Polish Journal of Agronomy
2010, 2, 73–77

Response of durum wheat (*Triticum durum* Desf.) to protection intensity

Grzegorz Szumiło, Leszek Rachoń

Department of Plant Cultivation, University of Life Sciences in Lublin
ul. Akademicka 15, 20–950 Lublin, Poland

Abstract. The field study was carried out in years 2007–2009. The experimental field was located on soil derived from loess silt, which is categorized as good wheat soil complex. The aim of the experiment was to establish the influence of varied plant protection levels: minimal (seed dressing and herbicide) and comprehensive (seed dressing, 2 types of herbicide, retardant, fungicide and insecticide) on the yield, crop structure components and selected physical quality parameters of the grain of spring wheat *Triticum durum* (Desf.) and *Triticum aestivium* (L.). The yield of minimally protected wheat was reduced by approximately 22.6% compared to intensively protected wheat, which was caused by a significant decrease in the number of ears, thousand grain weight (TGW) as well as grain weight and number per ear. Limited plant protection resulted in overall decrease in grain bulk density and uniformity as well as grain glassiness. Depending on a genotype, the yield of durum wheat made up from 68.3% to 85.1% of the yield of common wheat. The grain of durum wheat was characterised by greater TGW, uniformity and glassiness compared to common wheat.

key words: plant protection, grain yield, grain quality, durum wheat, spring wheat

INTRODUCTION

The consumption of resources such as fertilizers or plant protection products is one of the main indicators of cultivation intensity. Yield growth and stabilization are the most frequent results of increased production intensity. It is also important to mention a beneficial or unfavourable influence of production intensification on the quality of harvested crops (Kołodziejczyk et al., 2007). Growing consumer awareness concerning negative effect of agrochemicals on their health, and activity of environmental organisations force producers to strictly limit the use of plant protection products (Panasiewicz et al., 2008; Pruszyński, 2009). However, weed, diseases and insects are still inseparable elements of wheat cultivation. They have to be controlled which should be performed with the use of all available methods and techniques in accordance with the principles of environment protection (Korbas et al., 2008). In Polish climate, beneficial characteristics of varieties should be supported with adequate crop management practices, and limitations in the use of production resources contribute to a decrease in grain quality parameters. Grain harvested at a plantation cultivated without protection during years characterized by intensification of pathogens is characterised by decreased milling quality. On the other hand, grain from weed-infested fields is characterised by low protein and gluten content, low gluten quality and high susceptibility to pre-harvest sprouting (Podolska, 2007). Making the most out of the full yield potential of cultivated plants is only possible as a result of the provision of optimum growth conditions (Nowak et al., 2005), which involves, inter alia, proper plant protection (Panasiewicz et al., 2008). Therefore, the decision concerning the cultivation of durum wheat in Polish climate conditions will be based on, inter alia, sensitivity to pathogenic fungi infection and necessity to use of plant protection products (Pląskowska, Chrzanowska-Drożdż, 2008).

The aim of this study was to determine an influence of two systems of managing pests and diseases on the yield, crop structure components and selected physical quality parameters of spring grain of durum and common wheat.

MATERIAL AND METHODS

The field study was carried out in years 2007–2009 in Experimental Farm Felin owned by the University of Life Sciences in Lublin. The experimental plot was located on soil derived from loess silt, which is categorized as good wheat soil complex. The experiment was carried out as

Corresponding author:
Grzegorz Szumiło
e-mail: grzegorz.szumilo@up.lublin.pl
tel. +48 81 4456793

Received 16 March 2010

a randomized block design with four replications. Wheat varieties were classified as first-order factors. A total of 10 levels of the first factor were taken into account: durum wheat (*Triticum durum* Desf.) – cultivars Navigator (Canadian), Lloyd (American), Chado, Izolda, Kharkivska 27, Kharkivska 39, Kharkivska 41 (Ukrainian), Puławska Twarda (Polish) and $LGR_{896/23}$ line selected in the Institute of Plant Genetics, Breeding and Biotechnology, University of Life Sciences in Lublin; spring common wheat (*Triticum aestivium* L.) – Torka cultivar. Various levels of chemical protection were classified as a second-order factor: minimal – seed dressing Oxafun T 75 DS/WS (at 200 g per 100 kg of grain) and herbicide Chwastox Trio 540 SL (at 2.0 $dm^3 \cdot ha^{-1}$ used in the BBCH 29 phase) and comprehensive – seed dressing Oxafun T 75 DS/WS, herbicides Chwastox Trio 540 SL and Puma Uniwersal 069 EW (1.2 dm^3 ha^{-1} – BBCH 24–25), growth regulator Stabilan 750 SL (1.8 $dm^3 \cdot ha^{-1}$ – BBCH 30–31), Alert 375 SC fungicide (1.0 $dm^3 \cdot ha^{-1}$ – BBCH 41–49) and insecticide Decis 2.5 EC (250 $cm^3 \cdot ha^{-1}$ – BBCH 61–69). Cultivation was typical of the ploughing system. Before the sowing the following fertilization was applied: P – 26; K – 66 and N – 40 $kg \cdot ha^{-1}$. The second dose of nitrogen (40 $kg \cdot ha^{-1}$) was introduced at the beginning of the shooting phase. The area of each plot at harvest was 10 m^2. The seeds were sown at a rate of 500 grains per 1 m^2 in a field previously cropped to winter rapeseed.

Prior to the harvest the number of ears in the area of 1 m^2 was assessed. Once the grains had reached full maturity the harvest was made. Yield, grain weight and grain number per ear and TGW were assessed. The grain samples were subjected to laboratory investigation in order to establish bulk density (in accordance to PN-73/R-74007), grain uniformity (in accordance to BN-69/9131-02) and glassiness (in accordance to PN-70/R-74008). The results were statistically analysed by two-way ANOVA at the significance level of $\alpha = 0.05$. LSD was also calculated. Since during the study the reaction of wheat to the factors under investigation was similar; the results were given as three-year averages.

Table 1. Rainfalls and air temperatures according to the Meteorological Observatory at Felin.

Year	Month						
	III	IV	V	VI	VII	VIII	III–VIII
	Rainfalls (mm)						Sum
2007	30.2	17.4	81.5	87.8	87.0	37.6	341.5
2008	64.8	55.8	101.6	25.9	77.1	45.0	370.2
2009	69.6	2.9	71.1	125.5	57.1	54.7	380.9
Mean for 1951–2000	25.8	40.6	58.3	65.8	78.0	69.7	338.2
	Temperature (°C)						Mean
2007	6.2	8.7	15.0	18.1	19.2	18.4	14.3
2008	3.4	9.3	12.8	17.7	18.3	19.3	13.5
2009	1.4	11.4	13.6	16.4	19.9	19.0	13.6
Mean for 1951–2000	1.0	7.5	13.0	16.5	17.9	17.3	12.2

Over the three year-long cycle (Table 1), the year 2007 was the most favourable for spring wheat yields (in the period from May to July high temperatures and rainfall exceeding the long-term average were recorded, which contributed to intensive growth and development. The year 2008 was characterised by above-average rainfall in May and rain deficiency in June compared to the long-term average. The lowest yield and the lowest quality of grain was harvested in the last year of the study – 2009. In that period, severe rainfall deficiency in April and at the beginning of May inhibited the emergence, growth, and development of spring wheat, while subsequent frequent rainfalls contributed to weed infestation.

RESULTS

Regardless of varieties and lines, the use of the minimal level of chemical protection significantly reduced the yield of spring wheat compared to comprehensive protection (Table 2). The decreased use of chemical agents resulted in a decrease in wheat yield by from 14.1% (Izolda) to 29.5% (Kharkivska 41 and $LGR_{896/23}$). The yield of common wheat (6.59 t ha^{-1}) was significantly greater than the yield of durum wheat (5.07 t ha^{-1} on average). Depending on a genotype, the yield of durum wheat was lower than

Table 2. Grain yield and number of ears of spring wheat (means for 2007–2009)

Cultivars and line	Yield of grain [$t \cdot ha^{-1}$]			Number of ears per 1 m^2		
	M	C	mean	M	C	mean
Navigator	4.12	4.87	4.50	383	456	420
Lloyd	4.02	5.38	4.70	345	408	376
Chado	4.78	5.92	5.35	343	405	374
Izolda	5.18	6.03	5.60	368	423	396
Kharkivska 27	4.37	5.86	5.11	340	403	372
Kharkivska 39	4.35	5.43	4.89	301	360	330
Kharkivska 41	4.64	6.59	5.61	351	448	399
Puławska Twarda	4.16	5.77	4.96	394	501	447
$LGR_{896/23}$	4.08	5.79	4.93	362	402	382
Torka	5.91	7.28	6.59	485	552	518
Mean	4.56	5.89	–	367	436	–
$LSD_{0.05}$ a		0.702			55.6	
b		0.189			15.0	
a×b		ns			ns	

M – minimal plant protection
C – comprehensive plant protection
a – for cultivars and line
b – for protection levels
a×b – for interaction cultivars and line × protection levels
ns – not significant

the yield of common wheat by 14.9–31.7%. Among the compared cultivars and lines of durum wheat, Ukrainian varieties (Kharkivska 41 and Izolda – respectively 5.61 and 5.60 t ha^{-1}) were proven to be characterized by the greatest productivity. Navigator, Lloyd and Kharkivska 39 varieties were significantly less productive (4,50–4,89 t ha^{-1}). Polish Puławska Twarda variety and $LGR_{896/23}$ line yielded at a similar level; however, the yield was significantly lower than that of the Torka variety.

The intensification of chemical protection in relation to the minimal level of the use of chemical agents resulted in an significant increase in the number of ears per m^2, TGW as well as grain weight and number per spring wheat ear (Table 2 and 3). Regardless of the level of plant protection, the common wheat had significantly higher number of ears per m^2 than all varieties and the line of durum wheat. However, the analysed genotypes showed significant variation in the value of this crop structure components. Kharkivska 39 (330 ears), Lloyd, Chado and Kharkivska 27 varieties as well as $LGR_{896/23}$ line (372–382 ears) were characterised by a small number of ears; while Puławska Twarda showed a significantly larger number of ears (447 ears). It was also observed that the TGW of durum wheat amounted to 43.3 g on average and was greater by 22% compared to the TGW of common wheat. The Ukrainian varieties showed high TGW, especially Kharkivska 39, and the latter proved to

Table 3. Yield structure elements of spring wheat.

Cultivars and line		1000 grain weight (TGW) [g]			Number of kernels per ear			Weight of grains per ear [g]		
		M	C	mean	M	C	mean	M	C	mean
Navigator		42.5	42.8	42.6	25.9	26.3	26.1	1.099	1.103	1.101
Lloyd		41.5	43.7	42.6	28.0	30.8	29.4	1.167	1.371	1.269
Chado		44.4	45.8	45.1	32.8	33.7	33.2	1.455	1.521	1.488
Izolda		43.4	43.4	43.4	32.3	33.7	33.0	1.384	1.448	1.416
Kharkivska 27		43.2	45.9	44.5	30.3	32.7	31.5	1.342	1.476	1.409
Kharkivska 39		46.0	47.6	46.8	32.2	33.0	32.6	1.451	1.522	1.486
Kharkivska 41		44.4	46.3	45.3	31.4	33.0	32.2	1.394	1.510	1.452
Puławska Twarda		37.3	39.2	38.3	29.4	30.7	30.1	1.074	1.189	1.132
$LGR_{896/23}$		39.3	42.3	40.8	29.7	34.4	32.1	1.158	1.471	1.314
Torka		35.0	36.1	35.5	35.9	37.7	36.8	1.229	1.337	1.283
Mean		41.7	43.3	–	30.8	32.6	–	1.275	1.395	–
$LSD_{0.05}$	a		3.18			4.15			0.2552	
	b		0.86			1.12			0.0684	
	a×b		ns			ns			ns	

Explanations in Table 2

Table 4. Quality of spring wheat grain.

Cultivars and line		Test weight [kg m^{-3}]			Grain uniformity [%]			Grain glassiness [%]		
		M	C	mean	M	C	mean	M	C	mean
Navigator		726	747	736	86.1	90.3	88.2	77.6	81.4	79.5
Lloyd		695	721	708	75.6	81.2	78.4	77.1	79.9	78.5
Chado		735	764	750	91.1	92.6	91.8	75.3	79.8	77.5
Izolda		763	768	766	88.8	90.5	89.7	70.6	75.9	73.3
Kharkivska 27		722	742	732	84.7	89.9	87.3	68.7	75.7	72.2
Kharkivska 39		749	756	752	92.8	94.5	93.6	69.9	74.1	72.0
Kharkivska 41		722	738	730	89.5	92.5	91.0	70.2	77.3	73.8
Puławska Twarda		768	786	777	85.4	87.5	86.5	64.0	69.4	66.7
$LGR_{896/23}$		710	735	723	80.5	84.7	82.6	80.0	83.0	81.5
Torka		750	776	763	75.6	79.7	77.6	39.3	44.8	42.0
Mean		734	753	–	85.0	88.3	–	69.3	74.1	–
$LSD_{0.05}$	a		25.6			6.31			7.26	
	b		6.9			1.71			1.96	
	a×b		ns			ns			ns	

Explanations in Table 2

be significantly more advantageous than the Polish line and variety as well as Navigator, Lloyd and Izolda. The number of grains per ear in common wheat was greater by 18.2% on average compared to durum wheat. The Ukrainian varieties were characterised by a significantly greater number of grain per ear than the Navigator variety. On the other hand, grain weight per ear of Ukrainian cultivars was significantly greater than that of Navigator and Puławska Twarda varieties.

Bulk density, uniformity and glassiness were to a large extent determined by the level of plant protection and genetic characteristics (Table 4). The intensification of chemical protection resulted in an increase in all the analysed grain quality factors. The varieties that showed the lowest bulk density and grain uniformity was $LGR_{896/23}$ and Lloyd while Chado and Kharkivska 39 showed significantly greater values of those indicators. Grain that showed the greatest bulk density was that of Puławska Twarda and Izolda – respectively 777 and 766 kg m^{-3}. A large percentage of glassy grain was found in $LGR_{896/23}$ line (81.5%) and in Navigator, Lloyd and Chado (77.5–79.5%). The grain of the Polish variety Puławska Twarda was significantly less glassy (66.7%). It was found that the grain of durum wheat was slightly more uniform (by 10.1 percentage points on average) and significantly more glassy (by 33.0 pp on average).

DISCUSSION

One of the most important factors of the comprehensive wheat management system critical for high grain yield is plant protection (Rachoń et al., 2002). Spring durum wheat and common wheat reacted to the use of full chemical protection by an increase in yield by 22.6% on average. The results obtained by Rachoń et al. (2002) show that the use of fungicide, insecticide and retardant resulted in an increase in yield by 1.15 t ha^{-1}. Also other studies showed greater wheat yield achieved through the use of comprehensive plant protection (Podolska et al., 2004) or in better crop management conditions (Kołodziejczyk et al., 2007, Kwiatkowski et al., 2006). On the other hand, according to a study carried out by Pląskowska, Chrzanowska-Drożdż (2008) and Woźniak (2006), protection intensity did not influence the yield of durum wheat. The analysis of the influence of applied plant protection products on ear number per m^2, TGW and grain weight and number per ear showed a significant increase in the value of these elements after the application of comprehensive protection. Other authors have found a similar beneficial influence of intensification of the use of chemical agents on the size of wheat grain (Ciołek, Makarska, 2004), number of ears per m^2 (Kołodziejczyk et al., 2007), grain number per ear (Kwiatkowski et al., 2006) and grain weight per ear (Rachoń et al. 2002).

Rachoń (1997), summarizing results of other studies, said that cultivation of durum wheat is profitable, when its yields are from 70–75% of those of common wheat. In the presented studies, the yield of durum wheat made up from 68.3% to 85.1% of the yield of common wheat. The potential yield of durum wheat smaller than that of common wheat has been also shown by other authors (Rachoń, 1999; Rachoń et al., 2002; Rachoń, Szumiło, 2006; Segit, Szwed-Urbaś, 2009; Woźniak, 2006). The higher yield of *Triticum aestivum* compared to *Triticum durum* is primarily attributable to a significantly grater number of ears, as highlighted in other papers (Rachoń, 1997, 1999; Szumiło, Rachoń, 2008; Woźniak, 2006). According to the literature (Ciołek, Makarska, 2004; Rachoń, 1997, 1999; Rachoń, Szumiło, 2002), a basic quality parameter – TGW – is higher in durum wheat than in common wheat. A similar relation has been found in this study. Grain number and weight per ear of the compared varieties and lines of durum wheat varied, which was also observed by Rachoń et al. (2002).

The analysis of this experiment shows a significant increase in the values of physical quality indicators of wheat after application of comprehensive chemical protection. According to Ciołek and Makarska (2004) the application of pesticides has only a slight influence on glassiness of durum wheat grain. Similarly, Nowak et al. (2005) and Kwiatkowski et al. (2006) found that wheat grain tends to improve its filling after the intensification of chemical application. However, experiments carried out by Podolska et al. (2004) show that the intensification of chemical protection had a positive influence on bulk density. Quality parameters were also determined by the genetic factor, which has a strong influence on grain quality. A variety carries information about its potential quality, which can be achieved in typical weather and agricultural conditions (Podolska, 2007). The research carried out by Rachoń (1997, 1999) and Szwed-Urbaś et al. (1995) shows greater bulk density of common wheat than that of durum wheat, which in the case of most of the compared genotypes was also observed in this study. On the other hand, durum wheat showed slightly higher grain uniformity than common wheat. Similar relation can be found in the literature (Rachoń, 1999). Also grain glassiness, among other quality parameters, determines the quality of durum wheat. The greater the value the better the processing characteristics, since milling results in obtaining more groats than flower. In milling industry to produce good quality semolina, hard and glassy grain is required, since it allows coarse semolina to be produced, which is characterised by low water absorption – desirable quality in pasta production (Segit, Szwed-Urbaś, 2009). In this study, durum wheat grain has been proven to be significantly more glassy compared to common wheat grain, which has been confirmed by other studies (Ciołek, Makarska, 2004; Rachoń, Szumiło, 2002).

CONCLUSIONS

1. The application of comprehensive plant protection, compared to limited protection, increased the spring durum wheat yield by 22.6% on average. An increase in yield was caused by an increased ear number per m^2, TGW, grain number and weight per ear.

2. The limitation of chemical protection resulted in a significant reduction of bulk density, glassiness, and uniformity of spring wheat grain.

3. Depending on a genotype the yield of spring durum wheat made up from 68.3% to 85.1% of that of common wheat.

4. Durum grain was characterised by greater TGW and glassiness and slightly higher uniformity compared to common wheat grain.

REFERENCES

Ciołek A., Makarska E., 2004. The effect of differentiated nitrogen fertilization and chemical protection levels on grain quality traits of durum wheat (*Triticum durum* Desf.). Ann. UMCS, Agricultura, 59(2): 777-784. (in Polish)

Kołodziejczyk M., Szmigiel A., Oleksy A., 2007. Effect of cultivation intensity on yielding of some spring wheat cultivars. Acta Scientia. Polon., Agricultura 6(4): 5-14. (in Polish)

Korbas M., Mrówczynski M., Paradowski A., Horoszkiewicz-Janka J., Jajor E., Pruszyński G., 2008. Plant protection in integrated wheat production. Progr. Plant Protect., 48(4): 1502-1515. (in Polish)

Kwiatkowski C., Wesołowski M., Harasim E., Kubecki J., 2006. Yield and grain quality of winter wheat varieties depending on agricultural level. Pam. Puł., 142: 277-286. (in Polish)

Nowak W., Sowiński J., Pietr J.S., Kita W., 2005. The effect of plant protection treatments on the quality of winter wheat grain. Pam. Puł., 139: 117-127. (in Polish)

Panasiewicz K., Sulewska H., Koziara W., 2008. Efficacy of biological and chemical active compounds in protection of triticum durum against fungal dieseases. J. Res. Appl. Agric. Engin., 53(4): 30-32. (in Polish)

Pląskowska E., Chrzanowska-Drożdż B., 2008. The assessment of plant health status and yielding of winter hard wheat triticum durum as dependent on the chemical protection. Zesz. Probl. Post. Nauk Rol., 531: 177-184. (in Polish)

Podolska G., 2007. Formation of grain quality of wheat through production technology. Stud. Rap. IUNG-PIB, 9: 55-64.

Podolska G., Stypuła G., Stankowski S., 2004. Yield and grain quality of winter wheat depending on different plant protection intensity. Ann. UMCS, Agricultura, 59(1): 269-276. (in Polish)

Pruszyński S., 2009. Plant protection in different cropping systems and biological diversity. Progr. Plant Protect., 49(3): 1091-1101. (in Polish)

Rachoń L., 1997. Yield and grain quality of some hard wheat cultivars (*Triticum durum* Desf.). Biul. IHAR, 204: 141-144. (in Polish)

Rachoń L., 1999. Yield and grain quality of durum wheat (*Triticum durum* Desf.) fertilized with different nitrogen doses. Pam. Puł., 118: 349-355. (in Polish)

Rachoń L., Szumiło G., 2002. Yield and grain quality of some Polish and foreign varieties and lines of hard wheat (*Triticum durum* Desf.). Pam. Puł., 130: 619-624. (in Polish)

Rachoń L., Szumiło G., 2006. Yielding and profitability of hard wheat (*Triticum durum* Desf.) cultivation. Pam. Puł., 142: 404-409. (in Polish)

Rachoń L., Szwed-Urbaś K., Segit Z., 2002. Yielding of new durum wheat (*Triticum durum* Desf.) lines depending on nitrogen fertilization and plant protection levels. Ann. UMCS, Agricultura, 57: 71-76. (in Polish)

Segit Z., Szwed-Urbaś K., 2009. Evaluation of yield structure and technological value of 6 durum wheat (*Triticum durum* Desf.) lines grain. Ann. UMCS, Agricultura, 64 (3): 120-128. (in Polish)

Szumiło G., Rachoń L., 2008. Response of selected species of winter wheat on the sowing date. Ann. UMCS, Agricultura, 63(4): 78-86. (in Polish)

Szwed-Urbaś K., Segit Z., Grundas S., 1995. Preliminary estimation of durum wheat grain quality in the conditions of Lublin region. Biul. IHAR, 194: 149-154. (in Polish)

Woźniak A., 2006. The yield and quality of grain of spring wheat (*Triticum aestivum* L.) and hard wheat (*Triticum durum* Desf.) in dependence on agrotechnical level. Acta Agrophys., 8(3): 755-763. (in Polish)