J. Sci. Soc. Thailand, 9 (1983) 37 - 45

COMPETITION BETWEEN UPLAND RICE *(ORYZA SATIVA* L. VAR. *GATI* AND SPINY PIGWEED *(AMARANTHUS SPINOSUS* L.*)*

A. THONGPUKDEE[a] and J.H.H.EUSSEN[b]

a. Department of Biology, Faculty of Science, Silpakorn University, Nakhon Pathom, Thailand.

b. Botanical Laboratory, Lange, Nieuwstraat, 106 Utrecht, Netherlands.

(Received 18 December 1982)

Abstract

Replacement series experiments, in which two plant species are grown in monocultures and in mixtures, provide information on whether both plant species utilize the same complex of environmental factors or 'space'. Upland rice(Oryza sativa L. var. Gati) *and spiny pigweed* (Amarantus spinosus *L.*) *were grown as monoculture at a density of 1,2,3,4,5 and 1, 2, 4, 8, 16, 32 plants/pot respectively. In the mixtures, the density of the upland rice was fixed (2 plants/pot) and that of spiny pigweed varied (1, 2, 4, 8, 16 plants/pot). The spiny pigweed was highly competitive even when growing at the ratio 1:2. At 60 days of growing both plants together, a reduction of 79 % and 84 % of dry matter of the aerial and root parts respectively were found in the upland rice.*

Introduction

In agroecosystems, biotic and abiotic factors are the two main factors which influence the competition of vegetation[1].Weeds and crops may compete for all factors required for their growth performances if these factors are limiting [2].Growth and yield reduction of crop caused by weed may not be related only with competition for that space, but allelopathic effects may also play a role. A principle of plant competition is that the first plant species which occupy the area of soil, small or large, tend to exclude the others. Therefore, the relative rate of space occupation of two plant components in the same available space will represent their competition ability. Weed species, weed density, time and duration of weed competition apparently influenced the magnitude of yield loss[2].Spiny pigweed, *Amaranthus spinosus* L., is defined as a serious weed in upland rice areas in many countries of America and Asia, and as troublesome in many crop plantations[3].

The experiments reported in this paper were aimed at determining the nature of competition between spiny pigweed and upland rice. Such information is essential for the development of effective and economical weed control measures.

Materials and Methods

The experiment was conducted in the greenhouse of BIOTROP, Tajur, Bogor, Indonesia. The average temperature ranged from 21.6 ° C - 33.5 ° C, the average humidity from 43 % - 83 % and the average light intensity from 19,400 - 27,300 lux.

Mature seeds of *A. spinosus* L. were collected in the surroundings of the BIOTROP, Bogor, and were broadcasted on the soil under greenhouse condition. After 20 days seedlings were transplanted into pots (20 cm diameter, capacity 4.5 l) filled with local soil at a density (Za) of 1, 2, 4, 8, 16 and 32 seedlings per pot for monocultures and 1, 2, 4, 8 and 16 plants per pot for mixtures with upland rice. Upland rice *(Oryza sativa* L. var. *Gati)* was sown at a density (Zr) of 2 plants per pot in mixtures with spiny pigweed and 1, 2, 3, 4 and 5 plants per pot for monocultures. Rice seeds were distributed uniformly at 1 cm soil depth, and after emergence the mentioned densities were established. The planting scheme is designed to determine the effect of rice and spiny pigweed on each other at a fixed density of rice of 2 seedlings per pot and an increasing density of spiny pigweed. Furthermore it is allowed to determined whether both plant species utilize the same factors in their dry matter production, following the replacement principle developed by de Wit[4]. DAT (days after transplanting) indicated the time after the seedling were transplanted. Phosphorus and potassium fertilizer were applied respectively as triple super phosphate and potassium sulphate at a rate of 120 kg P_2O_5/ha and 120 kg K_2O/ha broadcasted on the soil one day before transplanting. Nitrogen fertilizer were applied as urea at a rate of 100 kg N/ha in a split application of 17,33 and 50 % of total dose at 15,40 and 60 days after transplanting. The plants were watered adequately and their growth activities followed by determining periodically the plant height, time of flower formation and the tiller number of rice in which the original shoots are included.

At 60 DAT, the plants were harvested and the dry weight of their aerial plant parts and root parts were determined separately. Three and four replicates were used for each plant density in the monocultures and mixtures respectively. The growth performances (yield) of the species in mixtures and monocultures then can be defined by the ralative yield (RY) which is calculated by the equation :

$$\text{Relative yield} = \frac{\text{yield in mixtures}}{\text{yield in monocultures}}$$

Finally, relative yield total (RYT) can be calculated by the formula :

Relative yield total = relative yield of rice in the monocultures + relative yield of spiny pigweed in the monocultures

The value of relative yield total gives information on the competition mechanism of both plant species.

Results and Discussion

In Fig. 1, some plant characteristics of rice and spiny pigweed grown in monocultures or in mixtures for 60 days are presented. Rice plant height is reduced by the presence of spiny pigweed at Za = 1 to Za = 16 to a similar degree starting at 25 DAT (Fig. 1 A and B). At 60 DAT the presence of spiny pigweed decreased rice plant height by 33 %. Rice tiller production was severely restricted by the presence of spiny pigweed when present at Za = 1 to Za = 16, tiller production is almost completely inhibited (Fig. 1 C and D).

The presence of rice did not effect spiny pigweed plant height at Za = 1 (Fig. 1 E and F). Spiny pigweed plant height was strongly affected by its own density as it decreased in a similar way in the absence or presence of rice as the density of spiny pigweed increases. At Za = 16 this height was 50 % lower than at Za = 1.

Rice dry matter production at 60 DAT was severely affected by presence of spiny pigweed (Fig. 2). The roots of spiny pigweed and of rice grown in mixture could be easily seperated because of a difference in structure of the root systems and a difference in root colour. Spiny pigweed produces a long tap root with secondary root at different distances.

The dry matter production of the rice aerial parts decreased by 79 % at Za = 1, 87 % at Za = 2 and 95 % at Za = 4 to 16. The same holds for root dry matter production decreased by 84 %, 91 % and 93 %, at Za = 1, Za = 2 and Za = 16 respectively. By contrast, spiny pigweed growth and development was not affected by the presence of rice.

Spiny pigweed therefore appeared to be a strong competitor, as even when presence of one plant per pot obviously decreased rice dry matter production. This strong competition ability also is clear in the replacement diagrams (Fig. 3, 4). For the aerial parts as well as for the roots, spiny pigweed is hardly affected by the presence of rice, but rice dry matter production is decreased by the presence of spiny pigweed. The RYT with respect to dry matter production of both aerial and root parts approached 1 at all densities combination (Table 1). Both plant species thus utilize the same factors for their growth performances[4, 5, 6].

Acknowledgements

The authors wish to express their sincere gratitude to BIOTROP, SEAMEO Regional Center For Tropical Biology for the financial support and valuable assistance.

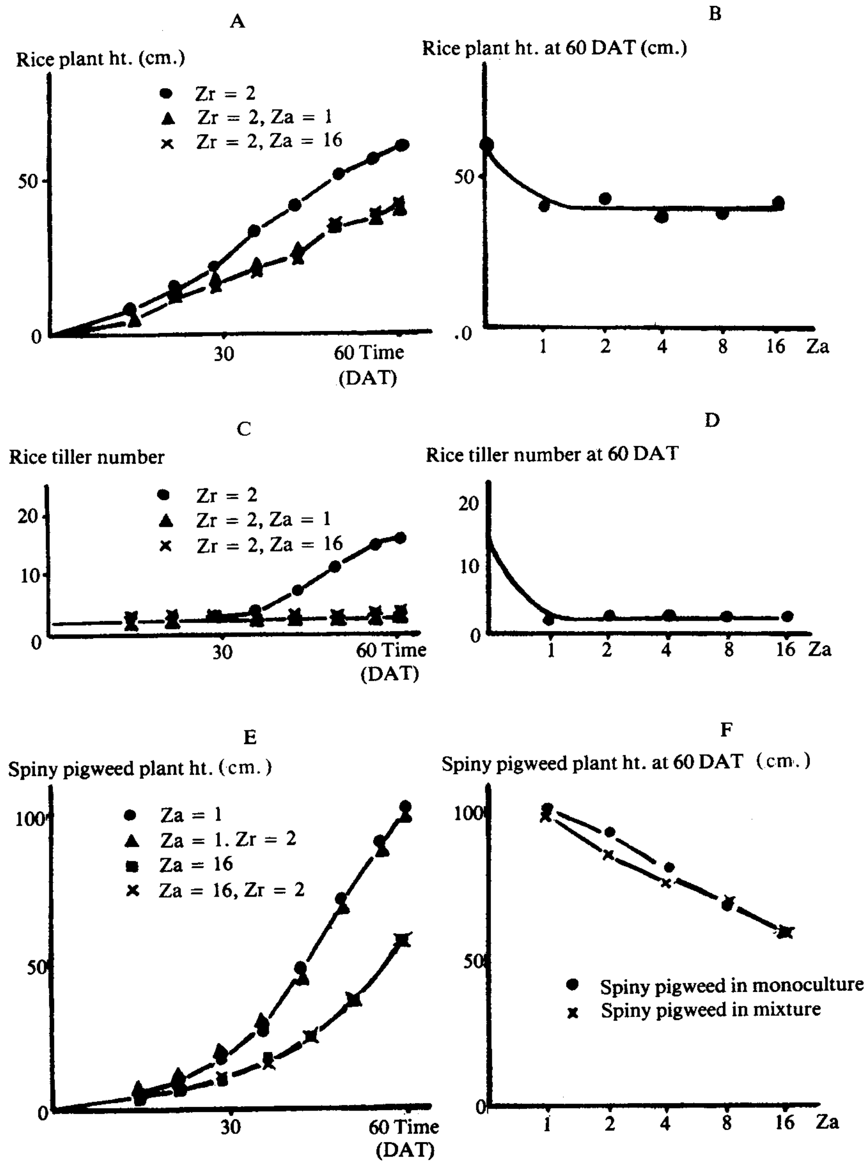

Fig. 1. Some growth characteristic comparing in rice and spiny pigweed in monoculture and mixture.

A, rice plant height as a function of time; B, rice plant height as a function of spiny pigweed density; C, rice tiller number as a function of time; D, rice tiller number as a function of spiny pigweed density; E, spiny pigweed plant height as a function of time; F, spiny pigweed plant height as a function of density.

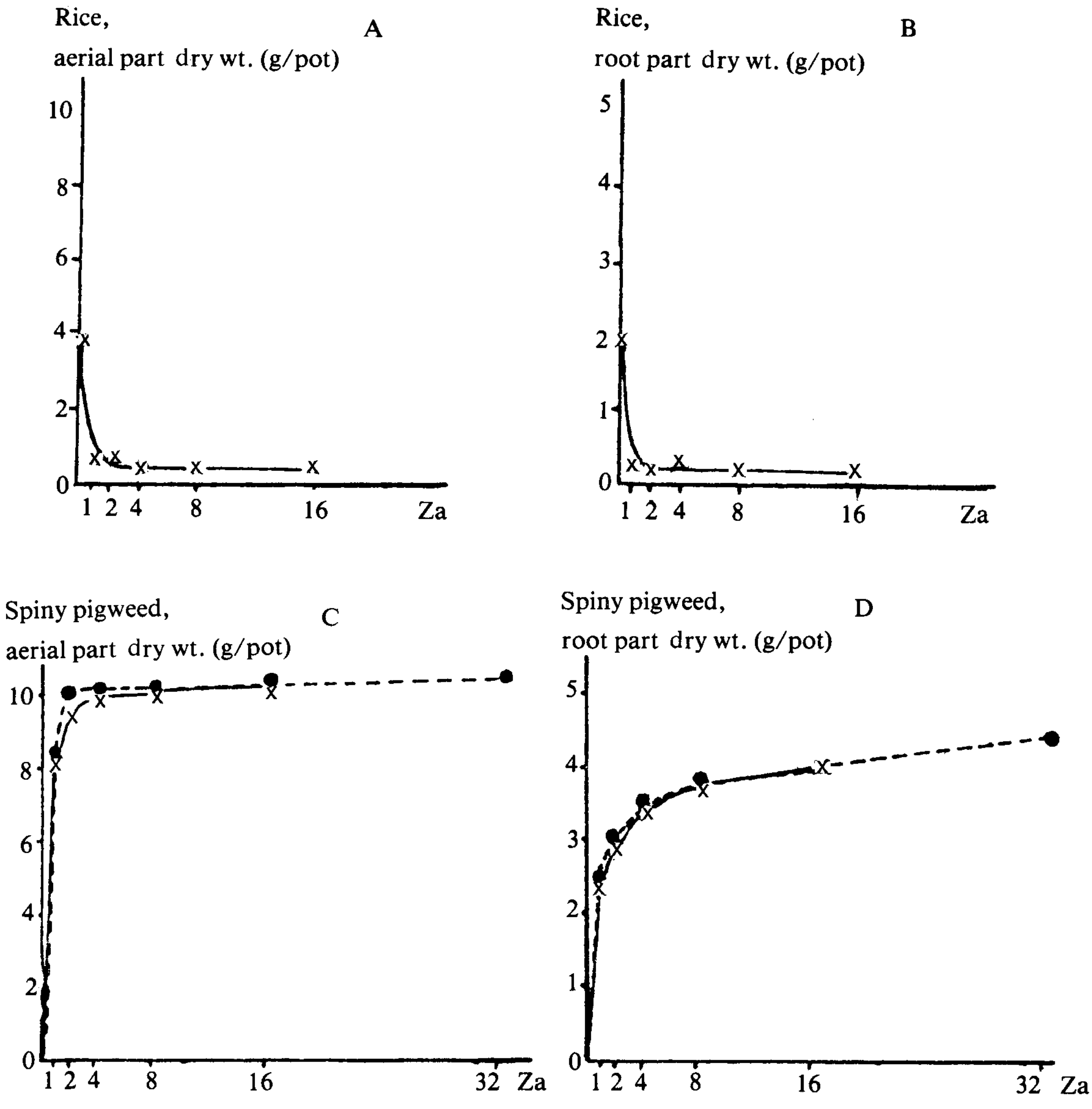

Fig. 2. The dry matter yield of rice and spiny pigweed at 60 DAT for aerial and roots parts in monoculture and in mixture as function of density of spiny pigweed.
A, aerial part of rice; B, root part of rice; C, aerial part of spiny pigweed; D, root part of spiny pigweed.
yield in mixture of rice and spiny pigweed
yield in monoculture of spiny pigweed
Za = density of spiny pigweed

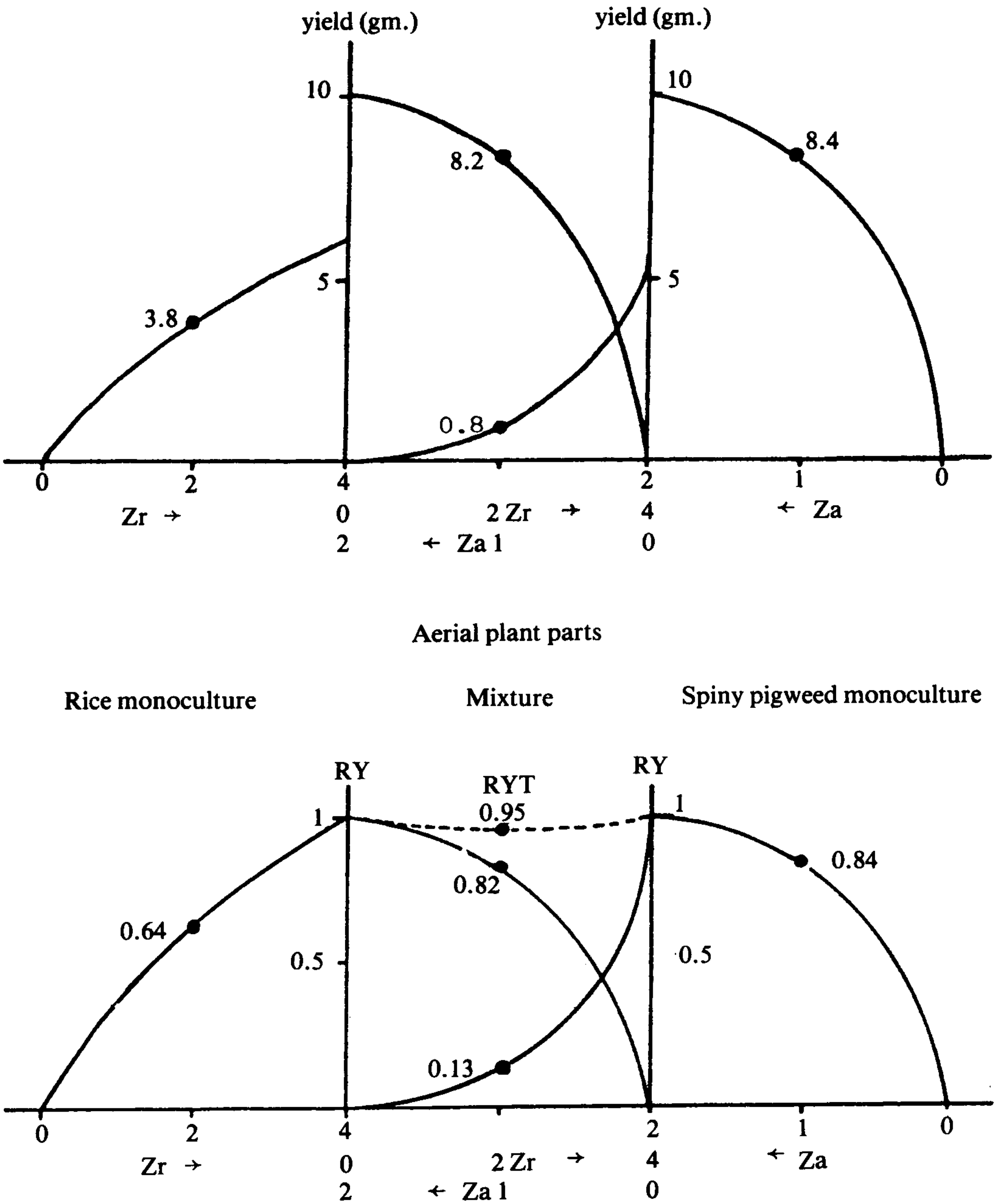

Fig. 3. The result in replacement series for aerial dry matter production of rice and spiny pigweed.
Zr = density of rice, Za = density of spiny pigweed
RY = relative yield, RYT = relative yield total

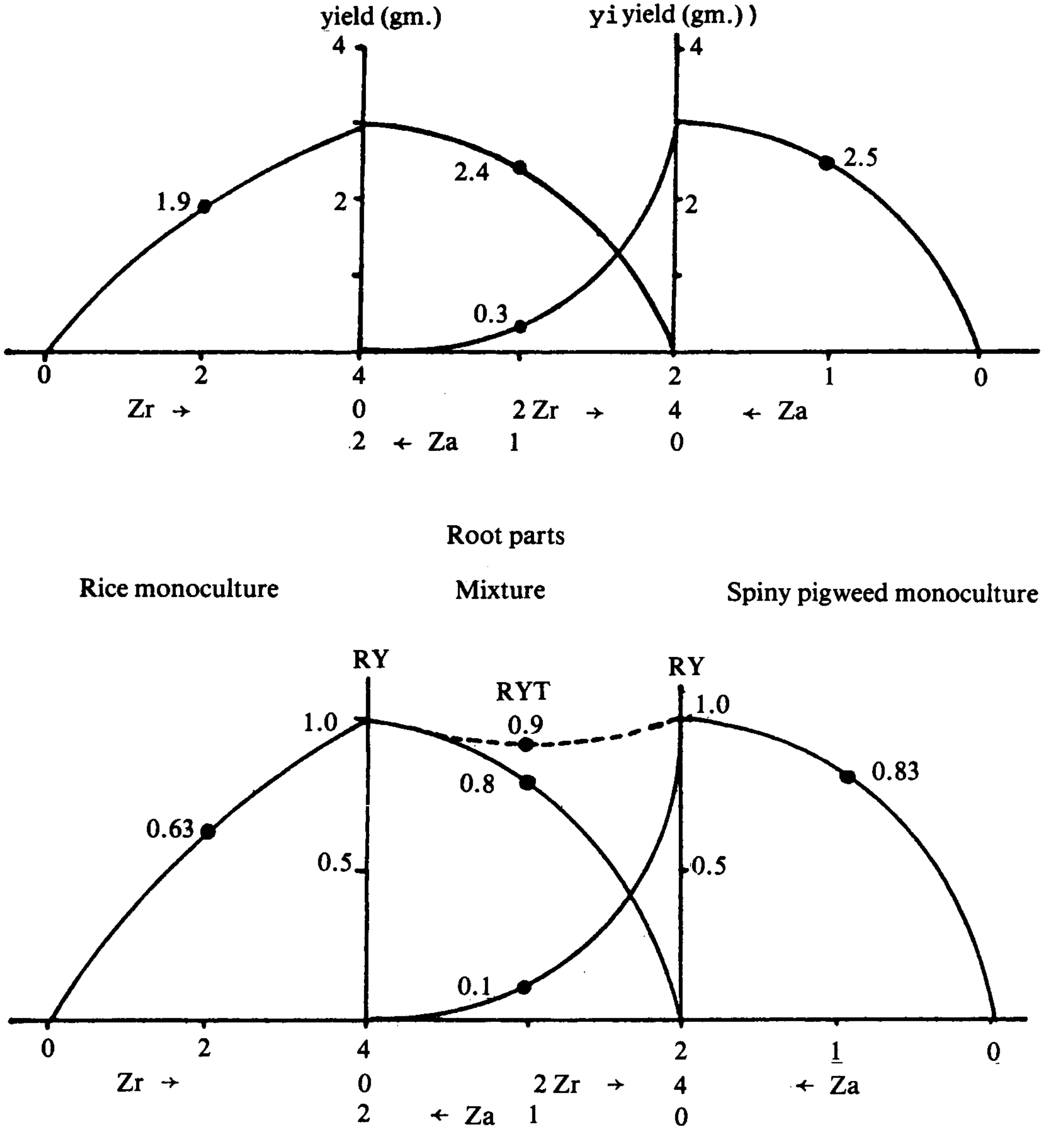

Fig. 4. The result in replacement series for root dry matter production of rice and spiny pigweed.
Zr = density of rice, Za = density of spiny pigweed
RY = relative yield, RYT = relative yield total

TABLE 1 ABSOLUTE AND RELATIVE YIELDS OF RICE AND *AMARANTHUS SPINOSUS* L. IN THE MONOCULTURES AND IN THE REPLACEMENT SERIES AT 60 DAT (DAYS AFTER TRANSPLANTING)

	Plant density		Yield monoculture		Yield heighest yielding mixt.		RY monoculture		Yield mixture		RY mixture		
	r	a	r	a	r	a	r	a	r	a	r	a	RYT
aerial	2	1	8.4	5.9	3.8	10.0	0.64	0.84	0.80	8.2	0.13	0.82	0.95
plant	2	2	10.0	5.9	3.8	10.1	0.64	0.99	0.50	9.4	0.08	0.93	1.01
parts	2	4	10.1	5.9	3.8	10.2	0.64	0.99	0.40	10.0	0.07	0.98	1.05
	2	8	10.2	5.9	3.8	10.3	0.64	0.99	0.30	10.1	0.05	0.98	1.03
	2	16	10.3	5.9	3.8	10.5	0.64	0.98	0.20	10.2	0.03	0.97	1.00
roots	2	1	2.5	3.0	1.9	3.0	0.63	0.83	0.30	2.4	0.10	0.80	0.90
	2	2	3.0	3.0	1.9	3.5	0.63	0.86	0.17	2.9	0.06	0.83	0.89
	2	4	3.5	3.0	1.9	3.8	0.63	0.92	0.16	3.4	0.05	0.89	0.94
	2	8	3.8	3.0	1.9	4.0	0.63	0.95	0.15	3.7	0.05	0.92	0.97
	2	16	4.0	3.0	1.9	4.4	0.63	0.91	0.13	4.0	0.04	0.91	0.95

r : rice; a : *Amaranthus spinosus* L. Densities in plants per pot and dry matter yield in g per pot.

References

1. Muzik, T.J. (1970) *Weed Establishment in Weed Biology and Control,* Mc Graw Hill Book Company, New York.
2. Mercado, L.B. (1979) *Introduction to Weed Science,* South East Asian Regional Center for Graduate Study and Research in Agriculture, Laguna.
3. Holm, G.L., Plucknett, D.L., Pancho, J.V. and Herberger, J.P. (1977) *World's Worst Weeds, Distribution and Biology,* Univ. Hawaii Press, Honolulu, Hawaii.
4. de Wit, C.T. (1960) *On Competition,* Versl. Landbouwk. Onders. 66.8, Wageningen.
5. Berg, J.P. van den. (1968) *Analysis of Yields of Grasses in Mixed and Pure Strands,* Versl. Landbouwk Onders, 714, Wageningen.
6. de Wit, C.T. and Gougriaan, J. (1974) *Simulation of Ecological Processes,* Centre for Agricultural Publishing and Documentation, Wageningen.

บทคัดย่อ

ในการศึกษาว่าพืช 2 ชนิดเจริญเติบโตในสิ่งแวดล้อมเดียวกันที่จำกัดจะมีการแก่งแย่งหรือต้องการปัจจัยต่อการเจริญเติบโตอย่างเดียวกันหรือไม่นั้น เดอวิทแนะให้ปลูกพืชแต่ละชนิดเพียงอย่างเดียวทั้งหมด และปลูกปนกันในระดับความหนาแน่นต่าง ๆ แล้ววัดผลผลิตของการเจริญจากพืช ในกรณีระหว่างข้าวไร่และผักขมหนามที่ปลูกชนิดเดียวล้วนด้วยความหนาแน่น 1, 2, 3, 4, 5 ต้นข้าวต่อกระถาง และ 1, 2, 4, 8, 16, 32 ต้นผักขมหนามต่อกระถาง ส่วนที่ปลูกผสมกันโดยคงความหนาแน่นของข้าวไว้ 2 ต้นต่อกระถางแล้วแปรความหนาแน่นต้นผักขมหนามเป็น 1, 2, 4, 8, 18 ต้นต่อกระถาง จากการวิเคราะห์ผลผลิตแยกส่วนต้นและรากของพืชแต่ละชนิดตามหลักที่ตั้งไว้ ปรากฏว่าพืชทั้ง 2 ชนิดมีความต้องการใช้ปัจจัยในการเจริญเติบโตอย่างเดียวกันและผักขมหนามมีความสามารถในการแก่งแย่งปัจจัยนี้สูงกว่าต้นข้าวไร่ แม้เมื่อเจริญเติบโตอยู่ในอัตราส่วนความหนาแน่น 1 ต่อ 2 ยังมีผลลดน้ำหนักแห้งของต้นและรากข้าวไร่ถึง 79% และ 84% ตามลำดับ จากผลการเก็บเกี่ยว 60 วัน หลังการย้ายปลูก