UDC 632.5:631.543.1+631.84
Original scientific paper

Reproduction of Cleavers (*Galium aparine* L.) under Different Densities and Nitrogen Rates

Ralitsa Nakova
Plant Protection Institute, 2230 Kostinbrod, Bulgaria

SUMMARY

Field experiments were conducted at the Plant Protection Institute to study the reproduction of cleavers (*Galium aparine* L.) under different densities and nitrogen fertilizer rates. The treatments consisted of five *G. aparine* L. densities (D_{11}; D_2 5; D_3 10; D_4 15; D_5 20 plants m^2) and three nitrogen rates (N_1 0 ; N_2 200; N_3 300 kg N /ha^{-1}). Measurement data on cleavers included: plant height, dry weight, number of seeds and seed weight per plant at maturity. The effect on *G. aparine* L. reproduction was established. An increase in weed density leads to a decrease in height, dry weight, seeds number and weight per plant. The rate of nitrogen application is an important factor in determining *G. aparine* L. seed production, but its influence varies as a function of weed density. Under all densities of cleavers the increase in nitrogen rates to 200 kg N/ha^{-1} and 300 kg N/ha^{-1} resulted in an increase in reproductive abilities of the weed due to its high biomass production. The relationship between *G. aparine* L. density and different nitrogen rates in terms of reproduction was largely dependent on weed density, nitrogen levels and intraspecific competition. The coefficients of determination (R^2) were very high, ranging from 0.94 to 0.99. Regression analysis of the data showed that *G. aparine* L reproduction was linearly affected by cleaver densities and nitrogen rates. Regression models may have practical applications in predicting reproduction of *G. aparine* L. at different densities and nitrogen rates of application.

Keywords: *G. aparine* L.; Density; Nitrogen rates; Reproduction; Coefficient of determination; Regression models

INTRODUCTION

G. aparine L. is considered to be the most troublesome broadleaved weed in cereals in Bulgaria which causes large crop losses. Many factors interact in determining the outcome of weed production. Reproduction of *G. aparine* L. can be affected by weed density and nutrition application. In contemporary investigations, the effect of weed density has been studied for: *Papaver rhoeas* L., *Avena fatua* L., *Chenopodium album* L., *Setaria viridis* L., *Amaranthus retroflesus* L. (Nakova, 2003a, 2003b, 2004, 2007), *Solanum nigrum* L. (Serafimov, 2005) and *Arabidipsis paliana* L. (Alwerd et al., 2006). The authors found that the effects of densities vary in terms of height, weed biomass and leaf area per plant. Weed growth and development decrease with increasing weed density. Several parameters (plant height, leaf area, fresh weight of leaves, stem and roots, root length, number of leaves and side shoots) measured at the growth stage BBCH 51 of *Iva xanthifolia*. Nutt significantly decreased as the density of the weed increased. The presence of 8 and 16 weed plants per pot decreased fresh weight of stem and root by 89-91% and 87-91%, respectively, compared with control pots (Valkova, 2007). Weed density influences seed production. It depends on the density of the weed. *Setaria glauca* L. Beauv, *Ehinochloa grus-galli* L. Beauv. and *Amaranthus retroflexus*

L. densities of 18, 15 and 20 plants m^2 were found to increase the seed banks in soil by 16,000, 1,800 and 20,000 seeds m^2, respectively (Van Heems, 1995; Zimdahl, 1999). The estimated seed production by 10 g means (dry matter) of *Sinapis arvensis* L., *Trifolium inodorum* L. and *Stellaria media* L. was 590, 6,300 and 8,600, respectively (Lutman, 2002). A strong linear relationship between seed production and plant above- ground dry weight was identified for *Chenopodium album* L. (Grundy et al., 2004).

Nitrogen (N) is a nutrient whose amounts are most often limited in situations of weed infestation. Competition between weeds for nitrogen is influenced by N amounts and weed species. Studies on nitrogen in weeds are generally missing in literature. Rastgoo et al. (2005) noted that seed production of *Sinapis arvensis* L. increased with increasing nitrogen rates due to high weed biomass production. The estimated *Sinapis arvensis* L. seed production was 161, 311 and 488 million seeds ha^{-1} under 100, 150 and 225 kg N/ ha^{-1}, respectively. The minimum biomass of seed production was determined at 1.12 g per plant. Increasing N increased the relative biomass of weeds. Interaction between weeds under the applied N is affected by horizontal and vertical distribution patterns (Peterson, 2005). Nitrogen had a high effect on radiation use efficiency (RUE) of *Avena fatua* L. at rates 25, 50, 70 and 100 kg N/ha^{-1}. Intraspecific competition indexes and Niche Differantiation Index (NDI) of *Avena fatua* (L.) at different nitrogen levels of 0, 70, 140, 210 and 250 kg N/ha^{-1} showed that the weed is very competitive and that increased nitrogen application increases its reproductive ability (Ahmadvand, 2005). Different nitrogen rates have been found to affect some morphological parameters of *Avena fatua* L.. The highest growth (100.3%) of above-ground weight of the weed was determined at high nitrogen rates (Duric et al., 2004). A series of experiments indicated the likely effect that reduced N supply may have on the competition among cleaver plants. The root system of *G. aparine* L. was shallow and often had great total length. When in mixture and under full nitrogen supply, cleaver was more competitive than other weeds (Rood-Williams, 1985; Ronney et al., 2000).

The aim of this study was to investigate: 1) reproduction of cleavers (*G. aparine* L.) under different densities and nitrogen rates 2) a model formulation for predicting reproduction in these explanatory variables.

MATERIAL AND METHODS

Two field experiments were carried out at the Plant Protection Institute in 2005 and 2006 on a fine sandy loam soil. *G. aparine* L. seeds were collected in the region of Kostinbrod. Their germination was more than 87% in both years. The experimental design was a randomized complete block with four replicates. Plot size was $1m^{-2}$ (1m wide by 1m length). The seeds of *G. aparine* L. were sown by hand in plots and after emergence the weed plants were thinned to 1, 5, 10, 15, 20 plants per plot. Treatments consisted of five *G. aparine* L. densities ($D_1$1; D_2 5; D_3 10; D_4 15; D_5 20 plants m^2) and three nitrogen rates (N_1 0 ; N_2 200; N_3 300 kg N /ha^{-1}). The conventional fertilizer was ammonium nitrate, which was applied at the same total rate of N. The number of cleaver plants m^{-2} in each variant present at maturity were determined. All other weeds were removed by hand during plant cycle. Weed plants were harvested at maturity. The data recorded for cleavers were: plant height (cm), dry weight per plant (g), number of seeds per plant, seed weight per plant (g). The reproduction components were determined on all plants in all treatments from each replication.

Regression analysis of the data was done using Microsoft Excel. The relationships between *G. aparine* L. densities, nitrogen rates and the examined parameters (height, dry weight, number and weight of seeds) of weed plants were summarized by the coefficient of determination (R^2). The regression models followed the equation y= bx+a, where *y* is the examined parameter, *b* is proportionality (regression coefficient), *a* is the initial value of *y* at x=1. The regression line graphically depicted the relations. The graphs and models are presented as average values in both years.

RESULTS

The results showed that maximum (110 cm) height of *G. aparine* L. was recorded at its density of 1 plant m^{-2} (control variant), while minimum (51 cm) height was found at 20 plants m^{-2} (Figure 1). Regarding nitrogen levels, maximum (120 cm) height was recorded at 300 kg N/ha^{-1} and minimum (60 cm) height at 0 kg N/ha^{-1}. The effect

of weed density and nitrogen levels on dry weight were unidirectional. The number of seeds per plant decreased as the density of the weed increased. The greatest reduction in seeds number was found at 20 plants/m^{-2} - 89% (compared to the variant of 1 plant/m^{-2}). The data for nitrogen levels show that seed number was higher at 200 kg N /ha^{-1} and highest at 300 kg N/ha^{-1}. The results showed that *G. aparine* L. densities m^{-2} from 5 to 20 plants had negative effect on seed weight, compared to the control variant (1 plant/m^{-2}). Regarding nitrogen levels, maximum (12.5 g) weight of seeds was recorded at 300 kg N/ha^{-1} and minimum (1.0 g) at 0 kg N/ha^{-1}. The coefficients of determination (R2) between weed densities, nitrogen rates and height, dry weight, seed number and seed weight per plant were very high, ranging from 0.94 to 0.99 (Figure 2).

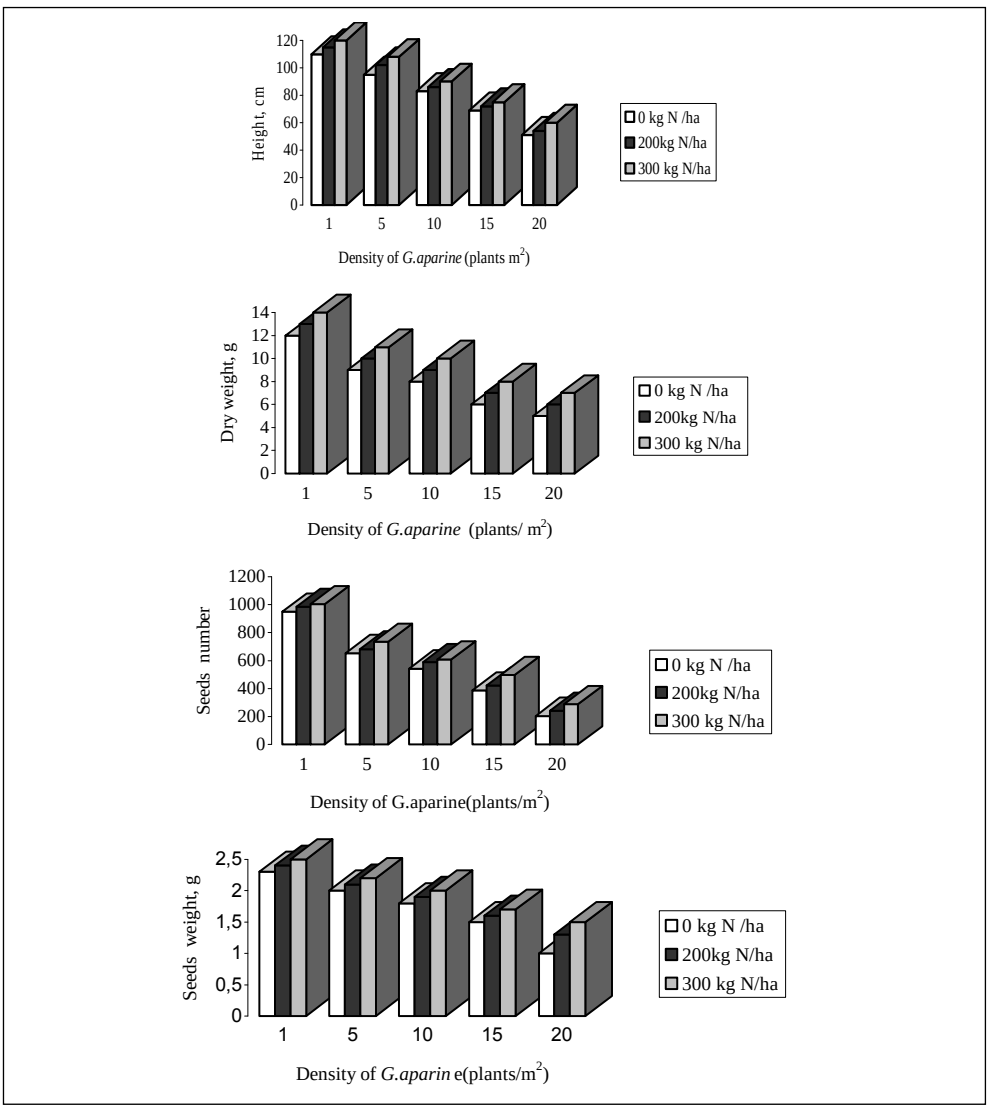


Figure 1. The effect of density and nitrogen rates on some parameters of *G.aparine* L.
Slika 1. Efekat gustine i doze đubrenja na neke parametre *G. aparine* L.

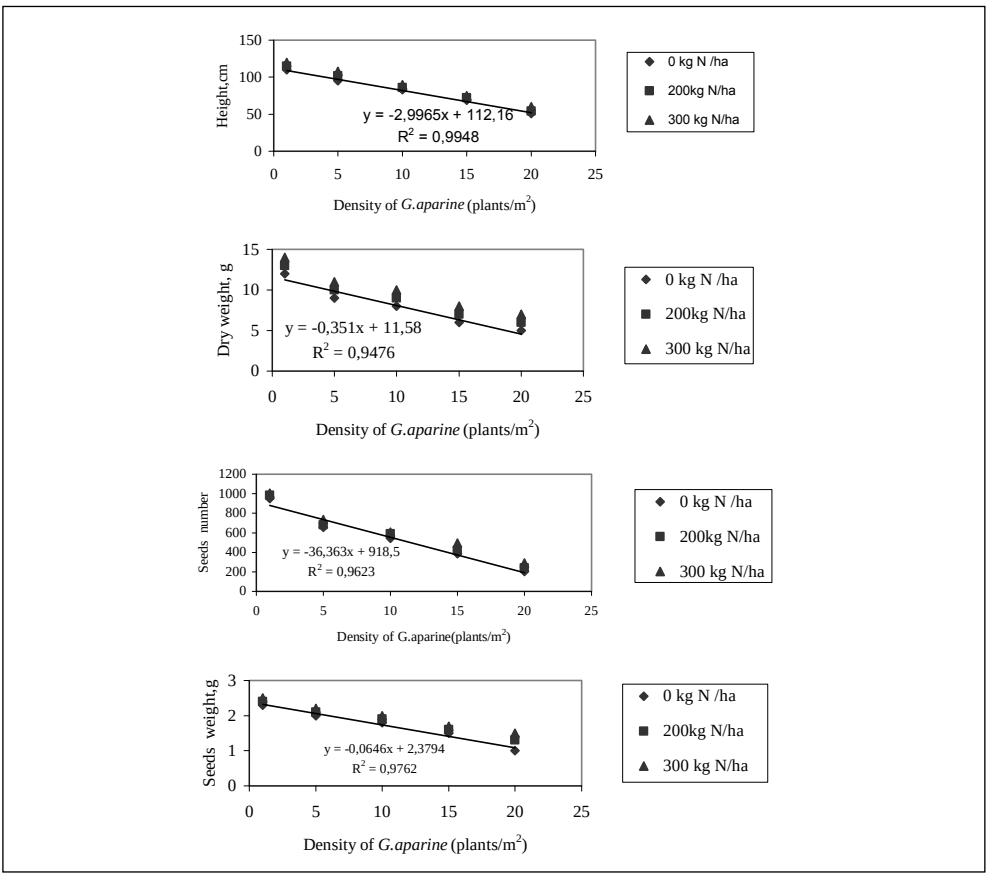


Figure 2. Relationship between some parameters of *G. aparine* L. and weed densities at different rates of nitrogen application
Slika 2. Odnosi između različitih parametera *G. aparine* L. i gustine korova pri različitim dozama primene azota

DISCUSSION

An analysis of data indicated that weed height at maturity was affected by *G. apparine* L. densities. With the increasing proportion of weed plants, their height decreased. The magnitude of height loss depended on cleaver density. The reason for this could be a higher intraspecific competition among weed plants at higher weed densities. Increase in nitrogen levels resulted in an increase in *G. apparine* L. height. Our conclusions are in line with the work of Milanova and Nakova (2002), who have confirmed that increasing N levels had positive effect on *Ambrosia artemisifolia* L. growth. Under the condition of N_{25} mg kg^{-1} soil, the plants were higher than the control by 36.8%, at N_{50}mg kg^{-1} soil by 53.8%, and at N_{100}mg kg^{-1} soil by 60.2%. Similar trends were observed regarding shoot dry weight of *A. artemisifolia* L. As for *G. aparine* L., its dry weight per plant was significantly affected by densities. Under increasing population density of the weed, this parameter decreased, but increasing nitrogen fertilizer rates increased its dry weight, reflecting further on seed yield. Increasing nitrogen increases interference of competition among cleaver plants for common resources, which is in agreement with Ronney et al., 1990. With the increasing density of *G. aparine* L. plants, the reproductive components, i.e. the seed number and weight per plant, decreased, which is consistent with reports by De Vit (2000) and Hakanson (2000). Reduction in these parameters affected the reproduction of cleavers. The reproductive components increased when *G. aparine* L. was treated with 200

and 300 kg N ha^{-1}, indicating that cleaver competition increases the exploitation of additional nitrogen fertilizer. Seed weight per plant was directly proportional to weed density. Under nitrogen fertilization, the weed was able to make better use of soil and environmental resources and partition photosinthates to the seeds, resulting in bolder grains. The increasing proportional density of *G. aparine* L. decreased reproduction, but increasing nitrogen applications increased the competitive ability of plants, reflecting on seed production.

The analysis of data indicated a relationship between cleaver density and height, dry weight, seed number and weight per plant at different N rates. The coefficient of determination increased in the order: dry weight > seed number > seed weight > height. Regression analysis of the data showed that *G. aparine* L reproduction was linearly affected by cleaver densities and nitrogen rates The regression models describe accurately the relationship between weed density, reproduction and nitrogen rates of application. The effect of *G. aparine* L. density on the growth, development and reproduction at different nitrogen levels was predicted by the equation. The regression lines show a dependence on reproductive parameters when there is no influence of another factor. The observed values for the studied variables fit the regression line very closely or in some instances exactly. Thus, these regression models may have practical application, such as prediction of reproduction for specific crop/weed interactions.

Thus, it can be concluded from the experiments that nitrogen levels can increase reproduction of *G. aparine* L., but nitrogen rates cannot suppress cleaver reproduction, so that other methods of weed control need to be applied within an integrated weed management programme.

REFERENCES

Ahmadvad, G.: The effect of nitrogen fertilizer and relative plant density on wheat and wild oat competitive indices. Proc. 13th E.W.R.S. Symposium, Bary, Italy, CD, 2005.

Alwerdt, L., Gibson, D., Ebbs, S., Wood, A.: Intraspecific interaction in *Arabidopsis thaliana* L. and the stomatal nutants tmm 1-1 and sdd1-2. Biological Planetarium, 50, 2, 205-209, 2006.

De Wit.: On competition. Varslagen van Landbouwkundige, 66, 71-81, 2000.

Duric, M., Dalovic, I., Nesie, S., Radislavevic, L.: Effect of different fertilizer doses on some morphological traits of wild oats in winter wheat. Herbologia, 5, 2, 79-87, 2004.

Grundy, A., Mead, A., Burston, S., Tores, S.: Seed production of *Chenopodium album* L.in competition with field vegetables. Weed Research, 44, 272-281, 2004.

Hakansson, S.: Competition and production in short lived crop-weed stand. Density effects. Sveriges Lanthbraksuniver-sited, Institutions for Vaxtoding, Rapport, 127, 2000.

Lutman, P.: Estimation of seed production by *Stellaria media* L., *Sinapis arvensis* L. and *Tripleurospermum inodorum* L. in arable crops. Weed Research, 42, 359-369, 2002.

Milanova, S., Nakova, R.: Some morphological and biological characteristics of *Ambrosia artemisifolia* L. Herbologia, 3, 1, 113-121, 2002.

Nakova, R.: Study the intraspecific competitive relations in *Papaver rhoeas.* Plant Science, 40, 3, 270-273, 2003a.

Nakova, R.: Study the intraspecific competitive relations in *Avena fatua.* Plant Science, 40, 3, 138-141, 2003b.

Nakova, R.: Study the intraspecific competition in *Setaria viridis* (L) Beauv. Bulg. J. of Agric. Science, 10, 195-198, 2004.

Nakova, R.: A comparison of shoot and root competition in *Amaranthus hibridus* L. Herbologia, 8, 2, 21-28, 2007.

Peterson, S.: Inter and intra specific competition for applied nitrogen. Proc. 13th E.W.R.S. Symposium, Bary, Italy, on CD, 2005.

Rastgoo, A., Ghanbari Bannayan, M., Rahimian, H.: Weed mustard (*Sinapis arvensis* L.) seed production in response to amount and timing of nitrogen application. Proc. 13th E.W.R.S. Symposium, Bary, Italy, on CD, 2005.

Ronney, J., Klarcson, P., Higgett, M., Hoor, J.: Growth of *Galium aparine* (cleavers) and competition with *Triticum aestivum* for N. Proc. EWRS Symposium, Integrated Weed Management in Cereals, 271-279, 1990.

Rooney, J., Huxley, M., Butler: Early weed competition by wild oats and cleavers in wheat. Annual Reports for Long Ashton Research Station, 1987, 29, 2000.

Rood-Williams, R.: The biology of cleavers (*Galium aparine* L.). Aspects of Applied Biology, 9, 189-195, 1985.

Serafimof, P.: Doctoral thesis. Plovdiv, 159-164, 2005.

Valkova, M.: Intraspecific competition within *Iva xanthofolia* (Nutt). Plant Science, 44, 1, 86-89, 2007.

Van Heemst, H.: The influence of weed competition on the seed production. Agricultural Sistems, 18, 81-93, 1995.

Zimdahl, L.: The influence of weed competition on growth parameters and seed production. Journal of Applied Ecology, 27, 863-874, 1999.

Razmnožavanje broćike (*Galium aparine* L.) pri različitim gustinama i dozama đubrenja

REZIME

Obavljeni su poljski ogledi u Institutu za zaštitu bilja kako bi se ispitalo razmnožavanje broćike (*Galium aparine* L.) pri različitim gustinama i različitim dozama đubrenja azotom. Tretmani su se sastojali od pet gustina *G. aparine* L. ($D_1$1; D_2 5; D_3 10; D_4 15; D_5 20 biljaka m^2) i tri doze azota (N_1 0 ; N_2 200; N_3 300 kg N/ha^{-1}). Mereni parametri kod broćike bili su: visina biljke, suva masa, broj semena i težina semena po biljci u zreloj fazi. Utvrđen je uticaj na razmnožavanje *G. aparine* L. Povećanje gustine korova dovodi do smanjenja visine, suve mase, broja semena i mase semena po biljci. Doza primene azota je važan faktor u određivanju produkcije semena *G. aparine* L., ali njen uticaj varira u zavisnosti od gustine korova. Pri svim gustinama broćike, povećanje doze azota na 200 kg N/ha^{-1} i 300 kg N/ha^{-1} dovele su do povećanja reproduktivnih sposobnosti korova zbog visoke produkcije biomase. Odnos između gustine *G. aparine* L. i različitih doza azota u pogledu reprodukcije prevashodno je zavisio od gustine korova, nivoa azota i kompeticije unutar vrste. Koeficijenti determinacije (R^2) bili su visoki, između 0,94 i 0,99. Regresiona analiza podataka pokazala je da je reprodukcija *G. aparine* L. bila u linearnoj zavisnosti od gustine broćike i primenjenih doza azota. Regresioni modeli mogu se primeniti u predviđanju razmnožavanja *G. aparine* L. pri različitim gustinama i primenjenim dozama azota.

Ključne reči: *G. aparine* L.; gustina; doze azota; razmnožavanje; koeficijent determinacije; regresioni modeli

Received June 7, 2008
Accepted July 9, 2008