INTERFERENCE BETWEEN *ECHINOCHLOA CRUSS-GALLI* AND SOYBEAN

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Summary:
The competitive interactions between Soybean (*Glicine max*) and *Echinochloa cruss-galli* have been studied, taking into consideration various factors. The effect of degree and duration of infestation as well as the influence of some meteorological elements on the soybean yield are analysed. The relationships between *E. cruss-galli* infestation and soybean yield are described using several models. The factors with main effect on the yield are determined.

INTRODUCTION

As a simplified biosystem, the agrophytocenose is described with a mobil equilibrium, which can be kept only by virtue of the interference of a man. The agriculture's improvement presupposes simplification of the agrophytocenoses with an ultimate aim - cultivation of plants as a pure stand, without weeds. This calls for obligatory regulation of the interaction between the cultivated plants and the weeds. The problem of effective weed control as one of the main technological and economic factors of productivity has a basic significance. Many authors have studied the competitive relationships between soybean and various kinds of weeds. The investigations of Nave and Wax/1971/ show that the annual dicotyledonous weeds compared to the annual cereals affect more negatively the soybean yield. These results are contrary to the study of Orwisk and Schreiber /1979/. In their opinion *Setaria viridis*/var. *Robusta alba* or *R. purpurea*/ causes larger losses in comparison with *Amaranthus retroflexus* under identical conditions/density and length of weed infestation. According to Rathman and Miller /1981/ the wild oats infestation in soybean fields at density 3, 9 and 30 plants/m^2, results in soybean yield losses respectively 25, 42 and 47%.

The aim of this paper is to analyse the competition relations between soybean and *Echinochloa cruss-galli*, depending on the length and density of infestation as well as on the climatic conditions.

METHODS AND MATERIALS

Series of field trials were conducted at the research station of Puchkarov Institute - Kostinbrod/region of Sofia/ on pelic vertisols between 1988-1990. The trials were made in a wheat-soy-bean crop-rotation pair after the perpendicular method of sowing in 4 replications with plot size 10 m^2 applying the scheme :

Factor A - degree/density/ of *E. cruss-galli* infestation in soybean field -, number/m^2: a1 - without weeds; a2 - 5 weed plants; a3 - 10 weed plants; a4 - 15 and a5 - 20 weed plants/m^2.

Factor B - length/duration/ of *E. cruss galli* infestation of the soybean field: b1 - from soybean emergence to anthesis; b2 - from soybean emergence to pod formation; b3 - from emergence to milky ripeness and b4 - from soybean emergence to physiological ripeness, i.e. the entire growing period. After recording weed infestation in the treatments b1, b2 and b3 the field was kept free of weeds until the end of vegetation.

The soybean field was not irrigated, phosphorus fertilizer was applied at a dose of 120 kg/ha P_2O_5 during the main soil ploughing in the autumn, nitrogen - at a rate 80 kg/ha N with the last pre-sowing cultivation. Before sowing, the seeds were inoculated with *Bradyrhizolium japonicum*, strain 273. The soybean cultivar Hudson was sown between May 9 and 15. Soybean crop density was 350,000 plants/ha spaced 70 cm between the rows. Weed plant density per m^2 was maintained by daily weeding out of all surplus weeds.

In all treatments of the trial the accumulation of fresh and dry biomass was followed up in kg/ha. The influence of weed infestation on the soybean yield from 5 m^2 in 4 replicates per treatment was determined. The following meteorological elements were accounted: quantity and distribution of rainfall; sum of the effective temperatures / sum of temperature above the biological minimum minus the biological minimum (10°C for soybean); number of days, during the different phenological stages of soybean development, with relative humidity below 40%. The models were fitted to the experimental data using the STATGRAPH statistical programs.

RESULTS AND DISCUSSION

The values of soybean yield and of *E. cruss-galli* dry biomass from the treatments a2b1, a2b2, a2b3 and a2b4 between 1988-1990 are represented in Fig.1. The yield from the control treatment without weeds /a1/ is also shown. The soybean yield from all treatments with weeds in comparison with the control treatment is strongly decreased, excepting the values in 1988 from emergence to anthesis. The reason for comparatively equal values of soybean yield from a2b1 and this from the control treatment in 1988 is due to the small quality of dry biomass of *E. cruss galli* / 320.8 kg/ha while in the next two years it is 440.8 and 650.9 kg/ha respectively. The poor growth of the weed from emergence to anthesis in 1988 can be explained with the value of the amount of effective temperatures /fig.3/. It is well known that *E. cruss-galli* is highly thermophilic/Fetfadjieva, 1990. The coefficient of correlation between amount of effective temperatures and dry matter of *E. cruss galli* for the same period varies between 0.83-0.98.

In 1988 with prolonging the period of infestation from emergence to pod formation, milky ripeness and botanical ripeness the density of 5 weed plants per m^2 causes large yield losses regardless of the meteorological parameters. Most significant are differences between soybean yield in the control and this in the treatments with 5 weed plants during all periods of infestation in 1990. It is described as a year with lowest amount of precipitation during the growing period /174.9 mm/ in conjunction with comparatively high sum of effective temperatures /1014, 6°C and many in numbers days with relative humidity below 40% /29/ - unfavourable climatic conditions, especially during the critical for soybean phenological phases. *E. cruss galli* grows faster and accumulates a large quantity of biomass/fresh and dry - fig. 1,2. As a result of that, the competitive power of soybean decreases and the negative effect of the weed on the yield increases. And vice versa - in years with favourable climatic conditions for soybean growth, the competitive ability of the plant increases, *E. cruss-galli* accumulates a small quantity of biomass and it's negative effect on the yield is relatively slightly expressed.

It is clear from fig. 4 that at weed density 15 plant/m^2 the soybean yield of all treatments is lower than the yield of the control treatment / at zero level of infestation. The main reason is the accumulation of great quantities of biomass by the weed. Compared to the treatments at density 5 p/m^2 the weight of fresh and dry biomass of *E. cruss-galli* is respectively 1.89-2.65 and 1.97-2.74 fold higher at the early stage of emergence to anthesis. In this connection 1990 is also the year with strongly expressed negative effect of weed infestation on the soybean yield, mainly as a result of the combination of unfavourable meteorological conditions for the growth of soybean.

The influence of *E. cruss-galli* on the soybean yield at density 10 and 20 plants/m^2 is similar.

The statistical analysis of data shows close correlation between the quantity of soybean yield and all those factors, which influence the competitive relationships between the plants: density/degree/ of the weed; quantity and distribution of rainfall during growing period; length of the inter stage periods and length of growing period; sum of effective temperatures. There is a negative correlation between soybean yield and the quantity of fresh and dry biomass of the weed - r varies respectively from -0.641 to -0.666 and from -0.698 to -0.912. These dependencies are closer in years with low precipitation. The correlation analysis of the yield and amount of rainfall during the phenological phases of two plants, is also of interest. In case of infestation from emergence to anthesis of soybean and quantity of precipitation from 100.4 to 164 mm for the same period, the soybean yield in the variant with 5 weeds per m2 does not depend on rainfall. But with increasing of weed density to 10, 15 and 20 plants/m^2, the yield is directly proportional to the quantity of this meteorological element - r varies within the range of 0.841 to 0.954. This indicates that at high degree of infestation, the soybean plant needs more moisture/rainfall, irrigation/even at early stages of it's development. Almost the same are the results from correlation analysis of the soybean yield and the length of infestation. At weed infestation from emergence to anthesis the yield is negatively correlated with duration of infestation. This is most clearly expressed at density 20 plants/m^2 /r - -0.841/ and mainly at pod formation - r - 0.923.

The results from the correlation analysis give an opportunity to distinguish the factors which have to be used in the model of the soybean yield. The aim of modelling is to determine the value of yield at different lengths and degrees of weed infestation, depending on the factors with a proved effect:

a - length / duration / of weed infestation from the beginning of growing period to the setting in of the relevant phenological stage of soybean / days.
b - sum of the effective air temperatures for the same period /°C/
c - fresh biomass of *E. cruss-galli* /kg/ha/
d - dry biomass of *E. cruss-galli* /kg/ha/
e - fresh biomass of soybean /kg/ha/
f - dry biomass of soybean /kg/ha/

For the period emergence-anthesis at a degree of weed infestation 5 plants/m^2 /1/; 10 plants /m^2 /2/; 15 plants /m2 /3/ and 20 plants/m2 /4/ the following multiple regressions are valid:

/1/ $Y = -752.10 + 22.30a - 0.94b - 0.21c + 0.18d + 0.21f$ $R^2 = 0.85$

/2/ $Y = 664.69 + 9.95a - 0.16b - 0.27c + 1.04d + 0.56e + 3.19f$ $R^2 = 0.85$

/3/ $Y = -598.55 + 6.47a - 0.9b - 1.33c + 7.61d + 0.7e + 3.42f$ $R^2 = 0.58$

/4/ $Y = 204.89 + 0.14b - 0.02c - 0.32d + 0.11e + 0.22f$ $R^2 = 0.74$

From emergence to pod formation the effect of the above mentioned factors on soybean yield can be expressed as:

/1/ $Y = 9.55 + 4.26a - 0.42b - 0.19c + 1.33d + 0.17e - 0.54f$ $R^2 = 0.58$

/2/ $Y = 51.35 + 3.56a - 0.64b - 0.1c + 0.51d + 0.35e - 0.28f$ $R^2 = 0.79$

/3/ $Y = 203.36 + 0.38a - 0.05b - 0.07c + 0.06d + 0.04e - 0.32f$ $R^2 = 0.46$

/4/ $Y = 542.52 + 0.32b - 0.48c - 0.7d + 2.21e + 8.26f$ $R^2 = 0.95$

The highest coefficients of determination are estimated for the period from emergence to milky ripeness:

/1/ $Y = 59.09 + 6.44a - 0.81b - 1.98c + 6.66d + 0.003e + 0.03f$ $R^2 = 0.86$

/2/ $Y = 786.04 - 1.21a - 0.39b - 0.04c + 0.34d + 0.09e + 0.11f$ $R^2 = 0.88$

/3/ $Y = 436.7 - 7.52a - 0.44b - 0.05c + 0.39d + 0.15e + 0.1f$ $R^2 = 0.86$

/4/ $Y = 76168.9 - 616.09a - 169.18b - 0.08c + 1.54d + 3.22e + 9.0f$ $R^2 = 0.99$

CONCLUSIONS

The negative influence of *E. cruss-galli* on the soybean yield depends on the degree, duration of weed infestation and meteorological conditions. During years with favourable for crop growth meteorological conditions, the competitive ability of the crop increases, *E. cruss-galli* accumulates lower biomass and the negative effect of the weed is relatively slightly expressed.

Factors with highest influence on the competitive interrelations between soybean and *E. cruss-galli* are : quantity of accumulated fresh and dry biomass of the weed; duration of the period of infestation and amount of the effective temperatures. The soybean plant is most sensitive to *E. cruss-galli* during the period emergence - anthesis. Competitive ability of the weed depends to the great extent on the sum of effective air temperatures, especially in the period emergence - pod formation. For the same period the coefficient of correlation between the sum of effective temperatures and the quantity of accumulated dry matter of Echinochloa is in the range of 0.83 to 0.98.

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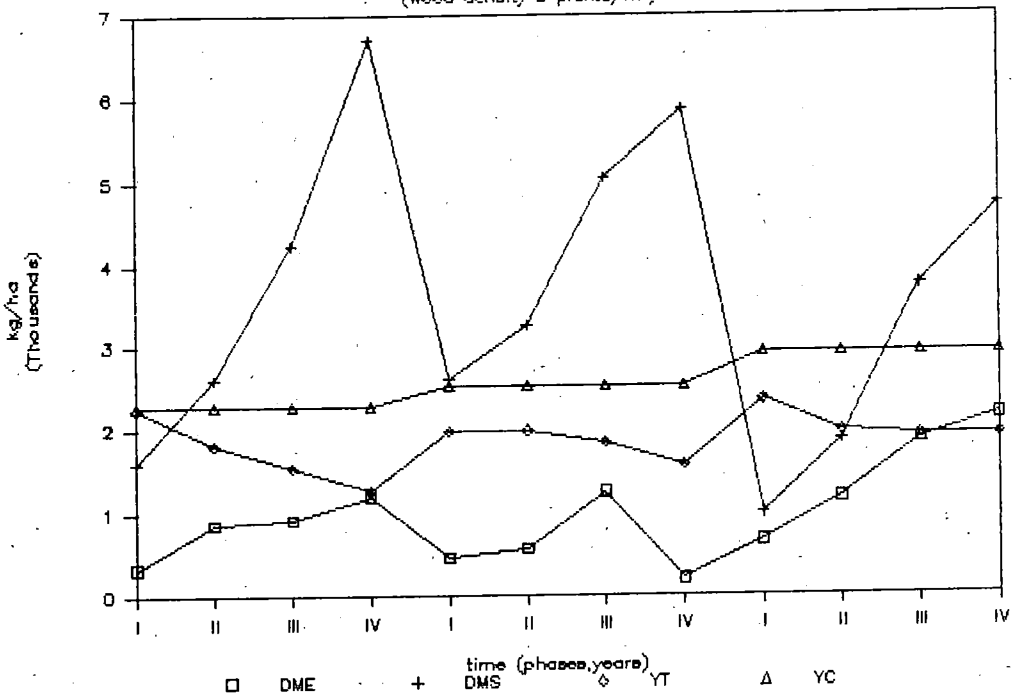
Fig.1 Dry matter accumulation and yield

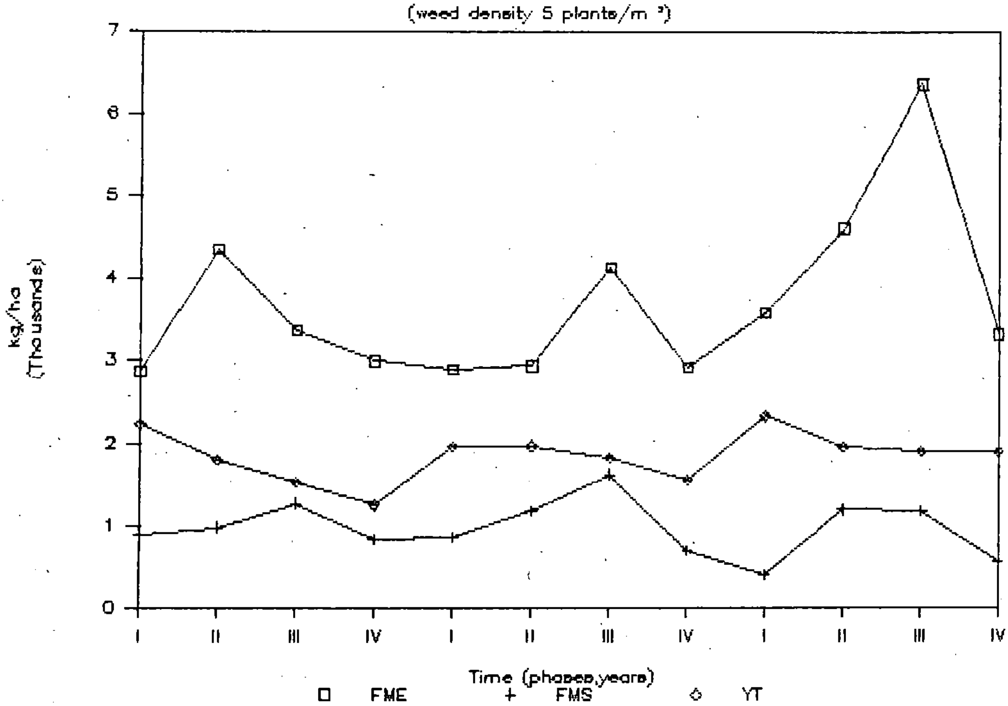
(weed density 5 plants/m²)



DME – dry matter of E. cruss galli
DMS – dry matter of soybean
YT – soybean yield in the variants with E. cruss galli
Yc – soybean yield in the control variant

Fig.2 Fresh matter accumulation

(weed density 5 plants/m ²)

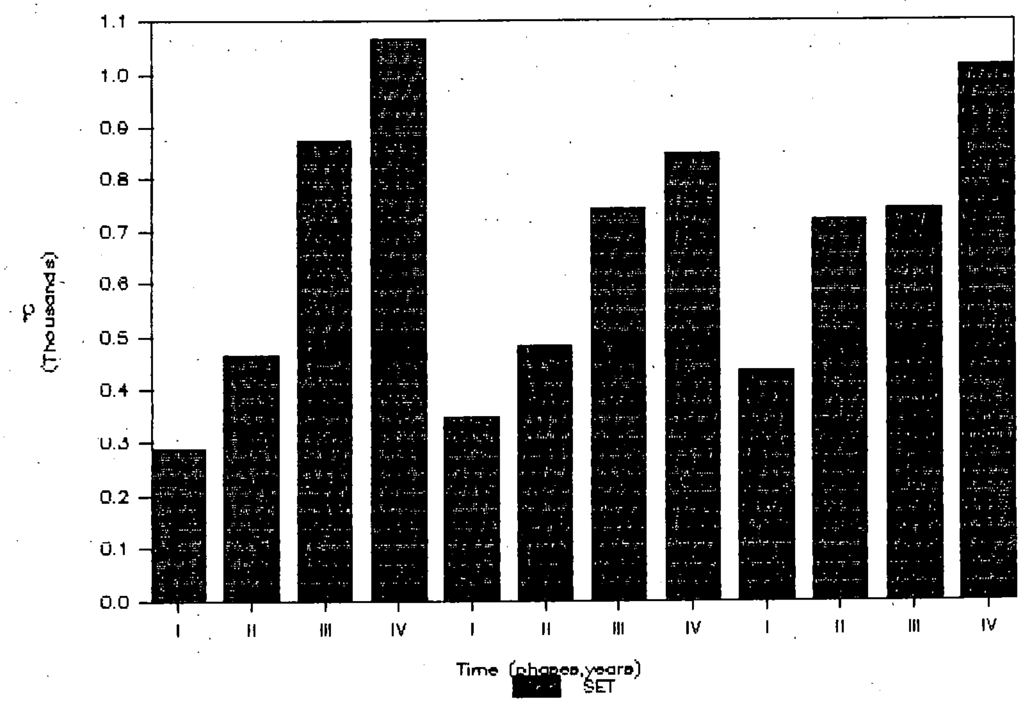


FME - fresh matter of E. cruss galli

FMS - fresh matter of soybean

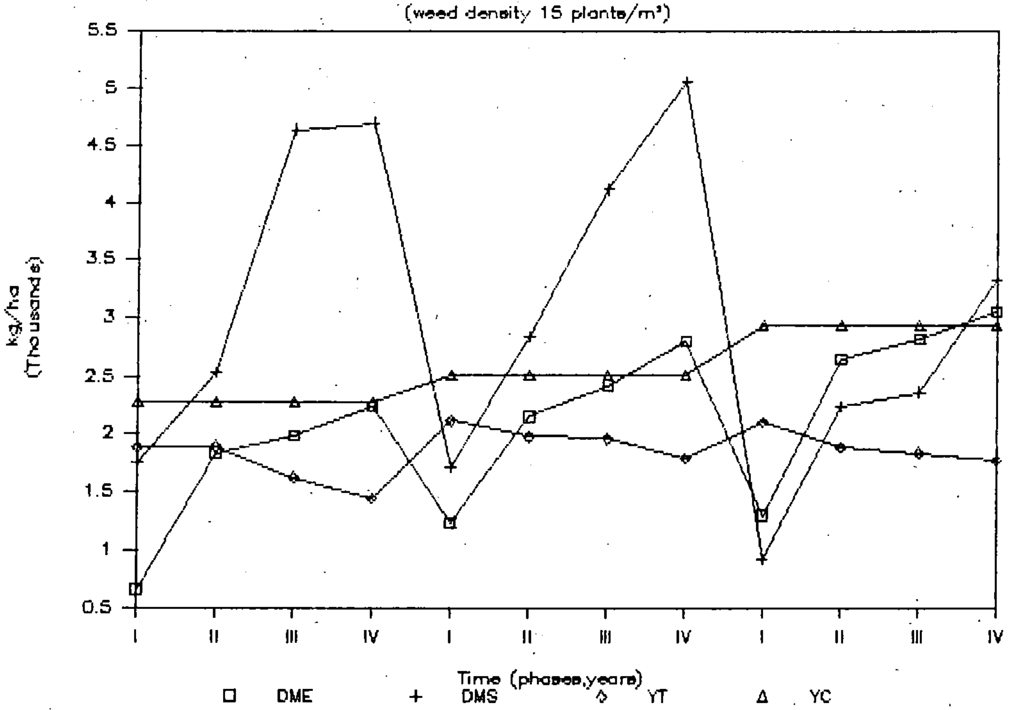
YT - yield in the variants with E. cruss galli

Fig.3 Sum of effective temperatures



SET - sum of effective air temperatures

Fig.4 Dry matter accumulation and yield
(weed density 15 plants/m²)



DME - dry matter of E. cruss galli
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