PROCEEDINGS

OF THE

35TH ANNUAL MEETING

25-31 July 1999

Castries, St. Lucia, W.I.

Proceedings Edited
By
Wilfredo Colón

Published by the Caribbean Food Crops Society

Proceedings of the Caribbean Food Crops Society. 35:137-143. 1999

ABOVE AND BELOW GROUND INTERFERENCE OF SMOOTH PIGWEED *Amaranthus hybridus* WITH LETTUCE *Lactuca sativa* AS AFFECTED BY PHOSPHORUS FERTILITY

***Bielinski M. Santos**, Horticultural Researcher, Departamento de Investigaciones Agropecuarias. Secretaría de Estado de Agricultura. República Dominicana.*

INTRODUCTION

Mechanisms of interference are related to both the effect that plants have on resources as well as the response of plants to changed resources (Goldberg, 1990). These resources (light, nutrients, water, and space), when supplied in limited amounts, can change competitive interactions between two plant species. Light plays an important role in the overall interference relationships among species. As it is well known, this factor is the energy source used to convert inorganic compounds to organic molecules during the process of photosynthesis. Therefore, when radiance levels and quality are reduced, significant changes in plant responses could be observed. These responses vary from mortality to plasticity expressed as redistribution of dry matter, altered leaf anatomy, and decreased respiration rates (Patterson 1985). It is generally understood that an aggressive competitor species is very plastic to shading, usually adapting to low light levels or changing its growth habits.

Plant nutrients are usually in limited concentrations in the soil solution, justifying the use of supplementary fertilizers to replenish supply. Unfortunately, nutrients applied to the soils are also available for weeds to be absorbed, establishing competitive relationships for this factor. In most farming systems, competition for nitrogen is the most important source of nutrient interference (DiTomaso, 1995). However, in organic soils, this element is frequently found in sufficient amounts for crop production, minimizing the effects of weed interference for this nutrient. On the other hand, because Histosols are naturally deficient in P, weed-crop competition for this nutrient occurs.

Competition for a given factor is not independent of competition for other resources (DiTomaso, 1995). The influence of a given limited resource (i.e. nutrients) can change the balance and nature of the interference for another resource (i.e. light) (Carlson and Hill, 1986; Liebman and Robicheaux, 1990). In other words, the enhanced ability of a given species to deplete nutrients from the soil faster than another may provide it an additional advantage to shade its competitor. The opposite situation may also occur, with tall plants being able to capture sunlight more efficiently, leading to more vigorous growth and subsequently being able to exploit soil nutrients more efficiently.

In order to avoid confounding results in terms of the main factor involved in weed-crop complexes, a partitioning approach has been devised. Under this methodology, the crop and the weed are grown under each of four conditions: a) no interference, b) full interference, c) above-ground interference, and d) below-ground interference (Groves and Williams, 1975; Silvertown, 1987). This partitioning allows to separate and compare the effects of unrestricted individual growth (no interference) with below ground competition (water and/or nutrients) and above ground competition (light).

Previous experiments have demonstrated that smooth pigweed (*Amaranthus hybridus*) compete with lettuce for available growth resources (Santos *et al.*, 1997; Santos *et al.*, 1998). Smooth pigweed has not shown significant responses to P fertility, while it has been more competitive than lettuce. Despite of all these studies, no mechanisms of interference have been examined in terms of their effects on plant size and nutrient uptake. The overall objectives to accomplish were: a) determine the effect of different partitioning conditions on smooth pigweed-lettuce complexes, and b) determine the primary mechanism of interference of this weed with lettuce as affected by P rates.

MATERIALS AND METHODS

Partitioning studies were conducted under greenhouse conditions during 1997. Lettuce (cv. South Bay) and smooth pigweed seeds were sown in styrofoam multi-cell flats (5 cm^3 $cell^{-1}$). When seedlings reached the two-true leaf stage, lettuce-smooth pigweed complexes were transplanted according to four partitioning regimes: no interference (NI), full interference (FI), below-ground interference (BI), above-ground interference (AI) (Figure 1).

For NI treatments, two plastic containers holding 3 L of screened Pahokee muck (Euic hyperthermic Lithic Medisaprist) were utilized, planting a single lettuce seedling in the center of one of the containers and a single weed seedling in the center of the other container. Seedlings of both the crop and the weed involved were in the two-true leaf stage. Hardware cloth was utilized to restrict aerial space above each container to approximately the same volume than the below-ground volume. Therefore, plants growing in NI treatments would have approximately 3 L of each soil and aerial volume to grow.

For FI treatments, one seedling of each lettuce and the weed involved were planted simultaneously in the same container equidistant from the center of the container. A volume of 6 L of the same soil described previously was provided. Similar aerial volume was restricted by using hardware cloth. Two different modifications to this approach were implemented for AI and BI treatments. For AI treatments, each 6 L container was divided in two equal soil chambers by using flat pieces of plastic material that allowed to isolate water, nutrients, and root growth within each soil chamber. Aerial volume remained as for FI treatments. Therefore, for AI treatments, each species involved had 3 L of soil while sharing 6 L of aerial space. For BI treatments, each species shared 6 L of soil volume, while hardware cloth was utilized to create two above-ground chambers of 3 L each. This procedure was done to avoid canopy overlapping.

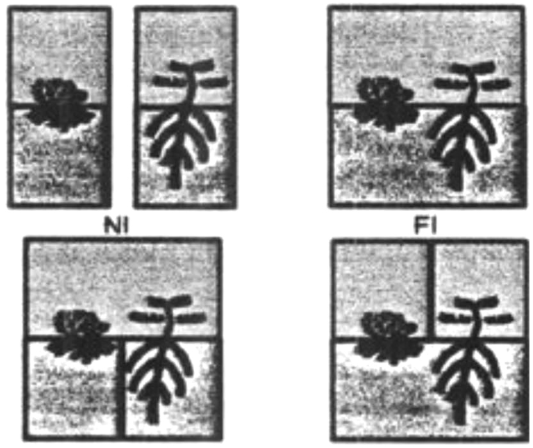

Figure 1. Partitioning for lettuce-weed complexes: no interference (NI), full interference (FI), below-ground interference (BI), above-ground interference (AI).

Soil utilized was low in P for optimum lettuce yields as revealed by soil tests (water extractable P of 3.0 mg P L^{-1} of soil). Phosphorus was provided at rates of 0, 0.4, and 0.8 g of P L^{-1} of soil, using $Ca(H_2PO_4)_2$ as P source, and thoroughly mixed with the soil 5 days before transplanting. Other plant nutrients were provided every 5 days with a non-P modified solution that ensured non-limiting conditions for other nutrients. Containers were watered daily during the first 5 days after transplanting with 0.5 L of deionized water per L of soil. Afterwards, 1 L of deionized water per L of soil was provided every 2 days.

Treatments were factorially arranged within a split-plot design with 3 P rates as main plots and 4 partitioning regimes as sub-plots. Four replications were established. After 25 days of mutual interference, lettuce-smooth pigweed associations were harvested. Weed and lettuce plant height, and shoot and root dry weights were collected 25 days after transplanting. Ground samples were obtained for each treatment. Wet-ash digestion was used to obtain liquid extract from tissues (Wolf, 1982). Phosphorus content was colorimetrically determined after using the molybdate-ascorbic acid solution method (Murphy and Riley, 1962). Resulting data obtained was subjected to analysis of variance (ANOVA) to test for treatment effects. If significant differences were found, treatment means were separated with standard error bars.

RESULTS AND DISCUSSION

Partitioning regimes and P rates interactively influenced lettuce shoot and root dry weight, and height (Figures 2, 3, and 4). However, smooth pigweed biomass variables were not affected by either P rate or partitioning regimes. Maximum values for lettuce shoot and root dry weight, and height were observed for NI treatments within each P rate. Lowest biomass production and height were measured in FI treatments. Lettuce shoot and root dry weight, and height increased with P rate within each partitioning.

Lettuce shoot dry weight was reduced in 27, 27, and 26% compared to NI control when smooth pigweed root interference was allowed (BI) with 0, 0.4, and 0.8 g P L^{-1} soil, respectively (Figure 2). When grown under AI conditions, lettuce shoot dry weight was reduced in 49, 49, and 51% with 0, 0.4, and 0.8 g P L^{-1} soil, respectively. As both species were allowed to interfere freely with each other (FI), lettuce shoot dry weight declined even further within each P rate. Reductions of 73, 65, and 64% occurred for each P rate, which were higher than the two previously described interference regimes.

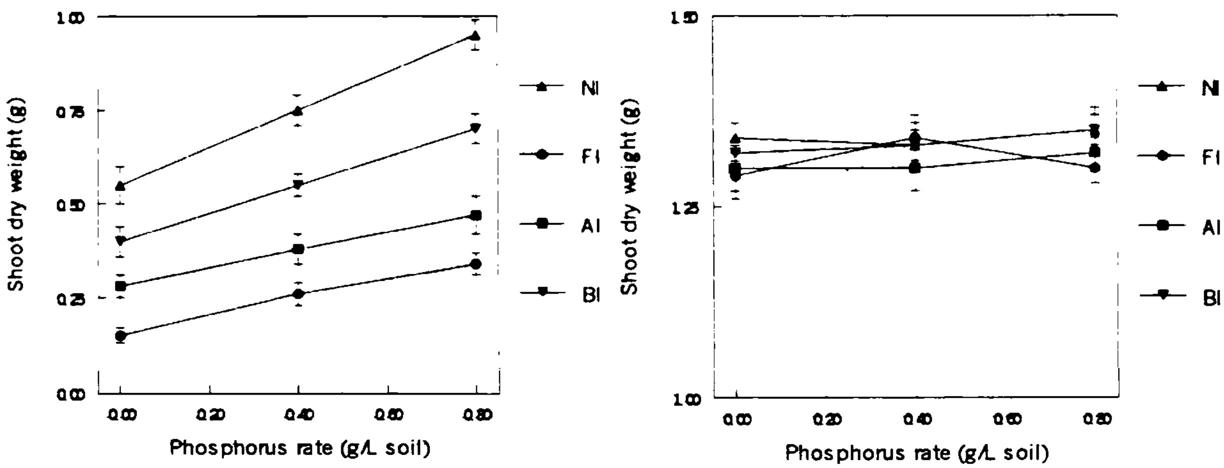

Figure 2. Effect of phosphorus (P) rates on lettuce (left) and smooth pigweed (right) shoot dry weight per plant.

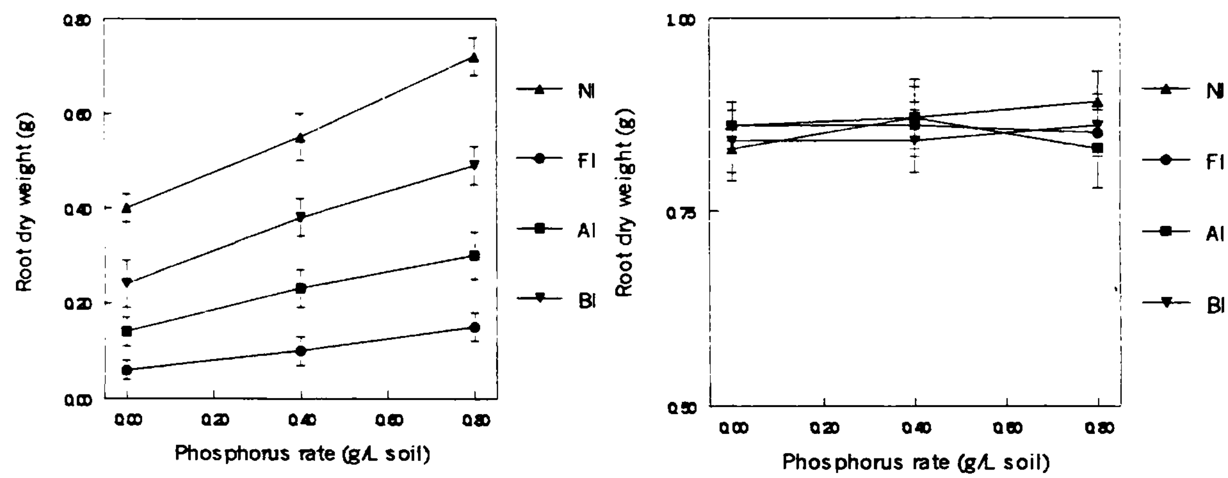

Figure 3. Effect of phosphorus (P) rates on lettuce (left) and smooth pigweed (right) root dry weight per plant.

Reductions in lettuce root dry weight due to smooth pigweed root interference (BI) were 40, 31, and 32% when P was supplied at rates of 0, 0.4, and 8 g P L^{-1} soil, respectively (Figure 3). When smooth pigweed shoots were allowed to interfere (AI), lettuce root dry weight declined 65, 58, and 58% compared to NI treatments for each P rate provided. When both shoot and root interference occurred (FI), reductions in lettuce root dry weight accounted for 85, 82, and 79% with respect to NI treatments for 0, 0.4, and 8 g P L^{-1} soil, respectively.

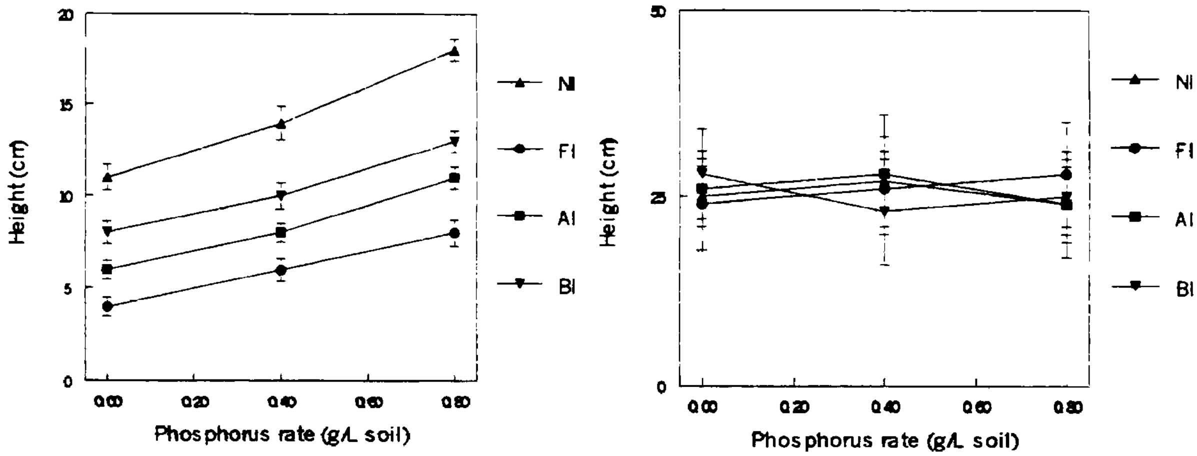

Figure 4. Effect of phosphorus (P) rates on lettuce (left) and smooth pigweed (right) plant height.

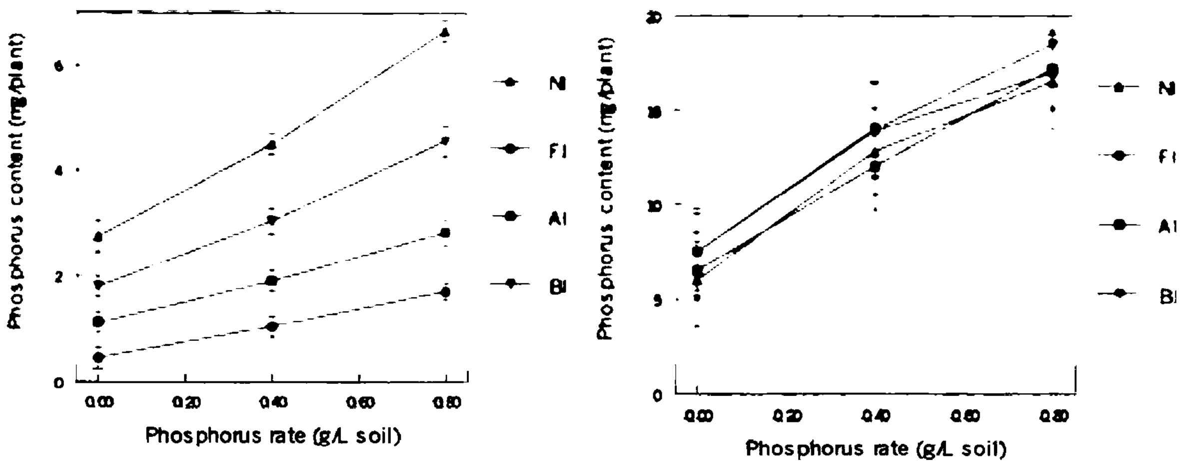

Figure 5. Effect of phosphorus (P) rates on lettuce (left) and smooth pigweed (right) P content per plant.

Smooth pigweed root interference (BI) negatively influenced lettuce plant height by 27, 29, and 28% for each P rate used (Figure 4). If AI occurred, then lettuce height reductions reached 45, 43, and 39% compared to the NI control for each 0, 0.4, and 8 g P L^{-1} soil. Lettuce height declined 64, 57, and 55% as smooth pigweed shoot and roots interfered (FI) with the crop with P rates of 0, 0.4, and 8 g L^{-1} soil, respectively.

Lettuce P content was interactively affected by P rate and partitioning regime, whereas only P rate influenced P content of smooth pigweed (Figure 5). Lettuce P content followed the same pattern than shoot and root dry weight per plant, where this variable increased with P rate applied. In the absence of weed interference (NI), lettuce P content had the highest values within each P rate. When smooth pigweed was allowed to interfere both above and below ground (FI), P content reductions of 84, 77, and 74% occurred for each 0, 0.4, and 8 g P L^{-1} soil. If shoot interference took place, then lettuce P content declined 59, 58, and 58% with respect NI treatments. Smooth pigweed root interference (BI) accounted for 35, 33, and 32% reductions in P content of the crop.

In contrast with the trends followed by previous smooth pigweed variables described (Figures 2, 3, and 4), P content of the weed increased with P rate (Figure 5).

Partitioning regime did not have an effect on smooth pigweed P accumulation. Because shoot and root dry weight of the weed did not change with varying P rate and partitioning regimes, these findings indicate that smooth pigweed increased its P absorption from the soil without producing any change in the weed biomass. Luxurious P consumption by smooth pigweed is occurring.

The data collected indicates that smooth pigweed shoot interference (AI) accounted for most of the damage caused by the weed compared to the combined effects of shoot and root interference (FI). Light intersection by taller smooth pigweed plants deprived lettuce foliage of capturing enough amounts of this essential factor. Under the conditions of these studies, it can be concluded that the primary mechanism of smooth pigweed interference with lettuce is light intersection by the weed canopy. A secondary mechanism of interference of smooth pigweed is the luxurious P absorption by the weed rooting system preventing lettuce of sufficient amounts of this nutrient for growth and development.

Allelopathic effects by smooth pigweed roots cannot be ruled out as a possible contributor to smooth pigweed noxiousness. However, allelopathic compounds are mostly released when plants are growing under stress conditions. In this case, because smooth pigweed shoot and root biomass was not affected by any factor involved and lettuce responses to increased P rates were found, allelopathy occurrence is unlikely.

Interactions among interference strategies by weeds are not a rare occurrence (Carlson and Hill, 1986; Liebman and Robicheaux, 1990). In this case, the influence of a given limited resource (light) combined with the changes in availability of another (P) enabled smooth pigweed to reduce lettuce biomass more than if only one mechanism of interference takes place.

REFERENCES

Carlson, H.L. and J.E. Hill. 1986. Wild oat (*Avena fatua*) competition with spring wheat: Effects of nitrogen fertilization. Weed Sci. 34:29-33.

DiTomaso, J.M. 1995. Approaches for improving crop competitiveness through the manipulation of fertilization strategies. Weed Sci. 43:491-497.

Goldberg, D.E. 1990. Components of resource competition in plant communities. In: J.B. Grace and D. Tilman (eds.). Perspectives on Plant Competition. New York, NY:Academic Press. pp. 27-49.

Groves, R.H. and J.D. Williams. 1975. Growth of skeleton weed (*Chondrilla juncea* L.) as affected by growth of subterranean clover (*Trifolium subterraneum* L.) and infection by *Puccinia chondrilla* Bubak and Syd. Aust. J. Agric. Res. 26:975-983.

Liebman, M. and R.H. Robicheaux. 1990. Competition by barley and pea against mustard: ffects on resource acquisition, photosynthesis and yield. Agric.Ecosys. Environ, 31:155-172.

Murphy, J. and J.P. Riley. 1962. A modified single solution method for the determination of phosphate in natural waters. Anal. Chim. Acta 27:31-36.

Patterson, D.T. 1985. Comparative ecophysiology of weeds and crops. *In* S. O. Duke (ed.). Weed Physiology, Vol. 1, Reproduction and Ecophysiology. Boca Raton, FL:CRC Press, Inc. pp. 101-129.

Santos, B.M., J.A. Dusky, W.M. Stall, D.G. Shilling, and T.A. Bewick. 1997. Influence of smooth pigweed and common purslane densities on lettuce yields as affected by phosphorus fertility. Proc. Fla. State Hort. Soc. 110:315-317.

Santos, B.M., J.A. Dusky, W.M. Stall, D.G. Shilling, and T.A. Bewick. 1998. Phosphorus effects on competitive interactions of smooth pigweed and common purslane with lettuce. Weed Sci. 46:307-312.

Silvertown, J.W. 1987. Introduction to Plant Population Ecology. Essex, England: Longman Sci. and Tech. 229 pp.

Wolf, B. 1982. A comprehensive system of leaf analyses and its use for diagnosing crop nutrient status. Commun. Soil. Sci. Plant. Anal. 13:1035-1059.