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CONTEMPORARY INVESTIGATIONS ON COMPETITIVE RELATIONS BETWEEN MAIZE (*Zea mays L.*) AND WEEDS

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Abstract

Competition between weeds and crops in agro-ecosystems is important factor which leads to decreasing crop yield. From this point of view, the competitive relations between maize and weeds is one of the basic common problems in agricultural science and practice. This paper presents a detailed literature review of the factors influencing the competition between maize and weeds.

The competitive ability of the maize plants depends on sowing time, seed rate, row width, crop density, nutrient regime. Determining the critical period (CP) of weed competition can help us to minimize weed interference in maize. Several factors such a climate, genotype and cultural practices may influence the CP. The factors: weed species and density have negative influence on accumulation of maize biomass (fresh and dry), plant height, surface areas of the leaves, ear length, ear diameter, ear weight, ear rows, kernels per row, 100-grain weight, as a whole reduce maize grain yield.

Mathematical models have good possibilities to demonstrate presence of competitive relations between maize and weeds and also prognostic abilities. Therefore, accurate prognosis of the relative damage caused by weeds is one of the essential necessary preconditions for accomplishment of a rapid raise in the effectiveness and ecological conformity of maize production.

Key words: maize, weeds, competitive relations, factors influencing the competition, thresholds of damage, grain yield, mathematical models

FACTORS OF COMPETITION

Competition is the most widespread form of adverse interaction in agrophytocenoses. Maize is very sensitive to weed competition. The importance of weed competition in maize depends on factors: the crop growth stage, the degree of water and nutrient stress and the species and density of weeds (Simic and Stefanovic, 2008). Maize is very sensitive to this competition during the critical period between the V_3 and the V_8 stages (Olorunmaiye and Olorunmaiye, 2009). The competitive ability of the maize plants depends on the many factors, as: sowing time, seed rate, row width, crop density, nutrient regiment, crop rotation, climatic conditions.(Simic et al., 2006).

In this sense Otto et al. (2007) have studied maize sown in late winter (early sowing) and also later in (traditional sowing). The results showed that the early sowing date increase the importance of late winter early spring emerging weeds such as *Alopecurus myosuroides*, *Anagallis* sp., *Avena* sp., *Lamium* spp., *Matricaria chamomilla*, *Poa* spp., *Polygonum aviculare*, *Poligonum convolulus*, *Stellarria media*, *Veronica persica.* Early sowing extends the period for sowing and harvesting operation, on the other hand, early sowing lengthens the critical period reducing the efficacy of the pre- emergence herbicide and therefore requires weed control strategies to be adapted.

The seed rates have been used as important factor in the competition between maize and weeds. Maize sown with 5 seed rates (10, 20, 30, 40 and 50 kg/ha) show that plots sown with 40 kg/ha produced the maximum grain yield (3773 kg/ha) and number of plants/m^2 was less infested with weeds when compared to the other seed rates (Mohammad et al., 2006). It was investigated the effect of 4 row width (0.4, 0.6, 0.8 and 1.0 m) with the weeds *Brasica plantaginea* and *Euphorbia heterophyiia* (Bolbiton and Fleck, 2005) and 75, 65 and 55 cm with *Trinthema portulacastrum*, *Cyperus rotundrus* and *Echinochloa colonum* (Magbool et al., 2006) on the ability of crop to compete against weeds. Weed shoot dry matter, maize grain yield and yield components were evaluated. Maize dry matter decreased with reduced row width. Maize grain yield increased with row width reduction. The row spacing of 55 cm in maize is effective in suppressing weeds.

Increasing maize density (40 816, 50 124, 59 523, 69 886, 79 365, 89 286 and 98 522, plants/ha) reduced significantly ($P < 0.05$) the fresh weight of weeds. The highest total fresh weight of *Convolvulus arvensis* and *Sorgum halepense* was recorded in the lowest maize density. The leaf area index (LAI) closely indicated the effect of crop densities on maize development and weed suppression. Obtained results point out that maize density combined with application of irrigation can successfully increase the competitiveness of maize on weed infestation (Simic et al., 2003; Makarian et al., 2005; Stefanovic et al., 2005). The maize crop density directly affects good crop coverage and thereby the increase of its competitive abilities against weeds. Ertain maize genotypes differ to each other significantly in relation to their morphological properties and competitive abilities against weeds (Videnovic et al., 2007). Nitrogen (N) is the nutrient that is most often limiting in situation of crop-weed competition. Competition for nitrogen between corn (*Zea mays* L.) and weed is influenced by N amount and weed species (Blackshaw, 2004). The effect of different N levels and weed densities on biomass accumulation, height and leaf area for maize in weed species: *Amaranths retroflexus*, *Abutilon theophrasti*, *Setaria farberi* and *Chenopodium album* was investigated (Lehoczky and Reisinger, 2003; Berger et al., 2007). The objective of research done by Catheart and Swanton (2004) was to determine how N influences the growth and development of maize and to explore how *Setaria viridis* density effects this relationship. The N rates were ranging from 0 to 200 kg N ha^{-1} and *S. viridis* densities from 0 to 300 plants m^{-2}. Under weed-free conditions, a higher rates of N fertilizer increased maize leaf and grain N content, leaf area index (LAI), plant height and aboveground dry mater (DM) production, including kernel weight. In the presence of weed this maize parameters were reduced at each N level. Other authors have reported competition for nitrogen between corn and *Chenopodium album* and *Setaria viridis* (Mahmoodi and Swanton, 2005), and *Abutilon teophrasty* (Barker et al., 2006). At the low level of N, the weeds had low dry weight. During the early stages of growth, so they had no significant effect on corn when competing separately. Addition of nitrogen increasing maize and *A. theopharasty* height by a 15 and 68%, LAI by to 51 and 90%, biomass up to 68 and 89%, respectively. Maize yield declined with increasing weed interference at all levels of N addition. Maize yield loss due to *A. theopharasty* interference may increase with increasing N supply when weed emergence and early season growth are similar to that of maize.

Determining the critical period (CP) of weed competition can help us to minimize weed interference and to design the best weed management system. Several factors such as climate, genotype, cultural practices may influence the CP. Several studies have shown that narrower rows of higher maize population may lead to a shorter CP because of quicker canopy closure and higher crop competitive ability (Chachalis and Zanakis, 2005). It was found, that maize plants must be kept weed-free during the first 25 – 30 days, when weed competition is greatest. Permanent weed infestation resulted in a 90% maize yield loss (Villissana et al., 2004). Maize was sensitive to weed competition. The initial growth stage of maize (3-4 leaves) was tolerant to weeds. If weeds were removed after this growth stage there was no reduction in green matter yield. Weeds which germinated 10 days after maize emergence were established by the beginning of the maize growth period of maize and able to out compete maize. Weeds which germinated 20 days after maize emergence did not have any noticeable effect on maize green matter yield (Adzgauskiene, Jakstaite, 1997). The duration of the critical period lasted for a month from the 2-3 leaf growth stage of maize and did not depend on soil and crop management practices (Kumar and Sundari, 2003; Auskalniene, 2006). The critical period of weed control and competitiveness with late emergence weeds was similar between wide-row (97 cm) and narrow (48 cm) corn light interception did not differ between row width (Norsworthy and Olivera, 2004).

Many factors interacts in the determining the outcome of competition between maize and weeds. Weed species and population density is a major factor in inter-specific competitive relationship. In the contemporary investigations the effect of weed density was studied. The effect of *Amaranths retroflexus* densities 0, 2, 4, 6, 8, 12 plants m^2 (Talaproshti et al., 2005); 9.5 plants m^{-2} (Macarian et al., 2005) and 0, 2, 3, 5 plants m^{-2} (Habibi et al., 2005) on maize yield and it components were evaluated. Most of the parameters were significantly affected by *A. retroflexus* density. An increase in redroot pigweed density decrease maize biomass, ear-fill duration, ear diameter, ear weight, rows per ear, kernels per row, seed yield. However, 100 seed weight and harvest index were not significantly affected. The different *Amaranths dubius* densities significantly affected the maize crop performance, with the exception of weight of 100 grains. Yield losses due to *A. dubius* with respect to the control treatment were 9.1, 15.1, 24.9 and 45.9% for densities 1, 2, 4 and 8 *A. dubius* plants per linear meter, respectively. The results indicate that, a maximum density of 2 plants of *A. dubius* produce significant reductions in the yield of maize crop (Anzalone and Cruz, 2004). It was established the effects of maize density and time of emergence on *Eriochloa villosa* growth and seed production. Within time of emergence, *E. villosa* density did not affect seed biomass, however, seed mass of late emerging cohorts was less than that of early emerging cohorts. Time of weed emergence relative to the crop was a very important factor in determining biomass and seed production (Mickelson and Harvey, 1999). Plant height and grain yield of maize were not affected by low densities of *Cyperus rotundus*. The highest weed populations were 139 plants/m^2 which did not reduce the development or production of the crop (Salazar and Ortis, 1999). Interspecific competitive relations between maize and weeds were studied in the species: *Mimosa invisa* (Alabi et al., 2003); *Setaria glauca* (Clay et al., 2006); *Ambrosia trifida* (Harrison et al., 2004); *Solanum elaeagnifolium* (Baye and Bauhance, 2007); *Datura stramonium* (Cavero et al., 1999); *Xanthium strumarium* (Nakova et al., 2004); *Cirsium arvense* (Kazinczi et al., 2006). Authors found that growth parameters (height, surface areas of the lives, dry matter) of maize were affected by the presence of the weeds. The longer the duration of competition, the greater reduction in these parameters. Effect of weed density on the ear length, ear dry weight, grain number per ear, seed diameter and dry weight were significant (19 to 31%). Seed diameter reduction decreased 100 grain weight. Results showed density treatment highest effect on yield components. The same trend occurred for the grain yield which decreased as the density of weeds increased. For example the total grain yield reduced by 25, 30, 90, 64, 71, 52% in the weeds: *S. glauca*, *A. trifida*, *S. elaeagnifolium*, *D. stramonium*, *X. strumarium*, *C. arvense*, respectively. According to data of (Warner et al., 2004) maize silage yield is more sensitive than maize grain yield to *Abutilon theophrasti* interference. Competition effects of weeds *Xanthium strumarium* and *Datura* *stramonium* at densities (0.4, 8, 12 and 16 plants/m^2) on maize yield, yield components and various growth parameters was determined (Karimonjeni et al., 2009). Author found that, yield, grain number ear^{-1} and grain weight were affected more by *X. strumarium* than *D. stramonium*. *X. strumarium* could be explained by a reduction in grain number ear^{-1}, whereas a greater portion of the maize yield loss from *D. stramonium* was explained by a reduction in grain weight.

The position of the weed to respect of the crop row and therefore the intensity of interspecific competition at the beginning of crop cycle, could be a important factor in determining competitive relationship between species. *Xanthium strumarium* was strong competitior against maize crop in the two position (15 and 35 cm) from the crop row and the densities (5, 10, 20 plants m^2). The maize height, fresh weight, dry weight, and leaf area are concerning growth phases and densities were more suppressive in the weed arranged neareast to the crop. Yield loss of maize in two *X. strumarium* position increased when the distance between crop and weed decreased (Nakova et al., 2007).

Economic weed threshold (EWT) consist of the number of weeds affecting crop grain yield to justify the cost of their control. Weed threshold for *Datura stramonium*, *Brasica plantaginea*, *Amaranthus retroflexus*, *Chenopodium album* in maize were 1, 13, 3, 4 plants m^2, respectively (Oldjaca et al., 2000; Vidal et al., 2004; Fischer et al., 2004).

Weed density has been used as a important factor in determining the competitive relationship between species. It has been used as an explanatory variable for yield decrease forecast in many regression models. Bagestani et al. (2007) indicated that the negative effect of the relative time of *Chenopodium album* emergence on maize yield loss more than weed density, so that the rectangular hyperbolic maize yield loss model based on weed density was more capable at predicting yield loss at each of weed emergence time. The same trend in the maize are reported for: *Abutilon theophrasti*, *Xanthium strumarium*, *Datura* spp., *Sorghum halepense*, *Echinochloa crus-galli* (Donald and Richa, 1999; Stoimenova and Alexieva, 2003; Dorado et al., 2008). Masin et al. (2010) validated a model relating yield loss to weed time of emergence and removal in traditional and early sown maize in support of the idea that the model is robust enough to be used a prediction tool for forecasting yield losses in a variety of conditions created by different sowing dates. The weeds were less competitive when maize is sown earlier.

Allelopaty is a natural phenomenon that refers to any direct or indirect positive or negative of one plant on another through the release of chemical compounds excreted into the environment (Delabys et al., 2004). According to data of Soufan et al. (2007) were studied allelopathic effects of root foliage and seed extracts of the three species of weeds: *Convolvulus arvensis*, *Cyperus rotundus* and *Sorghum halepense* on germination and growth of maize (*Zea mays*). The results revealed that the extracts of all plant studies inhibited either the germination the shoot length or the fresh weight of maize. They had also simulatory or inhibitory effects on dry weight of maize. In general the variable effects are related to the weed species, plant part and extract concentrations. Sorgaab can be used as a natural weed inhibitor in maize (Chcema et al., 2004). Many studies were investigated to know of common weeds on germination and seedling vigor on maize (Casini et al., 2004; Kayode, 2004; Peneva, 2005; Peneva, 2006). Allelopatic potentials of maize was low (reduction of dry mass/m^2) in the weed species: *Eleusine indica*, *Portulaca oleracea*, *Sorghum halepense*, *Cyperus rotundus*. The results support the use of maize plants within a weed management program in order to reduce weed population without chemical herbicides (Casillo, 2005).

It has done detailed literature review of the contemporary investigations on competitive relations between maize and weeds shows, that knowledge in this area are very important in choosing the best weed control strategy. Disclosure of basic regularities in relationship maize/weed will lead to ecologically and economically acquitted weed control in this crop. Clarifying of these issues is a priority for the science and practice of growing maize.

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Съвременни проучвания върху конкурентните взаимоотношения между царевица и плевели

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Резюме

Конкуренцията между плевели и култури в агро-екосистемите е важен фактор, който води до намаляване на добива от културните растения. От тази гледна точка конкурентното взаимодействие между царевица и плевели е един от основните проблеми в земеделската наука и практика.

В представената разработка е направен обстоен литературен преглед на факторите, влияещи върху конкурентните взаимоотношения между царевица и плевели.

Конкурентоспособността на царевичните растения зависи от срока на сеитба, сеитбената норма, ширината на реда, гъстотата на посева, хранителния режим. Установяването на критичния период на плевелна конкуренция може да помогне за намаляване на плевелното влияние при царевицата. Някои фактори като климат, генотип и агротехнически мероприятия могат да повлияят критическия период на конкуренция. Факторите плевелни видове и плътност имат негативно влияние върху акумулиране на биомасата на царевицата (свежа и суха), височината, листната повърхност на листата, дължината на кочана, диаметъра, теглото, броя на редовете, зърната в един ред, теглото на 100 зърна и като цяло – намаляване на добива от зърно при царевицата. Математическите модели имат добри възможности за доказване наличието на конкурентни взаимоотношения между царевица и плевели, а така също и прогностични способности. Ето защо точното прогнозиране на относителната вредност на плевелите е една от основните предпоставки за рязко повишаване ефективността и екологосъобразността при производството на царевица.