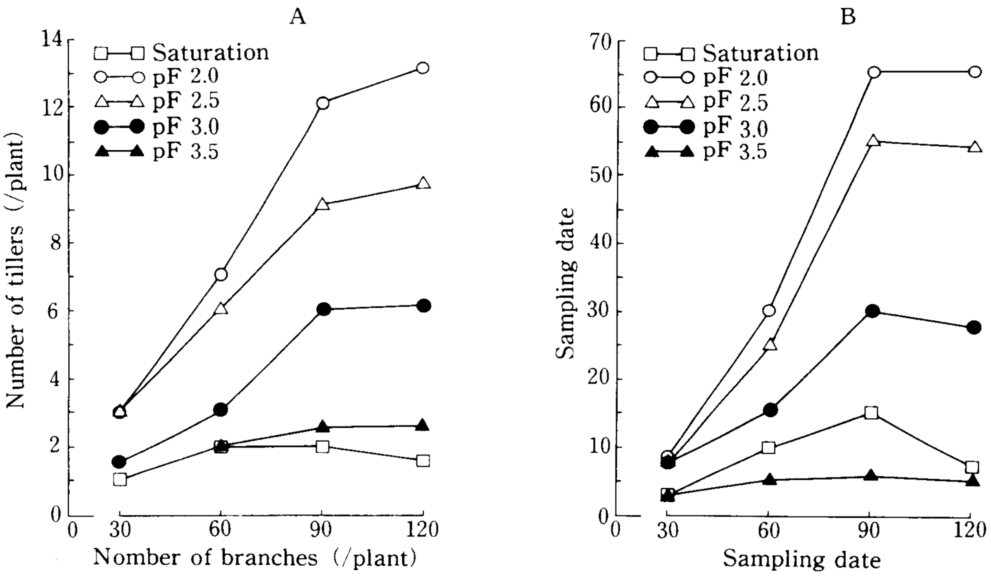

Fig. 2. Changes in number of tillers per plant of *Rottboellia exaltata* L. f. (A) and number of branehes per plant of *Solanum alatum* Moench. (B) with soil moisture intensity

Tiller number and branch number data are presented in Fig. 2. In *Rottboellia* the number of tillers per plant increased at smaller pF and a quick increase occurred at pF2.0 and 2.5 during the first 30 days of seeding. The value was largest at the last sampling ; 13 at pF2.0 and 9.5 at pF2.5. In *Solanum* the number of branches per plant was largest at 90 days after seeding ; 65 at pF2.0 and 55 at pF2.5. At pF3.0, 3.5 and at saturation, the number of tillers per plant and number of branches per plant at the last sampling were 6 at pF3.0, 2.5 at pF 3.5, 1.5 at saturation, respectively, while the number of branches per plant at pF2.0 was 27, that at pF3.5 was 5 and that at saturation was 7.

Leaf area data are presented in Fig. 3. In *Rottboellia* the leaf area per plant increased little during the first 30 days of seeding but then started increasing quickly, the value at the last sampling being 1,350cm² at pF2.0 and 1,150cm² at pF2.5. At saturation the figure was 250cm² at pF3.0, 100cm² at pF3.5, 500cm². In *Solanum* the leaf area per plant similarly showed little increase during the first 30 days of seeding but started to increase quickly at 60 days after seeding until a quick drop occurred at 90 days after seeinng, values at the last sampling being 1,100cm² at pF2.0, 800cm² at pF2.5. The figure was 500cm² at pF3.0, 200cm² at pF3.5, 100cm² at saturation.

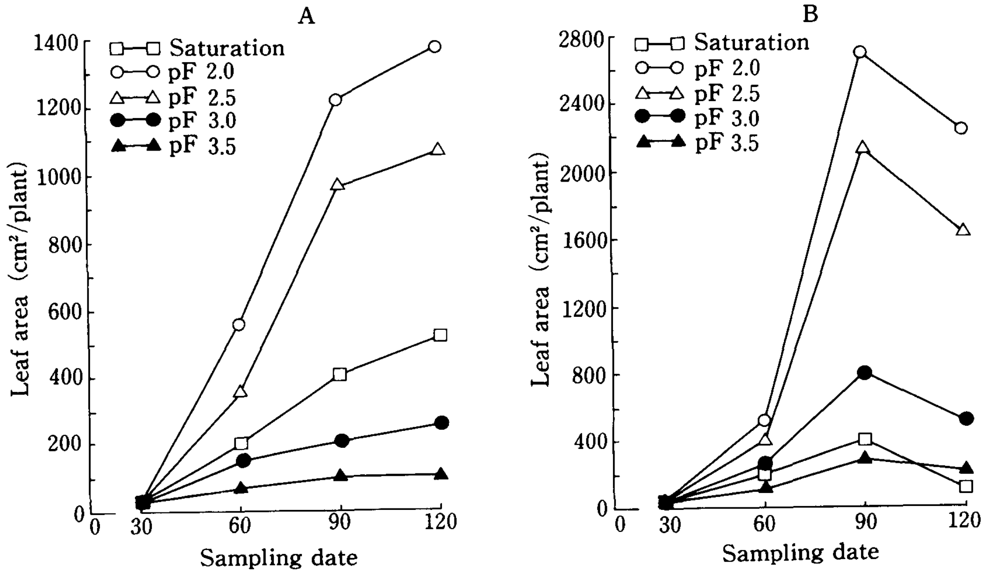

Fig. 3. Changes in leaf area per plant of *Rottboellia exaltata* L. f. (A) and *Solanum alatum* Moench. (B) with soil moisture intensity

Table 1. Effect of soil moisture on T/R retio in *Rottboellia exaltata* L. f. and *Solanum alatum* Moench

Saturation	8.0[a]	6.3[a]
pF2.0	3.5[b]	3.6[b]
pF2.5	4.2[b]	3.8[b]
pF3.0	2.7[bc]	3.0[b]
pF3.5	1.5[c]	2.0[bc]

Note : Means not followed by the same letter are different at the 1% level of significance, as determined by Duncan's multiple range test.

T/R ratio (ratio of top to root) data are presented in Table 1. In both *Rottboellia* and *Solanum* the T/R ratio decreased with decreasing soil moisture intensity, except that in *Solanum* the ratio was larger at pF2.5 than at pF2.0.

Total dry weight data at the last sampling are presented in Fig. 4. In *Rottboellia* the spike weight, stem-leaf weight and root weight increased at smaller pF and largest at pF2.0, values being 55g for the spike weight, 50g for the stem-leaf weight and 30g for the root weight. At pF3.0 a quick drop took place, values being smallest at pF3.5 ; lg for the spike weight, 2g for the stem-leaf weight and 2g for the root weight. Values at saturation were 10g for the spike weigh, 30g for the stem-leaf weight and 5g for the root weight. In *Solanum* the spike weight, stem-leaf weight and root weight similarly incresed with decreasing pF and were largest at pF2.0, values being 40g for the fruit weight, 65g for the stem-leaf weight and 30g for the root weight. At pF3.0 a quick drop took place, values being smallest at pF3.5 ; 2g for the stem-leaf weight and 1g for the root weight. No fruits formed under this soil moisture intensity. Values at saturation was 3g for the fruit weight, 17g for the stem-leaf weight and 2.5g for root weight.

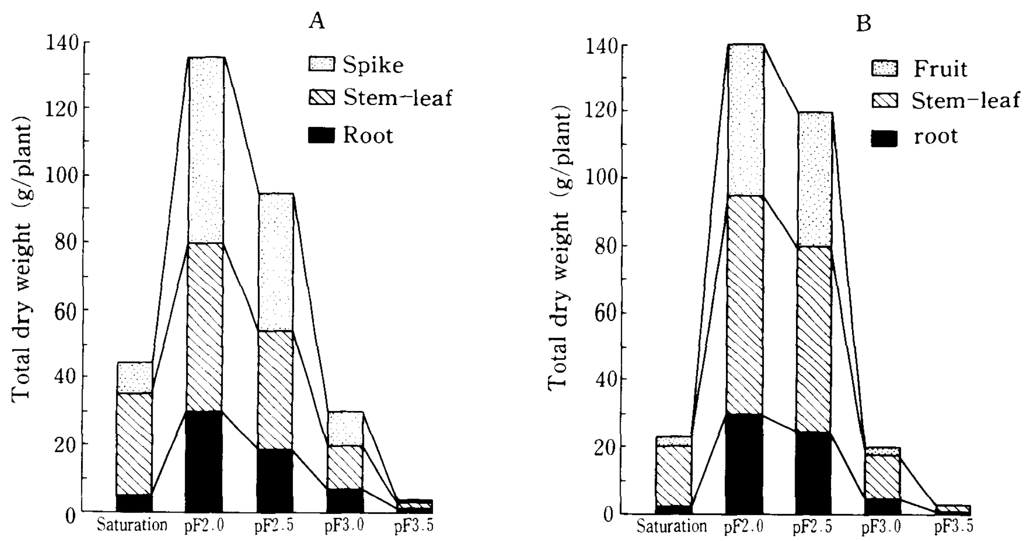

Fig. 4. Changes in total dry weight of *Rottbaellia exaltata* L. f. (A) and *Solanum alatum* Moench. (B) with soil moisture intensity

Table 2 illusterates data at the last sampling on number of days before heading, number of days before flowering, number of skikes per plant, number of fruits per plant, length of spike, weight of spike, weight of fruit. Heading and flowering were delayed longest at saturation. The number of spikes per plant and number of fruits per plant decreased at larger pF and no fruit formation was seen at pF3.5. Reductions were significant at the 1% level. The length of spike, weight of spike, weight of fruit, and number of fruits per plant similarly decreased with increasing pF. Reductions were significant at the 1% level.

Table 2. Effects of soil moisture of various characters of *Rottboellia exaltata L. f. and Solanum alatum* Moench.

Treatment	*Rottboellia*				*Solanum*		
	Number of days before heading	Number of spikes per plant	Length of skipe	Weight of skike	Number of days before flowering	Number of fruits per plant	Weight of fruit
Saturation	44.7^a	35^a	6.1^a	0.29^a	51.6^a	60^a	0.05^a
pF2.0	44.4^a	110^b	6.9^a	0.50^b	47.8^b	626^b	0.09^b
pF2.5	43.6^a	97^b	6.4^a	0.48^b	47.7^b	591^b	0.07^b
pF3.0	43.1^a	40^a	3.2^b	0.26^a	47.0^b	100^c	0.03^c
pF3.5	43.9^a	10^c	1.4^c	0.09^c	50.4^a	0	0

Note : Means not followed by the same leter are different at the 1% level of significance, as determined by Duncan's multiple range test.

Discussion

Soil moisture data obtained for *Rottboellia* and *Solanum* of the present investigation may be summarized as follows : The optimum soil moisture for plant height and plant length lies between pF2.0 and 2.5. At pF 3.5 or under excessively dry conditions, these characters were reduced considerably. The plant height and length values were largest at pF2.0 in the last stage of treatment. The optimum soil moisture for number of tillers per plant and number of branches per plant similarly lies between pF2.0 and 2.5. It is characteristic of these characters that the tiller number was reduced considerably at saturation or under excessively moist conditions, while the branch number was reduced appreciably at pF3.5 or under excessively dry conditions. The tiller and branch number values were largest at pF2.0 in the last stage of treatment. The optimum soil moisture for leaf area per plant also lies between pF2.0 and 2.5. In *Rottboellia* this character was reduced considerably at pF2.0 and 2.5. excessively dry conditions, while in *Solanum* it was reduced appreciably at saturation or under excessively moist conditions. In both *Rottboellia* and *Solanum* the leaf area value was largest at pF2.0 in the last stage of treatment. The quick drop in leaf area in *Solanum*, that took place after the first 90 days of seeding, may be accounted for by the simultaneous occurrence of defoliation. In the case of T/R ratio, the root increased more with decreasing soil moisture intensity than the top increased. The total dry weight also increased the most at pF2.0—2.5. At pF3.5 or under excessively dry conditions the seed, stem-leaf and root weights were reduced remarkably, while these characters were smallest at pF2.0. The remarkable growth difference between pF2.5 and 3.0 may be attributed to the fact that the pF value 3.0 had increased to 3.4 due to evaporation before the water loss was supplemented, resulting in excessive drying that reduced growth. A possible explanation for the growth reduction after the first 90 days of seeding is the fact that these weeds die in about 5 months (150 days) and growth begins declining after the reproductive period of growth. The seed production characters such as number of spikes per plant increased the most at pF 2.0 and were reduced considerably at pF3.5. Heading and flowering were delayed longest at saturation or under excessively moist conditions. These results suggest that *Rottboellia* and *Solanum* grow better and produce more seeds at pF2.0-2.5 and both species possess a high degree of tolerance to soil moisture stress.

Iwata and Takayanagi[2], Noguch and Nakayama[6] and Yamamoto and Ohba[10], reporting the effect of soil moisture on the germination and emergence of weec seeds, indicated that *Digitaria ciliaris* Koel. an *Portulaca oleracea* L. grow better at 70-100% soil moisture and the optimum soil moisture intensities in these weeds are higher than in other species. Yamamoto and Ohba[10] indicated that post germination growth of *Digitaria* and *Portulaca* is better when soil moisture is 70-80% of the maximum water holding capacity. The present experiment with *Rottboellia* and *Solanum* yielded similar results. Terasawa et al[9]. reported that the optimum soil moisture is 50% of the maximum water holding capacity for *Digitaria* and 25% for *Portulaca*. The optimum soil moisture *Paspalum urvillei* Steud[3] was 64% of the maximum water holding capacity, while that for *Bidens pilosa* var. *radiata* Scherff[4] was 42%. The relation between crop growth and soil moisture has also been described by several investigators. Miyazato et al.[8] indicated that the optimum soil moisture for sugarcane is pF2.8 and Fisher and Hagan[1] found the optimum soil moisture for wheat and soy bean to be 60-70% of the maximum water holding capacity. Jarvis and Jarvis[5], reporting the effect of soil moisture on young tree plants of four species, indicated that the optimum soil moisture lies between the maximum field water holding capacity and pF2.7.

Sugarcane with the optimum soil moisture at pF2.8-3.6 is considerably less tolerant to moisture stress than *Rottboellia* and *Solanum* having the optimum moisture at pF2.0-2.5. This fact seems to emphasize the importance of controlling irrigation in the cultivation of sugarcane in order to avoid the problem of excessive soil moisture.

Refernces

1. Fisher, R. A. and R. M. Hagan 1965: Exp. Agric. **1**: 161—177.
2. Iwata, I. and S. Takayanagi 1974: Weed Res. Japan **17**: 33—38(in Japanese with English summary).
3. Ishimine, Y., K. Miyazato and S. Matsumoto 1985: Weed Res. Japan **30**(2):59—64(in Japanese with English summary).
4. Ishimine, Y., K. Miyazato and S. Matsumoto 1986: Weed Res. Japan **31**(1): 16—23(in Japanese with English summary).
5. Jarvis, P. F. and M. S. Jarvis 1963: Physiol. Plant. **16**: 215—235.
6. Noguchi, K. and K. Nakayama 1976: Weed Res. Japan **21**: 24—29(in Japanese with English summary).
7. Nishida, F. and Y. Kasahara 1978: Nogaku Kenkyu. **57**(1): 55—72(in Japanese).
8. Miyazato, K., A. Nose and S. Murayama 1982: Okinawa Kanshyato Nenpo **21**: 7—15(in Japanese English summary).
9. Terasawa, T., H. Asano and S. Hirose 1981: Weed Res. **26**, 14—18(in Japanease with English summary).
10. Yamamoto, H. and T. Ohba 1976: Weed Res. Japan **21**: 172—176(in Japanese with English summary).
11. Yamashiro, S. and A. Yoshinaga 1979: Sci. Bull. Coll. Agric. Univ. Ryukyus. No. **26**, 273—285.

Sci. Bull. Coll. Agric. Univ. Ryukyus, No. 35 (1988)

琉球列島のサトウキビ畑における雑草の生理・生態

第11報　土壌水分がツノアイアシとテリミノイヌホウズキの生育と種子生産に及ぼす影響

仲間　操*・石嶺行男*・村山盛一**
琉球大学農学部

摘　要

サトウキビ畑の一年生雑草のうち発生量の最も多いツノアイアシとテリミノイヌホウズキの土壌水分の変化に対する反応を調査し，その結果を比較検討した。両草種とも概ね高土壌水分条件下で生育が旺盛となり，形質によって多少の相違はあるものの耐湿性に優れていることが明らかになった。

1．ツノアイアシの草丈とテリミノイヌホウズキの主茎長は土壌水分の増加とともにいずれも増加する傾向を示し，処理後期において pF 2.0でそれぞれ最高値をとった。両形質の最適土壌水分域は pF 2.0〜2.5と判断された。土壌水分 pF 3.5では著しい減少が認められ，過乾条件下では大きく抑制されることが推察された（Fig. 1）。

2．ツノアイアシの個体当り分げつ数とテリミノイヌホウズキの個体当り分枝数も高土壌水分条件下で増加したが，分げつ数が飽和，すなわち過湿条件下で著しく減少したのに対し，分枝数は逆に過乾条件の pF 3.5で著しい減少を示し，土壌水分に対する反応が両形質間で異なることが認められた。最高値は草丈，主茎長の場合と同様に処理後期において pF 2.0で示されており，pF 2.0〜2.5が最適土壌水分域と推定された（Fig. 2）。

3．葉面積もツノアイアシ，テリミノイヌホウズキともに処理後期において pF2.0 で最大となったが，葉面積が最も強く抑制されたのはツノアイアシでは過湿条件（飽和）下であり，テリミノイヌホウズキでは過乾条件（pF3.5）下であったことから土壌水分に対する両草種の反応が必ずしも同じでないことが推察された。なおテリミノイヌホウズキでは同じ処理後期に葉面積に急激な減少が認められたが，これは同時期に大量の落葉が生じたことが原因と思われる（Fig. 3）。

4．T/R 率は両草種とも低水分で減少した。すなわち土壌水分の減少とともに地下部（根）の割合が増加することが認められた（Table 1）。

5．全乾物重はツノアイアシ，テリミノイヌホウズキのいずれにおいても高土壌水分条件下で増大したが，ツノアイアシでは過乾条件下で種子の生産がほとんどみられず，テリミノイヌホウズキでは果実の形成が全くみられなかったことが注目された。この結果から過乾条件下では両草種が次代への再生産を確保できないことが推定された（Fig. 4）。

6．出穂と開花は飽和条件または過湿条件で最も長く遅延した。種子生産形質すなわち個体当り穂数，種子重，穂長，個体当り果実数，果重は高水分ほど増加し，pF 2.0で最大となり pF 3.5では最少となった（Table 2）。

＊琉球大学農学部附属農場
＊＊琉球大学農学部農学科