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# DETERMINATION OF THE CRITICAL PERIOD OF WEEDS COMPETITION IN PEPPER CROP (*Capsicum annum*, L.)

## Determinación del período crítico de competencia de arvenses en el cultivo del pimiento (*Capsicum annum*, L.)

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**ABSTRACT**. The determination of critical period of competition between weeds and economic crops is the only efficient way to establish methods of weeds management during the time that the crop requires. To achieve this aim, was conducted a research two-year (2012-2013) at the National Institute of Agricultural Sciences, where was evaluated using a randomized block design, with treatments at 20-30-40-50-60-70 days after the transplant with and without weeds and two controls, with and without management during the whole cycle of the pepper. The dominant weeds in the system were *Cyperus rotundus* L., *Amaranthus dubius* Mart. and *Portulaca oleracea* L. The critical period of weed competition with the pepper crop goes from 50 to 80 days before the transplant, period during which the crop can´t miss the weed management, to guarantee good yields. The highest yields were obtained when the weeds were managed at 50, 60, 70 days and the whole cycle of crop, with 8,8; 8,3; 12,3 and 12,4 t $ha^{-1}$ respectively and the lowest yields on the same days but with the reverse treatment with 0,6; 1,0 and 0,5 t $ha^{-1}$.

*Key words*: yield, interspecific relationship, arable management

**RESUMEN**. La determinación del período crítico de competencia entre las arvenses y el cultivo económico es la única vía eficiente para establecer métodos de manejo de arvenses durante el tiempo que el cultivo lo requiere. Para lograr ese objetivo, se llevó a cabo una investigación durante dos años (2012-2013) en el Instituto Nacional de Ciencias Agrícolas donde se evaluó mediante un diseño de bloques al azar, con tratamientos a los 20-30-40-50-60-70 días después del trasplante con y sin arvenses, y dos testigos, con y sin manejo durante todo el ciclo del pimiento. Las arvenses dominantes en el sistema, fueron *Cyperus rotundus* L., *Amaranthus dubius* Mart. y *Portulaca oleracea* L. El período crítico de competencia de las arvenses con el cultivo del pimiento transcurrió desde los 50 a 80 días después del trasplante, período durante el cual al cultivo no le pueden faltar las labores de manejo de las arvenses, para garantizar altos rendimientos. Los mayores rendimientos se obtuvieron cuando las arvenses fueron manejadas a los 50, 60,70 días y todo el ciclo con 8,8; 8,3; 12,3, y 12,4 t $ha^{-1}$ respectivamente y los menores rendimientos los mismo días pero con los tratamientos inversos 0,6; 1,0 y 0,5 t $ha^{-1}$.

*Palabras clave*: rendimiento, relación interespecífica, labores de manejo

## INTRODUCTION

Among the factors that limit the development of horticultural crops, the interference of weeds plays a very important role, both by the reduction in crop yield and by the control costs caused (1). The control of weeds requires knowing the species that cause the greatest interference to the crop, during which period it is economically adverse, which is known as the critical period of interference (2). Several works of this type were carried out in different crops, among them soybean (3) and tomato (1). The critical period for weed control is a key component of the integrated management strategy that provides farmers with knowledge of when to control those that are most detrimental to crop yield (4). It has been used in many economically important crops, under numerous systems and in a wide range of places and environments (1,3,4). A critical period for weed control is defined as the minimum period of time that a crop must be kept free of weeds to avoid

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unacceptable losses in yields (5). It is formed by the superposition of two separate components: (i) the critical moment of weed removal, or the maximum length of time they can remain in the crop before yield losses become unacceptable; (ii) Minimum time that the crop must remain free of weeds to avoid losses in yield (4,5). Clearly, the appearance and duration of these two components depends, mainly, on the moment of emergence of weeds with respect to the crop (6).

The pepper (*Capsicum annum* L.) is one of the most economically important vegetables in the country, given its widespread consumption by the population, as well as its level of export in some markets. Among the major limitations in the production of vegetables is the interference of weeds. Almost all of these plants develop slowly during the first weeks, after emergence and tend to be less competitive with weeds than many plants that grow in arable areas. It is considered that the critical period of competition of weeds for most vegetables is equivalent to the first third of its vegetative cycle (7), but in fact this period is variable and depends on the morphology of the arable plant, growth rate and development, distance of plantation and species of weeds present in the field. In order to reach higher yields per area and to extend its cultivable surface, it is necessary to combat weed plants, in the presence of which, although there are no precise data of their harmfulness, it has been observed that the pepper plants grow and develop poorly. From the above it is clear that weeds must be combated from the beginning of the development and growth of the vegetables and must be maintained until they are able to compete effectively with the weeds, in addition to serving as hosts to many pests, and that negatively affect the plant health and increase the expenses of inputs in the horticultural production. For the foregoing, this work had the objective of determining the critical period of competition of the weeds with the pepper culture.

## MATERIALS AND METHODS

The research was carried out during the winter cycle of 2012-2013 in experimental areas belonging to the National Institute of Agricultural Sciences (INCA), in San José de las Lajas, Mayabeque, located at 138 m a.s.l, on a typical leached red Ferralitic soil, Eutric, characterized by a medium to high fertility (8).

The experiment was conducted under a randomized block design with four replications and 14 treatments, consisting of maintaining a group of weed-free plots for a predetermined period of time, including a weed-free variant throughout the cycle.

Another group of plots received the inverse treatment, including a variant consisting of plots with weeds during the whole cycle (Table 1).

**Table 1. Treatments evaluated to determine the critical period of weed-pepper competition**

| Descrption of treatments |
|---|
| 20 days without weeds (SA-20) |
| 30 days without weeds (SA-30) |
| 40 days without weeds (SA-40) |
| 50 days without weeds (SA-50) |
| 60 days without weeds (SA-60) |
| 70 days without weeds (SA-70) |
| Without weeds the entire cycle (SATC) |
| 20 days with weeds (CA-20) |
| 30 days with weeds (CA-30) |
| 40 days with weeds (CA-40) |
| 50 days with weeds (CA-50) |
| 60 days with weeds(CA-60) |
| 70 days with weeds (CA- 70) |
| With weeds the entire cycle (CATC) |

The variety of peppers used was the California Wonder. The transplant was carried out in the month of November with a planting distance of 0.90 x 0.30 cm. The experimental area consisted of 0.58 ha. The fertilization was carried out before sowing and at the time of the beginning of flowering with complete formula NPK and a dose of 160-80-120 kg $ha^{-1}$, the irrigation was by sprinkling. The management of the weeds (weeding) was carried out with a hoe, with an interval of 10 days between each one of the plots, varying this, in the measure of the growth of the weeds in those plots subjected to periods of cleanliness that required it.

Soil preparation and other cultural attention were made following the technical norms of pepper cultivation (9).

The variables evaluated were:

*In weeds*: number of species, number of specimens (visually, from the use of a frame equivalent to 1 $m^2$, which was launched six times by replication), which allowed to determine the coverage (%) that was made at the end of each competition period, where the $m^{-2}$ weed species were extracted, subsequently

determining its fresh and dry mass (g) (samples were taken from the set of weeds delimited by the frame, which were extracted from the ground and placed in an oven at 70 °C to constant weight for the determination of dry biomass.

In the execution of these experiences the Maltsev scale methodology was used (10) for which the area is diagonally crossed and all the observed weed species are noted, to which the degree of corresponding weed growth, according to the following scale:

*Grade 1*: isolated weeds, weak weed growth, up to 5% coverage.

*Grade 2*: medium weed growth, from 6 to 25 % coverage

*Grade 3*: strong weed growth, from 26 to 50 % coverage.

*Grade 4*: very strong weed growth, more than 50 % coverage.

The data obtained were processed and analyzed statistically, using the analysis of variance of double classification and, in the necessary cases, Duncan's multiple range test was performed at 5 % probability.

*In the crop*: yield (t $ha^{-1}$).

## RESULTS AND DISCUSSION

### Composition of weeds and their dominance in the system

The dicotyledonous weeds that competed with the pepper culture were: *Amaranthus dubius* Mart., *Portulaca oleracea* L., *Parthenium hysterophorus* L., *Kalstroemia maximus* (L) T. and G., *Euphorbia heterophylla* L. and *Boerhavia* sp .; although the ones with the highest incidence in the experiment were the dicotyledonous short cycle *Amaranthus dubius* Mart. and *Portulaca oleracea* L. The rest of the detected species were *Rottbolellia exaltata* L, *Echinochloa colonum* (L) Link, D*igitaria sanguinalis* (L) M. Scop., *Eleusine indica* (L) Garth., *Brachiaria extensive* Chase, *Cyperus rotundus* L. and *Sorghum halepense* L., within the monocotyledons (Table 2).

A total of eight families and 13 species appeared in the system, of which only two are perennials. There were a smaller number of dicotyledonous species and dominated the monocotyledons *C. rotundus* and *R. exaltata* together with the dicotyledonous species *P. oleraceae*. This dominance could be attributable to cultural precedents, demonstrating that the composition of the weed census is not significantly modified because of the mechanical management, there being variability of dominance position among subordinates (species that have no marked influence on the cenosis of the weeds), apparently motivated by the prevailing climatic conditions (since many species of weeds develop better when there is abundant rainfall) and probably also allelopathic incidences (11).

Several authors have suggested that a large number of plants exude a varied range of organic compounds; some of these compounds exuded by the roots exert a marked inhibitory effect on the germination and growth of other species.

The literature establishes that these phytotoxic compounds are produced by cultivated species, among which include weeds (12).

**Table 2. Species of weeds found in the crop**

| Family | Species | Vulgar name | Life cycle |
|---|---|---|---|
| Amaranthaceae | *A. dubius* | Bledo | Annual |
| Asteraceae | *P. hysterophorus* | Escoba amarga | Annual |
| Cyperaceae | *C. rotundus* | Cebolleta | Perennial |
| Euphorbiaceae | *E. heterophylla* | Corazón de maría | Annual |
| Poaceae | *B. extensa* | Gambutera | Annual |
| | *E. colonum* | Armilán, Arrocillo | Annual |
| | *E. indica* | Pata de gallina | Annual |
| | *R. exaltata* | Grama de caballo | Annual |
| | *S. halepense* | Yerba de Don Carlos | Perennial |
| | *D. sanguinalis* | Don Juan de Castilla | Annual |
| Portulacaceae | *P. oleraceae* | Verdolaga | Annual |
| Zigofilacea | *K. máxima* | Abrojo | Annual |
| Nictaginaceae | *Boerhavia sp* | Tostón | Annual |

Among the cultivated species that have this characteristic, we can mention rye (*Secale cereale* L.), oats (*Avena sativa* L.), barley (*Hordeum vulgare* L.), corn (*Zea mays* L.), tomato (*Solanum lycopersicum* L.), cucumber (*Cucumis sativus* L.), among others. There are also several non-cultivated species and weeds that produce radical inhibitory exudates for other species, among which we can mention: *Setaria faberii* R.A.W. Herrm., *S. halepense*, *D. sanguinalis*, *R. exaltata*, *P. oleracera*, *E. crusgalli*, *C. rotundus*, among others (13). The species that were dominant are typical of the soils of the Mayabeque province (14), also demonstrated by other authors (12).

A total of 916 specimens were collected among all the treatments, observing the dominance of the species *C. rotundus* with a total of 200 specimens, followed by the species *R. exaltata* with 180 specimens; the third place was occupied by the species *P. oleraceae* with 150 specimens (Table 3). The dominance of *C. rotundus* is due to its characteristic of aggressive and invasive perennial species difficult to control (11) in addition to having high ecological plasticity against pre-energetic herbicides such as atrazine used in the previous crop.

**Table 3. Total number of individuals found in the pepper crop**

| Species | Individual number |
|---|---|
| *A. dubius* | 105 |
| *P. hysterophorus* | 21 |
| *C. rotundus* | 200 |
| *E. heterophylla* | 9 |
| *B. extensa* | 8 |
| *E. colonum* | 43 |
| *E. indica* | 20 |
| *R. exaltata* | 180 |
| *S. halepense* | 90 |
| *D. sanguinalis* | 25 |
| *P. oleraceae* | 150 |
| *K. máxima* | 15 |
| *Boerhavia sp* | 50 |

The dominance in these two species mentioned above (*C. rotundus* and *R. exaltata*) must also be closely related to the history of the field, due to the excessive use of herbicides, which caused these species to become dominant. It was demonstrated that when agro-ecosystems are continuously applied herbicides derived from symmetrical triazines and urea, resistant species such as *C. rotundus* and *R. exaltata* are increased and to structurally change that weed composition, it is recommended to establish rotations of crops, planting crops such as soybean, green beans or green manures (15,16).

Many of the species of these weeds that were presented at the beginning of the experiment did not appear at the end (*E. coli*, *B. extensive*, *P. hysterophorus*) this could be related to the presence of seeds in the soil or propagules that probably still it was in a state of latency and little competition would have stimulated the appearance of new species. This fact is important because, the conditions of monoculture at full sun exposure, favor the growth, development and permanence of other species of weeds that due to their aggressiveness could withstand these conditions (16). The coverage of the other monocotyledonous species, except for those that became dominant in the treatment of greater foliage and in a longer time (CATC), was around 10 %, considered low value (grade 2) (13,16).

## Production of dry weed biomass (g $m^{-2}$)

Table 4 presents the direct relation of abundance and production of dry biomass of the weeds (g $m^{-2}$) in the pepper culture.

**Table 4. Production of total dry biomass of weeds (g $m^{-2}$) in the different treatments**

| Treatments | Monocotyledons | Dycotiledonous | Total (g) |
|---|---|---|---|
| SA-20 | 19,62 | 67,16 | 86,78 |
| SA-30 | 12,55 | 25,5 | 38,05 |
| SA-40 | 25,6 | 12,7 | 38,3 |
| SA-50 | 16,2 | 12,8 | 29 |
| SA-60 | 16,4 | 8,25 | 24,65 |
| SA-70 | 1,10 | 4,70 | 5,8 |
| SATC | - | - | - |
| CA-20 | 8,04 | 10,1 | 18,14 |
| CA-30 | 19,27 | 17,29 | 36,56 |
| CA-40 | 11,57 | 29,46 | 41,03 |
| CA-50 | 37,95 | 15,38 | 53,33 |
| CA-60 | 26,55 | 76,73 | 103,28 |
| CA- 70 | 61,2 | 106,4 | 167,6 |
| CATC | 84,1 | 182,12 | 266,22 |

As can be seen, the dry biomass production reached total values higher than 2.5 t $ha^{-1}$ (266.22 g $m^{-2}$), of which 63.4 % corresponded to broad-leaved weeds (dicotyledonous); what supposes greater extraction of water and nutrients of the soil, in addition greater contribution for the production of biomass, easily degradable, having a C: N ratio much lower than the

monocotyledons, as some authors have proposed (17); therefore, the contribution of weeds to the system could be favorable.

However, for pepper production it is an obstacle, due to the competition established between them and the crop, which is why analysis by treatment can better express the advantages or disadvantages of its presence in the system, prior to the beginning of the economic damage to the crop.

The increase of the biomass in a period measured every 10 days after the 15 days of transplanted the crop, was always significant from the first measurement, reaching a weekly average increase higher than 0.1 t $ha^{-1}$ of dry biomass. The greatest increase occurred from CA treatment-70 days after transplanting the culture.

During the first three weeks, the increase in total biomass production showed proportionality with the time of stay of the weeds in their interspecific relationship with the crop. After that period, the production of biomass continued to increase notably reaching 266.22 g $m^{-2}$, perhaps due to a greater coincidence with the stage of higher rainfall, before a traditional spatial arrangement that does not cover the entire surface agricultural.

Periodic precipitations cause an increase in weed biomass; therefore, it is to be assumed that the spatial arrangement employed could favor such results.

If it is considered that for the pepper crop at the beginning of the critical period the dry biomass reached a value of 38.05 g $m^{-2}$ and that after the critical period the production reached a value of 103.28 g $m^{-2}$, it could be produce an important amount of dry biomass of weeds after the critical period and until the harvest that when incorporated into the soil would improve the physical and chemical properties of the same. On this subject, the use of weed biomass as an alternative to improve the physical properties of the soil is considered very useful (18).

### Variation of the yields (t $ha^{-1}$) with different periods of management of the weeds in the interspecific association with the cultivation of the pepper

Regularly the response of crops to the critical period of interspecific competition weeds-crops, has been presented historically in a figure superimposed with treatments of reverse management, seeking to coincide at a point, which has been called critical point, as noted (5) Thus, for years, there have been many similar investigations to this research, which is why the results are shown under these premises.

The information provided by the figure indicates that by maintaining the cultivated area with weed management during the whole cycle, competition actions were totally avoided, obtaining a yield of 12.4 t $ha^{-1}$. This production is equivalent to 100 % of the possible production to be obtained under these conditions, while the lowest production occurred in the treatment without weed management throughout the crop cycle, with yields of 0.5 t $ha^{-1}$; that is, a 4.0 % loss.

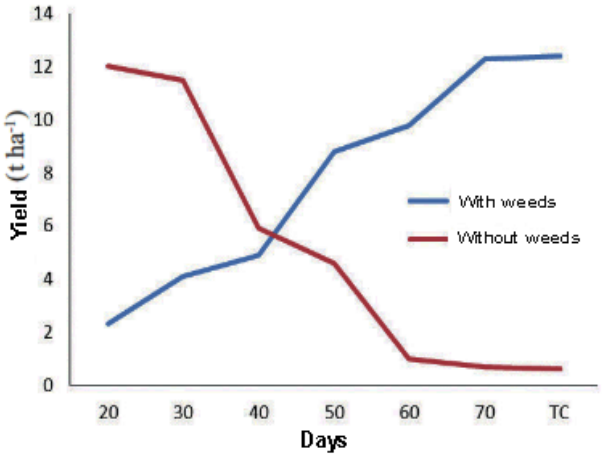


**Figure. Pepper yields (t $ha^{-1}$) in different periods with and without weed management**

In another investigation, it was reported that if the management of weeds is not carried out in a timely manner, there probably is no production (16); In addition, there are many examples of problems of reducing crop yields that indicate the great sensitivity of vegetables to the early competition of weeds and the need to control them in the early stages of growth.

In the cultivation of the transplanted pepper the weeds must be controlled between the second week to the third month after the transplant to prevent losses of 10% (16). Apparently some traditional techniques increase the competitiveness of the crop (eg, transplant, raised beds). Obviously, the weather conditions and density of weeds have a great influence on the duration of critical periods, since a cold wave that affects some vegetable crops can cause slow growth, greater competition and higher yield losses (7).

However, this period can vary by many factors; among them, the crop cycle, the population of dominant weeds, the cultural precedents, the type of management, the type of soil, the irrigation and the climatic conditions, among others (2,19), for that reason its determination by locality it constitutes an option to reduce losses in the production of this crop.

In the curve corresponding to the periods "with management of weeds until", it was observed that from 30 to 50 days after the transplant, it is defined as the essential time that the crop must be free of weeds, to prevent significant losses of the returns (4).

The treatment "without weed management until" showed that the yields were high until 30 days after the transplant, noticing from this date a decrease in yields. The lowest yields were obtained in treatments with weeds starting 60 days after planting (CA60, CA70 and CATC).

The opposite occurred in the treatments "with management of weeds until" in the different periods of competition, obtaining the lowest yields in "without weeds until" 30 days after the transplant of the crop (SA30) which reaffirms that, the pepper is very sensitive in the critical period; mainly due to the competition established in association with weeds by light, water and nutrients (16,20,21).

In the stages after the critical period, the weeds are significant only when there is a lack of water or nutrients, when the very aggressive weeds surpass the pepper and give it shade or have some allelopathic effect, which produce substances or secondary metabolites that damage the crop.

The treatments that were managed after 30 days of planting showed visible differences with respect to those that were managed after the critical period of competition; period during which, according to other authors, corresponds to the time in which the crop demands the most attention from the phytotechnical point of view (13,22,23).

## CONCLUSIONS

- The critical competition period for weeds in pepper cultivation is between 30 and 50 days after the transplant. Therefore, the measures of weed management should be extended for this period of time to avoid yield reductions.
- The dominant species in the agroecosystem are *C. rotundus, R exaltata*. and *P. oleraceae* which also have the largest number of specimens in the experiment, with 200, 180 and 150 respectively.
- In the dry biomass of the weeds there is greater production of the same in the treatments with weeds at 60 days, 70 days and the whole cycle of the crop, which was where the weeds remained the greatest amount of time, being the periods with greater clean times of infestation those that presented lower production of biomass.

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