Chapter 1. RECENT DEVELOPMENTS IN PLANT PROTECTION MANAGEMENT

ISSN 1392-3196
Zemdirbyste-Agriculture, vol. 95, No. 3 (2008), p. 5–12
UDK 633.16:631.531.04:631.576

THE INFLUENCE OF SPRING WHEAT PLANT DENSITY ON WEED SUPPRESSION AND GRAIN YIELD

Ona AUŠKALNIENĖ, Albinas AUŠKALNIS

Lithuanian Institute of Agriculture
Instituto al. 1, Akademija, Kėdainiai distr., Lithuania
E-mail: ona@lzi.lt

Abstract

The influence of plant density on weed suppression, grain yield, and its components in the spring wheat cvs. 'Triso' and 'Vanek' was investigated in three field trials at the Lithuanian Institute of Agriculture in 2006 and 2007. The soil of the experimental site is *Endocalcary-Endohypogleyic Cambisol* loam. Spring wheat was sown at 5 densities from 300 to 700 viable seeds per m^2 in 2006 and at 6 densities from 200 to 700 viable seeds m^2 in 2007. The annual dicotyledonous weeds prevailed in the field: *Chenopodium album*, *Euphorbia helioscopia*, *Viola arvensis, Polygonum aviculare, Stellaria media.* The number of weeds per m^2 in spring wheat stands was 23–48 in 2006 and 8.5–26.5 in 2007. With increasing spring wheat seed rate from 300 to 700 viable seeds per m^2 the fresh weed mass decreased from 62.4 to 6.4 g m^2 in 2006 and from 26.4 to 6.9 in 2007. When the seed rate was increased to 5 million viable seeds per hectare the decrease in weed mass was significant for both varieties and years. The share of weed biomass in the total biomass differed between the weed species. The weed species composition and abundance in spring wheat stands depended on the weather conditions of the growing period.

In extremely dry 2006 growing season the average spring wheat grain yield was 3.0–3.5 and in favourable 2007 growing season 6.2–6.5 t ha^{-1}. The results for both years suggest that increased sowing density can increase weed suppression in spring-sown wheat.

Key words: spring barley, sowing density, weeds, grain yield

Introduction

Efficient and timely weed control is one of the major tasks of competitive contemporary agriculture /Liebman, Staver, 2001; Sarrantonio, Gallandt, 2003/. Public concern about the effects of herbicide use on the environment and human health has increased the interest in reducing the use of herbicides in agriculture and in developing alternative methods for weed control. One way to control weeds in cereals is to improve the ability of the crop itself to suppress weeds /Jordan, 1993; Lemerle et al., 2001; Mohler, 2001/. The seeding rate of the crop is an important factor in determining the biomass production of weeds and most studies show a decreasing weed biomass at higher crop densities /Blackshaw, 1993; Tollenaar et al., 1994; Doll, 1997; Petraitis, 2001; Auškalnis, Auškalnienė, 2007/. At relatively low crop densities, crop cover early in the growing season is low, leaving a larger amount of resources available for the weeds, thus enabling them to establish and grow quickly /Medd et al., 1985; Murphy et al., 1996; Hakansson, 1997; Lemerle et al., 2001/.

Increased crop density had strong and consistent negative effects on weed biomass and positive effects on crop biomass and yield. At the highest crop density, weed biomass was less than half that at the lowest density. Weed biomass was generally lower, and yield higher, in the uniform pattern, except in one case in which a combination of factors gave one weed species an early size advantage over the crop. When weeds were controlled with herbicide, no effects of crop density or spatial uniformity on crop biomass or yield were observed. /Kristensen et al., 2008/. An increase from low to medium density resulted in 30% less weed biomass, and the increase from low to high density resulted in 45% less weed biomass. The proportion of weed biomass of the total biomass differed between the weed species /Olsen et al., 2005 a/.

When weed pressure is high, reduced weed biomass translates directly into yield /Christensen, 1995; Lemerle et al., 1996/. The ability of crops to suppress weeds at high crop densities may be limited by the spatial distribution of individual crop plants in the field /Miller, Weiner, 1989; Bonan, 1991/.

A combination of increased crop density and a more uniform distribution of the crop increases weed suppression and can play a role in weed management in cereals. The results also suggest that the relative size of the crop and weed plants when crop-weed competition becomes intense is critical in determining the effects of crop density and pattern on weed biomass. When the crop has an initial size advantage, increasing crop density and spatial uniformity can help the crop maintain its advantage and suppress the weeds /Olsen et al., 2006/.

Manipulating plant density is an effective practice to optimize tiller and main stem competition for light, water, and nutrition, therefore enhancing spring wheat grain yield and nitrogen use efficiency /Chen, Neill, 2006/. The coefficient of variation of leaf area index is higher at lower sowing density. The decrease in the leaf area index (LAI) variation may contribute to increased weed suppression and increased yield /Olsen et al., 2007/.

One potential problem with increased sowing density is the risk of an increase in fungal pathogens, especially in row pattern, but this has not been observed in this or in other experiments /Olsen et al., 2005 b; Weiner et al., 2001/.

In addition to reduced herbicide application, this weed management strategy may have other positive environmental effects, including less traffic on the field and, therefore, reduced soil compaction, fuel consumption, and carbon dioxide (CO2) production /Olsen et al., 2005 a/.

The aim of the present study was to investigate the influence of different seed rates on grain yield and on weed biomass in spring wheat stands.

Materials and Methods

The influence of plant density on weed suppression and grain yield in the spring wheat cvs. 'Triso' and 'Vanek' was investigated in three field trials conducted at the Lithuanian Institute of Agriculture in 2006 and 2007. The soil of the experimental site is *Endocalcary-Endohypogleyic Cambisol* loam. Conventional soil tillage was used. Spring wheat was sown at 5 densities from 300 to 700 viable seeds per m^2 in 2006 and at 6 densities from 200 to 700 viable seeds per $1m^2$ in 2007. The preceding crop of spring wheat in both years was winter wheat. Spring wheat was sown in the second half of April with a plot size of 2.2 by 10.0 m. The plots were replicated four times and arranged randomly. Prior to sowing the soil was fertilised with $N_{140}P_{90}K_{90}$: ammonium nitrate, granulated superphosphate and potassium chloride were applied. The spring wheat plots were treated with the herbicide Sekator OD (a. i. amido sulfuron 100 + yodosulfuronmethyl sodium 25 g l^{-1}).

The weed number and green mass were established in 4 places of 0.25 m^{-2}, in each plot of spring wheat in the plots untreated with herbicide when weed biomass was at its maximum (late June/early July), and grain was harvested in August by a combine "Wintersteiger".

All data were analyzed using ANOVA from package SELEKCIJA /Brewbaker, 1995; Tarakanovas, Raudonius, 2003/. To achieve homogeneity of variance, the weed biomass data were Sqr(X+1) transformed.

Results and Discussion

Weed biomass decreased with increasing sowing density. In spring wheat cv. 'Triso' with seed rate of 5 million and higher there were strong effects of sowing density (P>0.01) on weed biomass. In the stands of cv. 'Vanek' the effect of density with (P>0.01) were found in the fields with a seed rate of 6 million and higher, and in the treatments with a seed rate of 5 million seeds the effect of sowing density was at P> 0.05 (Figure 1).

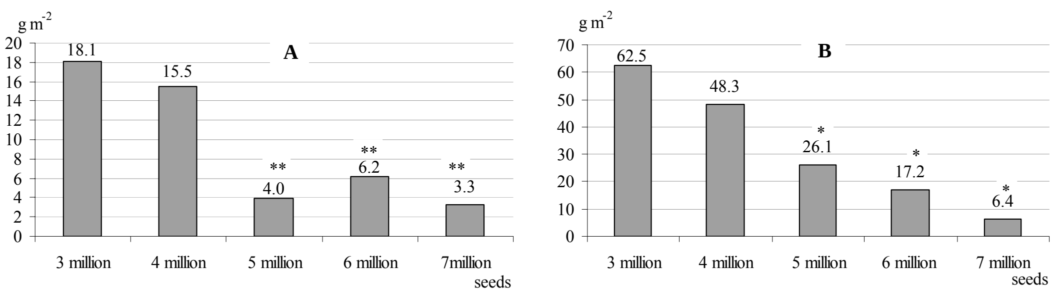


Figure 1. The effect of seed rate on weed biomass in the stands of spring wheat cv. 'Triso' (A) and cv. 'Vanek' (B), 2006, ** P>0.01

The weed mass in spring wheat cv. 'Triso' in 2007 decreased with sowing density also (Figure 2).

A significant (at P>0.05) decrease was obtained in the plots with a sowing density of 4 million viable seeds. Other studies showed likewise that the seeding rate of the crop is an important factor in determining the biomass production of weeds /Doll 1997, Olsen et al., 2006/.

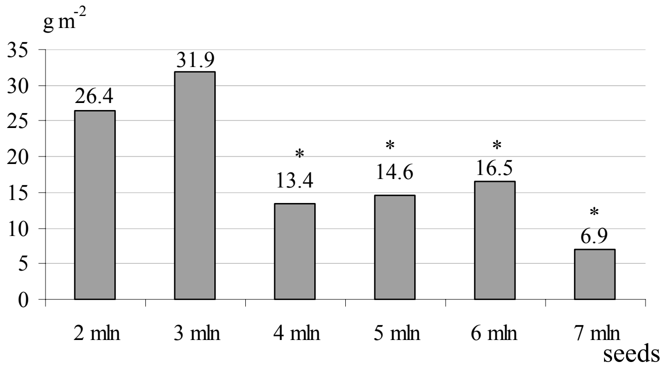
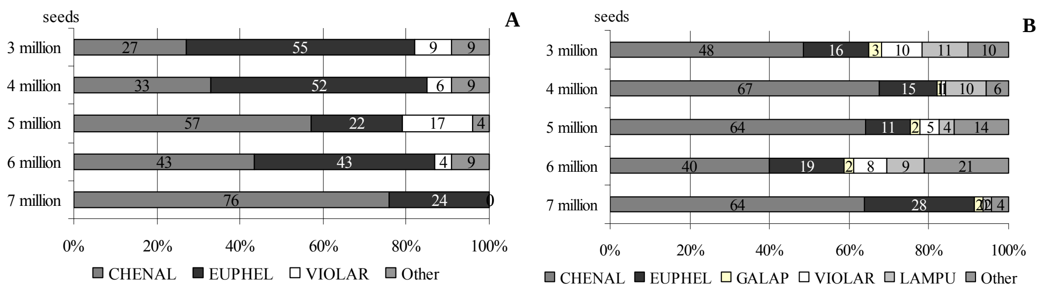


Figure 2. The effect of seed rate on weed biomass in the stands of spring wheat cv. ‘Triso’, 2007, * P> 0.05

The share of weed biomass in the total biomass differed between the weed species. *Chenopodium album* was prevalent in the spring cereal stands in both varieties in 2006 (Figure 3). In the spring wheat cv. ‘Triso’ *Chenopodium album* accounted for 27–76% of the total weed number. In the spring wheat stand of cv. ‘Vanek’ *Chenopodium album* totalled 40–67%. The densest stand of spring wheat had the lowest number of weed species, especially the stand of cv. ‘Triso’.

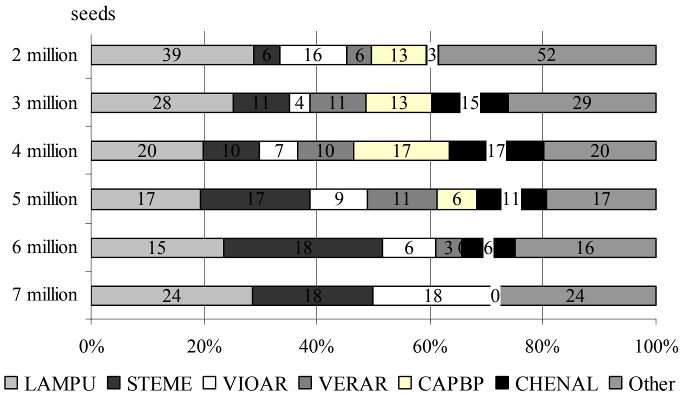


CHENAL – *Chenopodium album,* EUPHEL – *Euphorbia helioscopia,* VIOLAR – *Viola arvensis,* GALAP – *Galium aparine,* LAMPU – *Lamium purpureum*

Figure 3. The weed species composition in the spring wheat cvs. ‘Triso’(A) and ‘Vanek’ (B), 2006

Similar tendency was observed in the spring wheat stands in 2007 (Figure 4) – the densest stands of spring wheat had the lowest number of weed species.

The weed species in 2007 differed from those in the first year: *Lamium purpureum*, *Stellaria media* prevailed in the stands of spring wheat – these weed species accounted for 30–49% of the total weed number. In the densest stands *Viola arvensis* accounted for 18% of the total weed number. *Chenopodium album* accounted for 0–17% of the total weed number. In other studies it was noticed that *Chenopodium album* germinated late and could be effectively suppressed by the wheat, especially at higher densities in the uniform pattern /Colquhoun et al., 2001/. In our trials the differences occurred due to the weather conditions. The weather conditions, especially the amount of rainfall during the growing season affected weed incidence and conditions for crop – weed competition /Romaneckienė, 2007/. The growing period was very dry in 2006 and 2–4 weed species prevailed in the spring wheat stands. In 2007 the growing season was normally wet and 7–11 weed species were identified in the spring cereal stands, whereof *Stellaria media*, *Lamium purpureum*, *Viola arvensis* prevalented.



LAMPU – *Lamium purpureum,* STEME – *Stellaria media,* VIOLAR – *Viola arvensis,* CAPBP – *Capsella bursa - pastoris,* CHENAL – *Chenopodium album*

Figure 4. The weed species composition in the spring wheat cv. ‛Triso’, 2007

The grain yield of spring wheat was not significantly influenced by the seed rate (Table).

Table. The grain yield of spring wheat during 2006–2007

Seed rate (viable seeds)	2006				2007	
	‛Triso’		‛Vanek’		‛Triso’	
	t ha^{-1}	%	t ha^{-1}	%	t ha^{-1}	%
2 million	–	–	–	–	7.08	97.5
3 million	2.96	98.8	3.45	97.5	6.85	94.4
4 million	3.10	103.3	3.72	105.2	7.48	103.1
5 million	3.01	100.4	3.55	100.4	7.47	103.0
6 million	2.92	97.5	3.51	99.2	7.66	105.5
7 million	3.00	99.9	3.46	97.7	7.00	96.4
LSD_{05}	0.184 n.s	6.14	0.186 n.s	5.26	0.466 n.s	6.42

In extremely dry 2006 growing season the average grain yield was 3.54 t ha^{-1} of the spring wheat cv. 'Vanek' and 3.00 t ha^{-1} cv. 'Triso'. In more favourable growing season of 2007 the grain yield of spring wheat amounted to 7.3 t ha^{-1}. These results agree with those obtained by other researchers who suggest that the advantage of increased sowing density occurs only when weeds are present. When weeds are absent or well controlled, there is no advantage of increased sowing density /Weiner et al., 2001, Olsen et al., 2005 a/. Despite the differences in grain yield between the two years, the results for both years support previous findings and demonstrate that increased sowing density can increase weed suppression in spring-sown wheat /Weiner et al., 2001, Olsen at al., 2005 a/. A significant reduction of weed reproductive structures at higher crop densities for different winter wheat cultivars has been observed in other studies /Korres, Froud-Williams, 2002/.

Conclusions

1. Weed biomass decreased with increasing sowing density of spring wheat. At a sowing rate of 5 million viable seeds per hectare the decrease in weed mass was significant for both varieties and both years.

2. The share of weed biomass in the total biomass differed between the weed species. The weed species composition and abundance in the spring wheat stands depended on the weather conditions of the growing period.

3. The seed rate did not have any significant influence on the spring wheat grain yield. It was more markedly influenced by the weather conditions. The grain yield in favourable 2007 was twice as high as in 2006.

4. Despite the differences in grain yield between the two years, the results for both years suggest that increased sowing density can increase weed suppression in spring wheat.

Acknowledgments

The study was supported by the Lithuanian State Science and Studies Foundation project registration No. 6-06030.

Received 2008-06-06
Accepted 2008-08-13

REFERENCES

1. Auškalnis A., Auškalnienė. Sėjos laiko ir pasėlio tankumo įtaka javų piktžolėtumui // Augalų apsaugai Lietuvoje – 80. Šių dienų augalų apsauga mokslo ir agroverslo kontekste: konferencijos medžiaga. – 2007, p. 241 – 246

2. Blackshaw R. E. Safflower (*Carthamus tinctorius*) density and row spacing effects on competition with green foxtail (*Setaria viridis*) // Weed Science. – 1993, vol. 41, p. 403–408

3. Bonan G. B. Density effects on the size structure of annual plant populations: an indication of neighbourhood competition // Annals of Botany. – 1991, vol. 68, p. 341–347

4. Brewbaker J. L. Experimental design on a spreadsheet. University of Hawaii.- Honolulu, 1995. – 175 p.

5. Chen Ch., Neill K. Response of Spring Wheat Yield and Protein to Row Spacing, Plant Density, and Nitrogen Application in Central Montana // Fertilizer Facts. – Montana State University Extension, 2006, No. 37, p. 2–3

6. Colquhoun J., Stoltenberg D. E., Binning L. K., Boerboom C. M. Phenology of common lambsquarters growth parameters // Weed Science. – 2001, vol. 49, p. 177–183

7. Christensen S. Weed suppression ability of spring barley varieties // Weed Research. – 1995, vol. 35, p. 241–247

8. Doll H. The ability of barley to compete with weeds // Biological Agriculture and Horticulture. – 1997, vol. 14 p. 43–51

9. Hakansson S. Competitive effects and competitiveness in annual plant stands, 2: measurements of plant growth as influenced by density and relative time of emergence // Swedish Journal of Agricultural Research. – 1997, vol. 27 p. 75–94

10. Jordan N. Prospects for weed control through crop interference // Ecological Application. – 1993. vol. 3, p. 84–91

11. Korres N. E., Froud-Williams R. J. Effects of winter wheat cultivars and seed rate on the biological characteristics of naturally occurring weed flora // Weed Research. – 2002, vol. 42, p. 417–428

12. Kristensen L., Olsen J., Weiner J. Crop Density, Sowing Pattern, and Nitrogen Fertilization Effects on Weed Suppression and Yield in Spring Wheat // Weed Science. – 2008, vol. 56, p. 97–102

13. Lemerle D., Verbeek B., Cousens R. D., Coombes N. E. The potential for selecting wheat varieties strongly competitive against weeds // Weed Research. – 1996, vol. 36, p. 505–513

14. Lemerle D., Gill G. S., Murphy C. E. et al. Genetic improvement and agronomy for enhanced wheat competitiveness with weeds // Australian Journal Agricultural Research. – 2001, vol. 52, p. 527–548

15. Liebman M., Staver C. P. Crop diversification for weed management / Ecological Management of Agricultural Weeds. – Cambridge: Cambridge University Press, 2001, p. 322–374

16. Medd R. W., Auld B. A., Kemp D. R., Musison R. D. The influence of wheat density and spatial arrangement on annual ryegrass, *Lolium rigidum*, competition // Australian Journal of Agricultural Research. – 1985, vol. 36, p. 361–371

17. Miller T. E., Weiner J. Local density variation may mimic effects of asymmetric competition on plant size variability // Ecology. – 1989, vol. 70, p. 1188–1191

18. Mohler C. L. Enhancing the competitive ability of crops: / Ecological Management of Agricultural Weeds (ed. by M. Liebman, C. L. Mohler, C. P. Staver). – Cambridge: Cambridge University Press, 2001, p. 231–269

19. Murphy S. D., Yakubu Y., Weise S. F., Swanton C. J. Effect of planting patterns and inter row cultivation on competition between corn (Zea mays) and late-emerging weeds // Weed Science. – 1996, vol. 44, p. 856–870

20. Olsen J., Kristensen L., Weiner J. Effects of density and spatial pattern of winter wheat on suppression of different weed species // Weed Science. – 2005 a, vol. 53, p. 690–694

21. Olsen J., Kristensen L., Weiner J., Griepentrog H. W. Increased density and spatial uniformity increase weed suppression by spring wheat (*Triticum aestivum*) // Weed Research. – 2005 b, vol. 45, p. 316–321

22. Olsen J., Kristensen L., Weiner J. Influence of sowing density and spatial pattern of spring wheat (*Triticum aestivum*) on the suppression of different weed species // Weed Biology and Management. – 2006, vol. 6, p. 165–173

23. Olsen J., Weiner J. The influence of *Triticum aestivum* density, sowing pattern and nitrogen fertilization on leaf area index and its spatial variation // Basic and Applied Ecology. – 2007, vol. 8, p. 252–257

24. Petraitis V. Vasarinių kviečių sėjos laikas ir sėklos normos lengvame priemolyje // Žemdirbystė: mokslo darbai / LŽI, LŽŪU. – 2001, t. 74, p. 70–88

25. Romaneckienė R. Weed-spring barley competition and adaptivity to different environmental conditions. Summary of doctoral dissertation. Lithuanian University of Agriculture. – 2007. – 18 p.

26. Sarrantonio M., Gallandt E. R. The role of cover crops in North American cropping systems // Journal of Crop Production. – 2003, vol. 8, p. 53–74

27. Tarakanovas P., Raudonius S. Agronominių tyrimų duomenų statistinė analizė taikant kompiuterines programas *Anova, Stat, Split-plot,* from package *Selekcija.* – Akademija, 2003, p. 27–29

28. Tollenaar M., Dibo A. A., Aguilera A. et al. Effect of crop density on weed interference in maize // Agronomy Journal. – 1994, vol. 86, p. 591–595

29. Weiner J., Griepentrog H-W., Kristensen L. Suppression of weeds by spring wheat *Triticum aestivum* increases with crop density and spatial uniformity // Journal of Applied Ecology. – 2001, vol. 38, p. 784–790