

Competition between maize and *Xanthium strumarium* L.

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SUMMARY

Interference between maize (*Zea mays* L. cv. Kneja 605) and *Xanthium strumarium* L. was studied in the experimental field of the Plant Protection Institute, Kostinbrod, in 2002 and 2003. Experimental design was a randomized block with four replicates. Infestation was artificially created and the weed density range was 0, 5, 15 and 25 plants/m in maize rows during the crop cycle. Maize height, fresh weight, dry weight and leaf area were determined at the 4-5 leaf growth stage. Influence on maize grain yield was also established.

The results showed a high competitiveness of *X. strumarium* with maize. *Xanthium strumarium* density has an economically and statistically significant impact on the maize characteristics studied. The impact goes in the following direction – an increase in *X. strumarium* density causes a highly significant decrease in maize height, fresh weight, dry weight and leaf area at the 4-5 leaf growth stage, as well as maize yield. The highest decrease in these morphological and productive properties of maize was in the variant of *X. strumarium* 25 plants/m. Weed density is a key factor in determining the relationship between maize and *X. strumarium*. Statistical regression models may prove applicable in predicting a damage caused to maize grain yield through competition with *X. strumarium*.

Key words: Competition; Density; Maize; *Xanthium strumarium*; Growth parameters; Grain yield; Regression models

INTRODUCTION

Xanthium strumarium L. is a weed species found in maize (*Zea mays* L.) fields in Bulgaria and many other parts of the world. Its significance as a weed in this crop is increasing across the Balkan area, probably due to difficulties in its chemical control.

Competition with *X. strumarium* has been studied for bean (*Phaseolus vulgaris*) (Nakova, 2004) and soyabean (*Glycine max*) (Geddis et al., 1989).

Increased *X. strumarium* densities in these crops were found to decrease crop height, fresh weight, dry weight, leaf area and seed yield. Berti and Satin (1996) reported a role of the *X. strumarium* position relating to crop rows in determining the crop yield/weed density relationship in soyabean. It was established that weed position was important for the relationship between yield loss and weed density.

The influence of weeds on maize growth and yield has been evaluated in several studies, showing the severity of yield reduction as being dependent on weed species and their respective densities (Young et al., 1994; Beckett et al., 1998).

Cavero et al. (1999) have studied the competition between maize and *Datura stramonium* L. The density of weed plants was 8.33 per m. Maize yield decreased by 14–63% when competing with *D. stramonium*. Yield reduction increased as the time between the crop and weed emergence shortened. Other authors have reported interference between maize and *D. stramonium* density (0, 1, 3, 6 and 10 plants per m) within and between maize rows. An increase in weed densities significantly reduced plant height, dry biomass per plant, leaf area index and grain yield per maize plant. The greatest decrease in the productivity of maize and the weed itself was in the variant: *D. stramonium* in rows, 10 plants/m. A maximum yield loss of 37% was found in the same variant. Weed threshold for *D. stramonium* in maize was one weed plant per m² between rows (Oljača et al., 2000). An economical threshold level for chemical control was 5.5 plants per m when *D. stramonium* competed with a spring-sown maize crop but this threshold decreased to one plant per m for a late-sown maize crop (Zanin et al., 1994).

Weed density has been used as an important factor in determining the competitive relationship between species. It has been used as an explanatory variable for yield decrease forecasts in many regression models (Cousens, 1985). Kropff and Spitters (1991); and Kropff and Weaver (1992) developed an empirical model that accounted for the effects of weed density and relative time of emergence.

The objective of this study was to evaluate: (1) the effect of *X. strumarium* densities on maize growth parameters (4–5 leaf growth stage) and grain yield, and (2) a model for predicting decreases in those explanatory variables.

MATERIAL AND METHODS

Experimental locations

Field trials were carried out on a chernozem smonitza soil (pH= 6.2 and 9.6% organic mater)

at the Plant Protection Institute, Kostinbrod, in 2002 and 2003. Both experiments consisted of four replicates in a randomized block design. The plots were 2.80 m wide (four crop rows) and 5 m long. The species studied were: crop – maize (*Zea mays* cv. Kneja 605), and weed – *Xanthium strumarium* L. (dicotyledone). The duration of competition between the maize crop and the weed, and the effect of *X. strumarium* densities were established during the crop cycle.

Experimental procedures

The crop was hand sown 5 cm into soil depth at 16.6/m density in both years and in rows 70 cm apart. *Xanthium strumarium* was hand sown within maize rows the same day. The desired weed densities (0, 5, 15 and 25 plants/m) were obtained by hand weeding within one week after the emergence. The dates of maize and weed emergence (80% of total emergence) in the stand in both years were uniform. Late emerging plants, all other weeds and subsequent flushes of *X. strumarium* were removed by hand on a weekly schedule.

The following growth parameters were determined at the 4–5 leaf growth stage of the maize crop: height, fresh weight, dry weight and leaf area (per plant). A total of 16 maize plants were sampled from each treatment depending on the initial weed density per plot. Leaf area was measured by LI-CORLI-3100 leaf meter. Maize plants were harvested by hand from the outer to central rows of each plot for determination of grain yield.

Statistical analysis

The regression and linear regression analyses were employed using the statistical program SAS (SAS Version 5.0, SAS Institute Cary, USA). The interdependence between *X. strumarium* densities and maize height, fresh weight, dry weight, leaf area and grain yield is summarized by the coefficient of determination (r). The regression model was characterized by the equation $y=a-bx$, where a is the initial value of y at $x=0$, and b the proportionality (regression coefficient). The regression line graphically depicted the relation. *Xanthium strumarium* density was

an independent variable (x). Maize height, fresh weight, dry weight, leaf area and grain yield were represented on the graph as a dependent variable (y). All graphs are based on the average data for the 2002-2003 period.

RESULTS AND DISCUSSION

The results show (Fig.1) that *X. strumarium* density had negative effect on maize growth parameters at the 4-5 leaf growth stage and grain yield. The highest values of the morphological properties of maize were recorded in the maize monoculture variant (0 plants of *X. strumarium*). Higher weed densities (5, 15 and 25 plants/m)

decreased maize height by 12.1, 24.3 and 59.6 cm, respectively, compared with the control variant. Maize fresh and dry weight decreases under the studied weed densities were 83.3-167.9 and 15.5-19.8 g, respectively. Regarding the leaf area parameter, the greatest effect had the density of 25 weed plants. The decrease in this case was 884.5 per cm in comparison with the variant of 0 weed plants/m. The weed presence at 5, 15 and 25 plants/m rate reduced maize production in both years by 1917.5 kg/ha, 2970.0 kg/ha and 3942.3 kg/ha, respectively, compared with the variant of maize monoculture (0 weed plants/m).

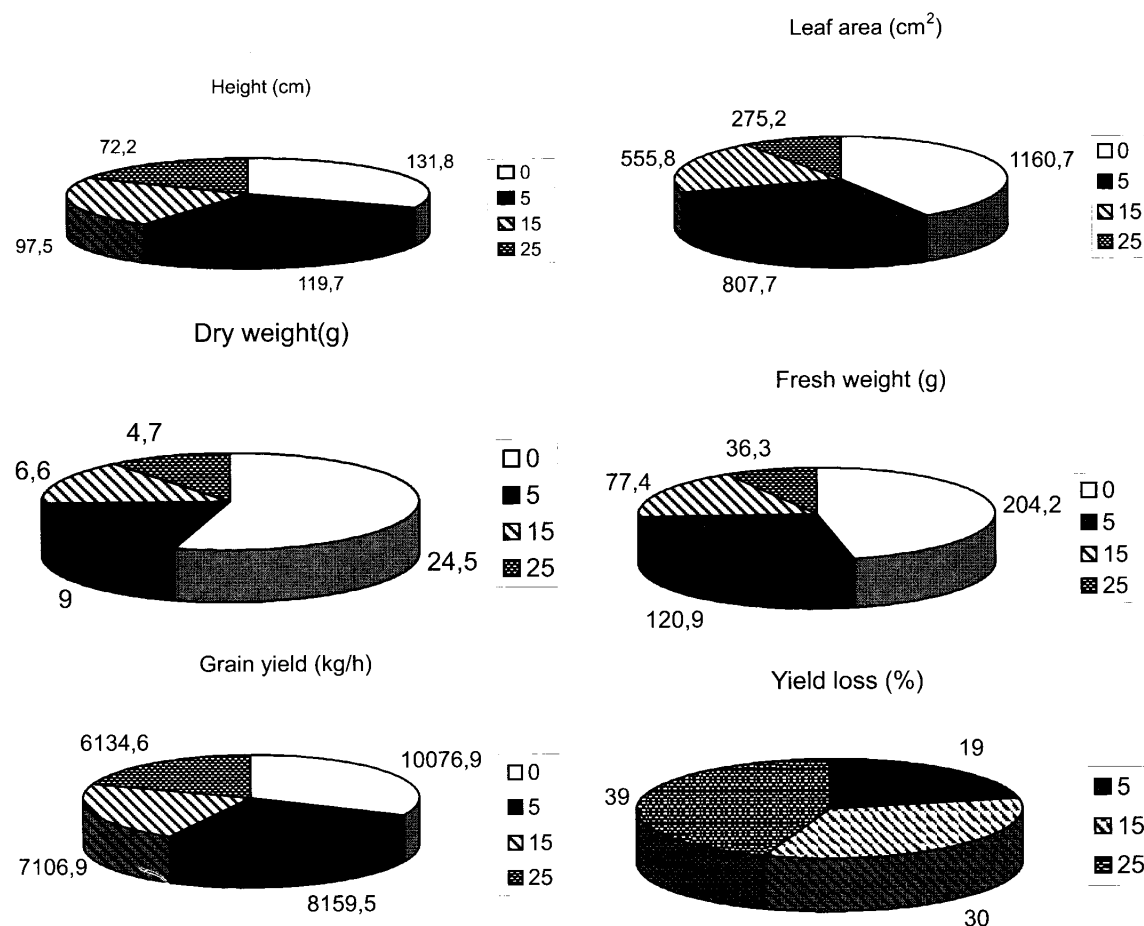


Fig. 1. Morphological (4-5 leaf growth stage) and productive properties of maize in monoculture and in association with *Xanthium strumarium*

Sl. 1. Morfološke i produktivne osobine kukuruza (u fazi 4-5 listova) u monokulturi i u zajednici sa *Xanthium strumarium*

The relationships between the maize parameters at the 4-5 leaf growth stage and grain yield, and *X. strumarium* density were highly significant ($P < 0.05$). The coefficients of determina-

tion (r) between maize height, fresh weight, dry weight, leaf area and grain yield, and the weed densities were high, ranging from -0.94 to -0.99 (Fig. 2 & 3).

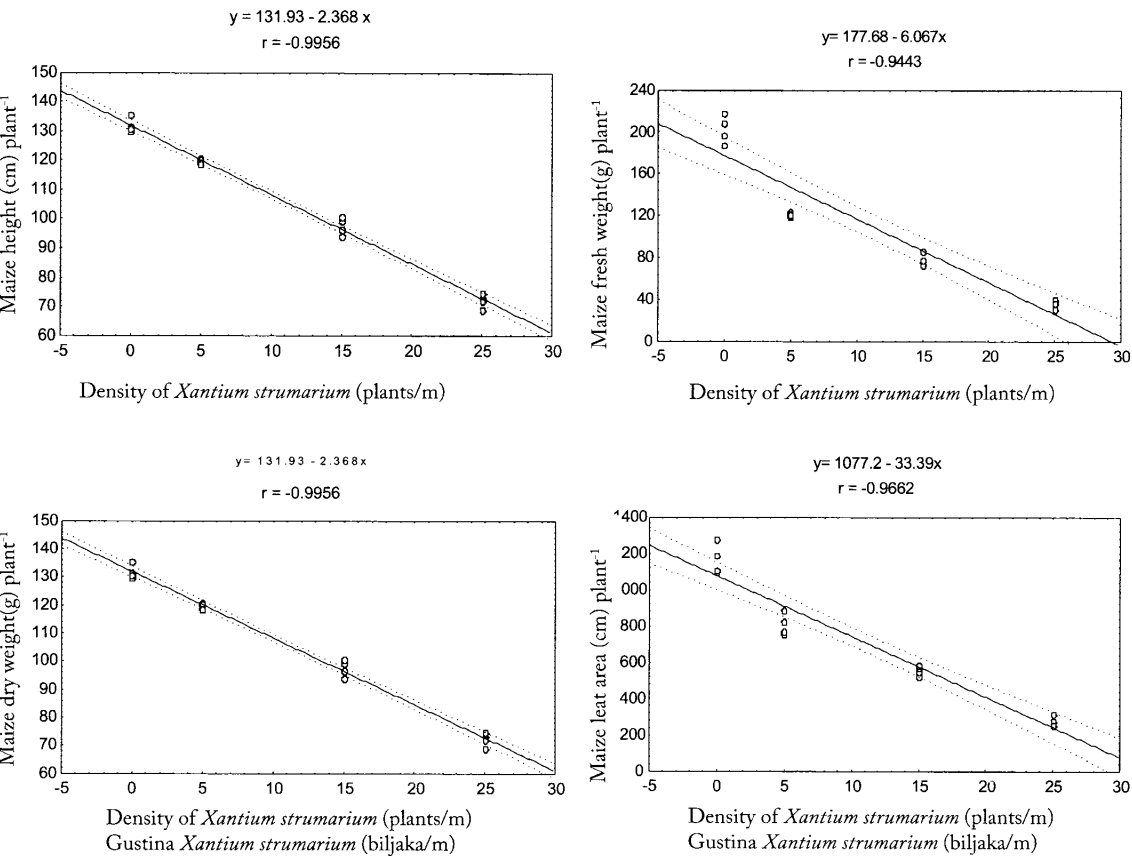


Fig. 2. Relationship between maize height, fresh weight, dry weight, leaf area at the 4-5 leaf growth stage and *Xanthium strumarium* density

Sl. 2. Odnos između visine kukuruza, sveže mase, suve mase, površine lista u fazi 4-5 listova i gustine *Xanthium strumarium*

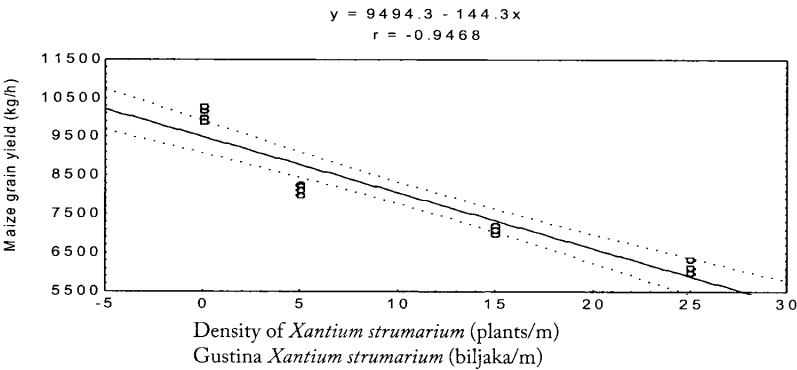


Fig. 3. Relationship between maize grain yield and *Xanthium strumarium* density

Sl. 3. Odnos između prinosa zrna kukuruza i gustine korovske vrste *Xanthium strumarium*

The results showed that the competitive effect on maize depends on the density of *X. strumarium*. Maize height, fresh weight, dry weight and leaf area at the early growth stage significantly decreased under the increasing weed densities. Other authors have shown that weed densities may have greater effects on maize growth parameters at the 4–6 leaf growth stage (Rambakudzibga and Makanganise, 2002). Their results showed that even a small number of *Eleusine indica* (5 plants/m) had a significant effect on maize. A density of up to 10 plants/m had almost similar effect, while higher densities of *E. indica* had greater effect. The studied densities and the dependent variables exhibited a negative correlation. The correlation coefficients (r) between *X. strumarium* density and each maize growth parameter were very high. They confirm the most possible effect of weed density on the studied indexes, determining interspecies competitive relations with *X. strumarium*. This study shows that weed density is a major factor in governing maize growth and development. A negative effect of *X. strumarium* on maize characteristics was established.

Maize grain yield was strongly influenced by *X. strumarium* density in both years. The results for 2002 and 2003 suggest a possible interactive effect of different weed densities on the maize grain yield. Yield loss was effected at each density of *X. strumarium*, and it was a function of weed density. Grain yield was significantly decreased in all experiments by the increasing densities of *X. strumarium*, and the weed is consequently considered to be a strong competitor. *Chenopodium album* and *Amaranthus retroflexus* have been found to cause similar reductions in maize grain yield (Zimdahl, 2000). Mrtskas and Tsolis (2002) found a maximum maize yield loss of 21% when the crop grew together with *Sorghum halepense* at 6 plant/m density from the seeds.

The density of *X. strumarium* has economically and statistically significant impact on the plant characteristics studied. The impact goes in the following direction – increase in *X. strumarium* density causes a highly significant decrease in maize height, fresh weight, dry weight, leaf area at 4–5 leaf growth stage and grain yield.

The regression models describe accurately the average relationship between weed densities, and maize parameters at the early growth stage and grain yield. They confirm the study hypothesis of competition existing between maize and *X. strumarium* considering the studied indexes. The effect of weed densities on maize growth and yield was predicted by the equation. The regression lines show dependence of the parameters when there is no influence of another factor. The observed values of the dependent variables – i.e. height, fresh weight, dry weight, leaf area and maize grain yield – are very close or in some instances fit exactly on the regression line. The factors unconnected with the number of *X. strumarium* plants have negligible influence on maize. This statistical regression model may have practical value, e.g. in predicting damage threshold for a specific weed/crop competition.

The results of the study contribute to a better understanding of the effects of weed densities on grain yield in maize. In a competitive situation, growing weed densities increasingly depress maize growth. The effect was similar regarding maize grain yield. The density of *X. strumarium* influences the intensity of interspecies competition with maize, and was a key factor in interference between the species.

Competition between *X. strumarium* and maize was found in this study to be sufficient to reduce the growth parameters and grain yield. Thence, control measures against this weed species need to be implemented early in the growing season to minimize crop yield losses. Additional research is required to develop management strategies for this increasingly prevalent weed in annual cropping systems.

The density of *X. strumarium* is a major factor governing maize growth, development and grain yield. *Xanthium strumarium* suppression abilities were found evident at the densities of 5, 15 and 25 plants/m. A negative correlation was established between the number of *X. strumarium* plants and the maize growth parameters at the 4–5 leaf stage and grain production. The increase in weed density from 5 to 25 plants/m decreased the height, fresh weight, dry weight, leaf area and grain yield of maize. Competition between maize and *X. strumarium* was found to depend on the weed density.

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Kompeticija između kukuruza i korovske vrste (*Xanthium strumarium* L.)

REZIME

Kompetitivni odnosi između kukuruza (*Zea mays* L. cv. Kneja 605) i čička (*Xanthium strumarium* L.) ispitivani su u poljskom eksperimentu Instituta za zaštitu bilja, Kostinbrod, tokom 2002. i 2003. godine. Ogled je postavljen po potpuno slučajnom blok sistemu, u četiri ponavljanja. Eksperimentalni dizajn je organizovan u četiri varijante, i to: 5, 15 i 25 biljaka po metru dužnom u redu kukuruza i varijanta bez korova. Kad je kukuruz bio u fazi 4 - 5 listova merena je visina biljaka, sveža i suva masa i površina lista. Na kraju sezone meren je i prinos zrna kukuruza.

Dobijeni rezultati pokazali su da postoji visok stepen kompeticije između čička i kukuruza pri zadatim gustinama. Dakle, kompetitivni pritisak između čička i kukuruza praćen kroz visinu, svežu i suhu masu, i površinu lista kukuruza potvrđen je preko ekonomskih i statističkih pokazatelja. Sa povećanjem broja biljaka *X. strumarium* po metru dužnom dobijane su niže vrednosti za sve merene parametre kao i niži prinos zrna kukuruza na kraju vegetacione sezone. Najveći stepen inhibicije merenih morfoloških karakteristika, kao i prinosa dobijen je u varijanti sa 25 biljaka po dužnom metru.

Potvrđeno je da je gustina korova ključni faktor u utvrđivanju kompetitivnih odnosa između kukuruza i korovske vrste *X. strumarium*. Regresioni model može poslužiti u predviđanju šteta tj. smanjenje prinosa useva kukuruza uzrokovanim kompeticijom sa vrstom *X. strumarium*.

Ključne reči: Kompeticija; gustina; kukuruz; *Xanthium strumarium*; parametri rastenja; prinos zrna; regresioni modeli