Chinese Agron. J. 2: 111-117 (1992)

Allelopathic potential of purple nutsedge (*Cyperus rotundus* L.) and barnyardgrass [*Echinochloa crus-galli* (L.) Beauv.] on corn (*Zea mays* L.). III. Influence of pH and the concentration of extracts on germination

Chwen-Ming Yang
Crop Stress and Weed Research Lab, Department of Agronomy, Taiwan Agricultural Research Institute (TARI), Wufeng, Taichung 41301, Taiwan (ROC)

Abstract. The influence of pH and the concentration of aqueous extracts of purple natsedge (*Cyperus rotundus* L.) and barnyardgrass [*Echinochloa crus-galli* (L.) Beauv.] on corn (*Zea mays* L. cv. Tainung No. 1) germination was investigated. To examine the pH effect, full strength (x) extracts and double distilled water (control) were adjusted to pH of 6.1, 5.7, 5.4, 5.1, 4.8 and 4.5 with hydrochloric acid and sodium hydroxide. It showed that germination percentage of corn was reduced when pH of the extracts were decreased, especially at pH of 4.5. Since the germination of corn seeds treated with weed extracts was lower than that of double distilled water treatment at the same pH, the results suggested that the differences of extract concentration may also be involved. To study the influence of the concentration, full strength extracts were diluted to five concentration levels, i.e., x, 1/2x, 1/4x, 1/8x and 1/16x, at pH of 5.7. It was found that both the maximal germination percentage and the germination rate were affected by the changes of the concentration of the weed extracts. The results also indicated that extracts of barnyardgrass were more suppressive than extracts of purple nutsedge on corn germination.

Key words: Purple nutsedge, Barnyardgrass, Toxic substances, Corn, pH, Concentration, Germination.

香附子與稗草殘株對玉米之相剋效應
㈢萃取液之酸鹼值及濃度對玉米種子發芽之影響

楊純明

臺灣省農業試驗所農藝系

摘要：本文試驗旨在以香附子(*Cyperus rotundus* L.)與稗草[*Echinochloa crus-galli* (L.) Beauv.]之2°C/1天植株萃取液，進行酸鹼值及濃度對萃取液相剋效應之探討。根據試驗結果，降低萃取液之酸鹼值減少玉米種子發芽百分比，惟改變萃取液酸鹼值從pH6.1至pH4.8對玉米僅造成低於5％以內的差異；當酸鹼值降至pH4.5或以下時，酸鹼值對玉米種子發芽之效應將超過濃度者。其次，由於在相同酸鹼值下處理雜草萃取液之玉米發芽百分比均低於處理予蒸餾水之對照組，顯然地除了酸鹼值之外，雜草萃取液中之其它因子（如萃取液濃度）亦對玉米發芽產生抑制作用。萃取液濃度的變化，係影響玉米發芽速率及最高發芽百分比。總此結果顯示，香附子與稗草萃取液之相剋效應乃由萃取液之酸鹼值及濃度所引起。同時，稗草植株萃取液較香附子對玉米發芽呈現明顯抑制作用。

關鍵語：香附子、稗草、相剋物質、酸鹼值、濃度、玉米、發芽。

INTRODUCTION

Interference of a weed on crops depends on season, density and duration of weed existence as well as physiological status and type of crops (Putnam 1984, Rice 1984). To further discern allelopathy from weed-crop competition, water extract of weeds is often employed to study its biochemical inhibition on crops (Meissner et al. 1982, Rice 1984, White et al. 1989, Yang 1991). Such a study is necessary, since it is essential for understanding the basic effects of a particular weed species on seed germination and growth of crops before determining weed control strategy.

Both purple nutsedge (*Cyperus rotundus* L.) and barnyardgrass [*Echinochloa crus-galli* (L.) Beauv.] are noxious weeds in temperate and tropical farm lands and throughout the island of Taiwan (Bendixen and Nandihalli 1987, Bhowmik and Doll 1983, Bhowmik and Reddy 1988, Chang 1970, Chiang and Leu 1982, Friedman and Horowitz 1971, Horowitz and Friedman 1971, Holm et al. 1977, Meissner et al. 1977, 1982, Vengris et al. 1966). Their allelopathic interferences, as those found in other plant species (Rice 1984), have been confirmed by many scientists (Bhowmik and Reddy 1988, Friedman and Horowitz 1971, Horowitz 1973, Meissner et al. 1977, 1982, Yang 1991, 1992).

In the previous experiments, Yang (1991) pointed out that allelopathic potential of water extracts of these two weeds was determined by the duration of stubble decay under the

influences of microbes and temperature. Yang (1992) also provided evidence for the allelopathic interference of these weeds on corn by showing that plant residues of these weed species incorporated into the soil affected corn emergence and its early growth.

In the present investigation, the influence of pH and the concentration of aqueous extracts of purple nutsedge and barnyardgrass on corn germination was studied.

MATERIALS AND METHODS

Mature field-grown plants of purple nutsedge and barnyardgrass, collected from experimental plot of Taiwan Agricultural Research Institute (TARI, 24°02' N, 120°40' S, elevation 85 m) in Spring 1991, were oven-dried at 80°C for 72 h. Dried plant materials were then ground with a Willey mill, passed through 40-mesh screen, and homogenized with double distilled water at the ratio of 50 g dry powder to 500 ml water (1:10). Then, the mixtures were stored in the dark at 2°C ± 0.5°C for 1 day (2°C/1 d), filtered through 2 layers of Whatman No. 1 filter paper, and sterilized at 120°C, 1.1 kg cm^{-2} for 15 min.

For pH study, full strength (x) of 2°C/1 d extracts and double distilled water (control) were adjusted to pH of 6.1, 5.7, 5.4, 5.1 4.8 and 4.5 with hydrochloric acid and sodium hydroxide using a Hanna pH meter model 8418 (Hanna Instruments, Italy). For the concentration study, 2°C/1 d extracts were diluted to 5 different levels, i.e., x, 1/2 x, 1/4 x, 1/8 x and 1/16 x, at pH of 5.7.

Certified commercial seeds of corn, cv. Tainung No. 1, were obtained from Taiwan Seed Service (Ta-nan, Shinshieh, Taichung, Taiwan, ROC) and were sterilized by soaking in a 5% (v/v) sodium hypochlorite solution for 3 min to reduce fungal infection. The sterilized seeds were then rinsed with double distilled water for 1 min three times and allowed to air-dry before experiments.

Twenty-five seeds were placed between 2 sheets of Whatman No. 1 filter paper in 9-cm grass petri dish. Each dish was received 10 ml of weed extract to germinate corn seeds at constant temperature of 25°C in the dark and additional aliquots of extracts were added daily to keep seeds moistened. Seeds were considered as germinated when the radical emerged greater than 1 mm. Germinated seeds were counted and removed every 12 h for 5 days.

A completely randomized design (CRD) with ten replications was used. Experiment was repeated three times. Data were combined over replication and subjected to do analysis of variance with mean values, which were compared using Fisher's Least Significant Difference (LSD) Test at the 5% probability level, and the standard errors of the means were also computed.

RESULTS AND DISCUSSION

Many scientists (Bhowmik and Reddy 1988, Friedman and Horowitz 1971, Horowitz 1973, Meissner et al. 1977, 1982) have showed the allelopathic interference of aqueous extracts of purple nutsedge and barnyardgrass on some crop plants. It was further shown that the weed extracts prepared at 2°C for 1 day (2°C/1 d) exerted the least inhibitive effects on corn germination, relative to those prepared at 30°C/7 d, 30°C/1 d and 2°C/7 d (Yang 1991). None of these reports, however, demonstrated the roles of pH and the concentration

in affecting the allelopathy of these two weed extracts.

The results from this study indicated that germination percentage of corn was reduced when pH of the extracts of purple nutsedge and barnyardgrass was decreased within the test range, especially at pH of 4.5 (Fig. 1). It implied that the toxic substance(s) existed in the weed extracts effectively inhibited corn germination in the lower pH. In other weed species, Wilson (1979) and Boyd and Murray (1982) found that germination of canada thistle [*Cirsium arvense* (L.) Scop] and silverleaf nightshade (*Solanum elaeagnifolium* Cav.) seeds were reduced to 40% or less between pH of 5.8 and 7.0. Soteres and Murray (1981) showed that maximum germination occurred in honeyvine milkweed [*Ampelamus albidus* (Nutt.) Britt.] at pH between 5.0 and 7.0. Inhibition of weed germinations at low pH were often reported by others (Thomson and Witt 1987, Shaw et al. 1987).

However, except in the extreme case at pH of 4.5, germination percentages were less than 5% different as affected by changing the values of pH from 4.8 to 6.1 at full strength (x) of both weed extracts. It is proposed that the toxic substances in extract are more active at pH 4.5. Moreover, since the germination of corn seeds treated with weed extracts was lower than that of double distilled water treatments at the same pH (Fig. 1), the results suggested that there existed other factors in the weed extracts, such as concentration, in causing the inhibition of corn seed germination. The results also revealed that extracts of barnyardgrass were more suppressive than extracts of purple nutsedge on corn germination under the experimental conditions.

From Figs. 2 and 3, it was found that both the maximal germination percentage and the germination rate were affected by the changes of the concentration of weed extracts. Corn germination was lowered by the increased of the extract concentration. The concentration effect was also found by Chou et al. (1987) in study of the allelopathy of kikuyu grass (*Pennisetum clandestinum*) and Chinese fir (*Cunninghamia lanceolata*). Chou et al. (1987)

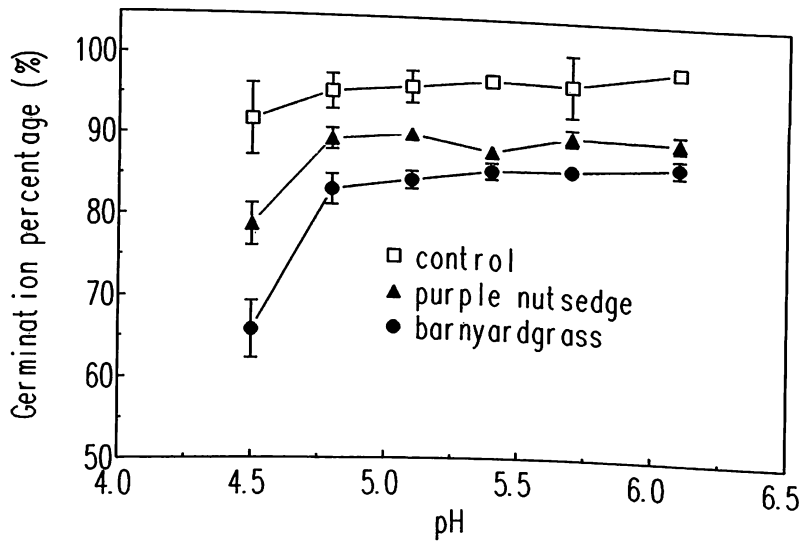

Fig. 1. Germination percentages of corn seeds treated with 2°C/1 d extracts of purple nutsedge and barnyardgrass and double distilled water (control) at various levels of pH.

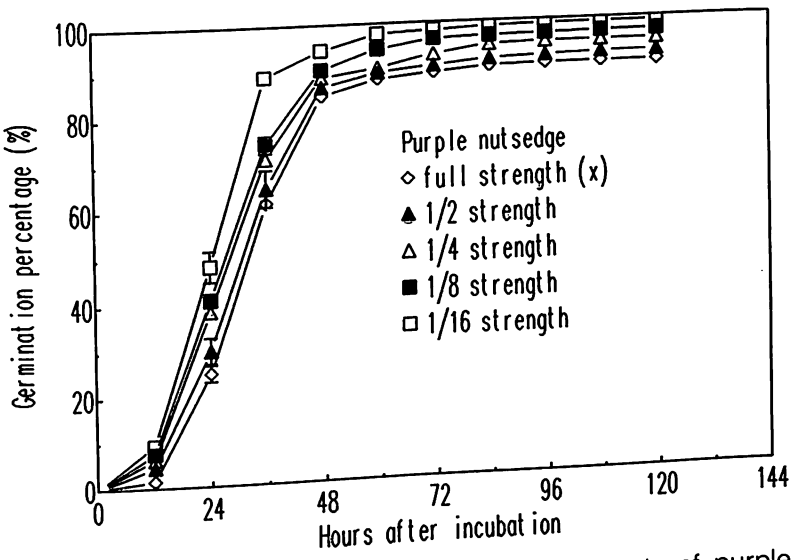

Fig. 2. Effects of the different concentrations of 2°C/1 d extracts of purple nutsedge on seed germination of corn.

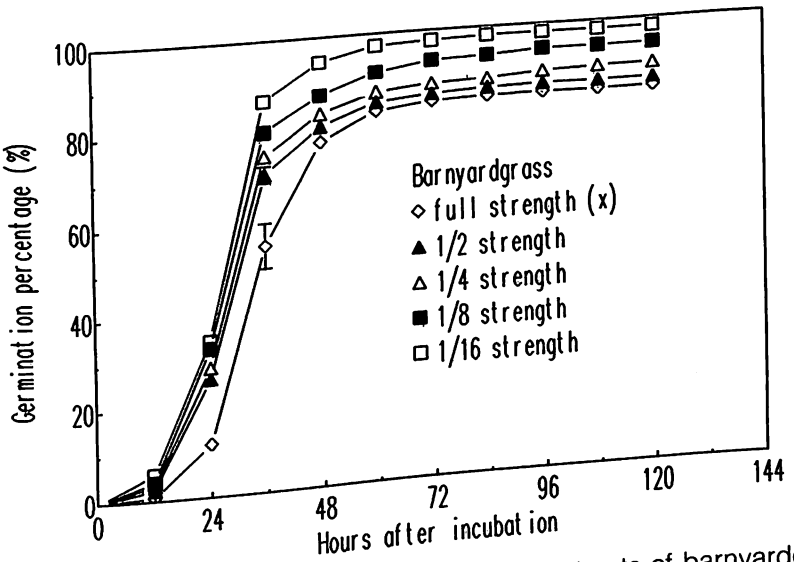

Fig. 3. Effects of the different concentrations of 2°C/1 d extracts of barnyardgrass on seed germination of corn.

identified that lettuce growth was not significantly suppressed by aqueous extracts of kikuyu grass at a concentration below 1.5% and seed germination of lettuce was significantly inhibited by the extract of Chinese fir at the concentration as low as 0.5%. Again, extracts of barnyardgrass were shown more suppressive on corn germination in spite of the changes

of the concentration.

This experiment did not distinguish which part(s) of the mature plants of these weeds causing such inhibition effect. However, Horowitz and Friedman (1971) and others (Horowitz 1973, Meissner et al. 1977, 1982, Singh et al. 1970) showed that tubers of purple nutsedge might produce allelopathic compounds. Friedman and Horowitz (1970, 1971) identified them as phenolic acids. Jangaard et al. (1971) and Sanchez-Tames et al. (1973) also pointed out that some phenolic compounds isolated from both yellow and purple nutsedges showing allelopathic properties. Few reports indicated part(s) of barnyardgrass plant showing differential allelopathic effects, which would be the subject for future study.

It was concluded that, it addition to the toxic substance(s), allelopathic interference of the extracts of purple nutsedge and barnyardgrass on corn germination might be affected by pH and the concentration differences. Further, the results confirmed the recent finding of Yang (1991) that extracts of barnyardgrass are more suppressive than those of purple nutsedge on corn germination.

Acknowledgements. Contribution No. 1576 from Taiwan Agricultural Research Institute (TARI). The author gratefully thanks the Department of Agriculture and Forestry, Taiwan Provincial Government, for partial funding of this study and Professor F.J.M. Sung for his constructive criticism and valuable suggestions.

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(Received October 30, 1991 and accepted March 3, 1992)

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