



Production Systems

Sowing characteristics of the durum wheat seeds (*Triticum durum* Desf.) by use of some antigraminaceous and combined herbicides

G. Delchev*

Department of Plant Production, Faculty of Agriculture, Trakia University, Stara Zagora, Bulgaria

(Manuscript received 31 May 2021; accepted for publication 13 December 2021)

Abstract. The research was conducted during 2018 - 2020 on pelvic vertisol soil type. Under investigation was Bulgarian durum wheat cultivar Predel (*Triticum durum* Desf.). A total of 18 variants were investigated: hand weeded control, 4 antigraminaceous herbicides – Imaspro 7.5 EB (fenoxaprop-ethyl) – 1 l/ha, Sword 240 EC (clodinafop-propargyl) – 250 ml/ha, Traxos 50 EC (pinoxaden + clodinafop-propargyl) – 1.20 l/ha, Axial 050 EC (pinoxaden) – 900 ml/ha and 13 combined herbicides - Axial one (pinoxaden + florasulam) – 1 l/ha, Zerrate (clodinafop-propargyl + piroxulam) – 250 g/ha, Palace 75 WG (piroxulam) – 250 g/ha, Corello duo 85 WG (florasulam + piroxulam) – 250 g/ha, Hussar max OD (mesosulfuron + iodosulfuron) – 1 l/ha, Pacifica expert (amidosulfuron + iodosulfuron-methyl-sodium + mesosulfuron-methyl) – 500 g/ha, Atlantis flex 20.25 WG (mesosulfuron-methyl + propoxycarbazone sodium) – 330 g/ha, Tolurex 500 SC (chlorotoluron) – 4 l/ha, Constell (diflufenican + chlorotoluron) – 4.5 l/ha, Battle delta (flufenacet + diflufenican) – 600 ml/ha, Eagle 75 WG (chlorosulfuron) – 20 g/ha, Prol aqua (pendimethalin) – 3 l/ha, Krum (prosulfocarb) – 5 l/ha. All of the antigraminaceous herbicides and foliar-applied combined herbicides were treated during tillering stage of durum wheat. Soil-applied combined herbicides were treated during after sowing before emergence period of durum wheat. Combined herbicides Tolurex and Constell decreased significantly germination energy and laboratory seed germination of durum wheat seeds. Length of coleoptile was decreased by influence of herbicides Tolurex and Constell. Lengths of primary roots are decreased by influence of herbicides Tolurex, Constell, Krum and Battle delta. The investigated 4 antigraminaceous and 13 combined herbicides did not prove influence on waste grain quantity. Application of combined herbicides Tolurex and Constell after sowing before emergence period led to obtaining the lowest grain yields of durum wheat. Soil-applied combined herbicide Eagle led to obtaining the highest grain yields.

Keywords: durum wheat, antigraminaceous and combined herbicides, grain yield, sowing characteristics

Introduction

The main accent in the study of herbicides in durum wheat crops is on their performance against the dominant weeds, selectivity in relation to the crop and their influence on the grain quality as regards the use as a raw material in the food industry (Rapparini et al., 2004; Hassan et al., 2006; Buczek et al., 2007; Giuliani, 2011; Nazco, 2012; Gerba et al., 2013; Houshmand et al., 2014; Ierna et al., 2016; Magallanes-López A, 2017; Abera et al., 2020). Herbicides will remain in future agriculture effective means of weed control as part of integrated control, therefore there is need for research to optimize their use (Campagna

and Rueegg, 2006; Wozniak, 2013; Jat, 2014; Campiglia, 2015; Woźniak and Stępniewska, 2017; Delchev, 2018, 2018a, 2020; Pagnani, 2019; Toukabri, 2021).

Part of the grain, however, is used as seed for sowing. The realization of the biological potential of durum wheat is closely related to the creation of well-topped and highly productive crops that require high-quality seeds. The question of the influence of herbicidal use in the seed production on the quality of the obtained durum wheat seeds has not yet been elucidated. The experience of their widespread use shows how important it is, having in mind all the factors that determine the effective application of these complex organic compounds.

*e-mail: delchevgd@abv.bg

The aim of this investigation was to establish the influence of 4 antigraminaceous and 13 combined herbicides on the sowing characteristics of durum wheat seeds and the quantity of waste grain.

Material and methods

The research was conducted during 2018 - 2020 on the experimental field of Trakia University, Stara Zagora. Under investigation was Bulgarian durum wheat cultivar Predel (*Triticum durum* Desf.). A field experiment was

conducted under the block method, in 4 repetitions; the size of the crop plot was 15 m². A total of 18 variants were investigated: hand weeded control and 4 antigraminaceous herbicides – Imaspro 7.5 EB, Sword 240 EC, Traxos 50 EC, Axial 050 EC and 13 combined herbicides - Axial one, Zerrate, Palace 75 WG, Corello duo 85 WG, Hussar max OD, Pacifica expert, Atlantis flex, Tolurex 500 SC, Constell, Battle delta, Eagle 75 WG, Prol aqua Krum. The active substances, doses of the tested herbicides and the treatment periods are given in Table 1.

Table 1. Investigated variants

No	Herbicides	Active substance	Dose	Treatment period
1	Control – hand weeded	-	-	-
Antigraminaceous herbicides				
2	Imaspro 7.5 EB	fenoxaprop-ethyl + mefenpyr-diethyl (antidote)	1 l/ha	tillering
3	Sword 240 EC	clodinafop-propargyl + cloquintocet-mexyl (antidote)	250 ml/ha	tillering
4	Traxos 50 EC	pinoxaden + clodinafop-propargyl + cloquintocet-mexyl (antidote)	1.20 l/ha	tillering
5	Axial 050 EC	pinoxaden	900 ml/ha	tillering
Combined herbicides				
6	Axial one	pinoxaden + florasulam clodinafop-propargyl +	1 l/ha	tillering
7	Zerrate	piroxulam + cloquintocet-mexyl (antidote)	250 g/ha	tillering
8	Palace 75 WG	piroxulam + cloquintocet-mexyl (antidote)	250 g/ha	tillering
9	Corello duo 85 WG	florasulam + piroxulam	250 g/ha	tillering
10	Hussar max OD	mesosulfuron + iodosulfuron + mefenpyr-diethyl (antidote)	1 l/ha	tillering
11	Pacifica expert	amidosulfuron + iodosulfuron-methyl-sodium + mesosulfuron-methyl + mefenpyr-diethyl (antidote)	500 g/ha	tillering
12	Atlantis flex 20.25 WG	mesosulfuron-methyl + propoxycarbazone sodium	330 g/ha	tillering
13	Tolurex 500 SC	chlorotoluron	4 l/ha	ASBE
14	Constell	diflufenican + chlorotoluron	4.5 l/ha	ASBE
15	Battle delta	flufenacet + diflufenican	600 ml/ha	ASBE
16	Eagle 75 WG	chlorosulfuron	20 g/ha	ASBE
17	Prol aqua	pendimethalin	3 l/ha	ASBE
18	Krum	prosulfocarb	5 l/ha	ASBE

Note: ASBE – after sowing before emergence

Herbicide Zerrate was used in addition with adjuvant Adigor – 1.5 l/ha,

herbicides Palace 75 WG and Corello duo 85 WG – with adjuvant Dasoil 26-2N – 500 ml/ha,

and herbicides Pacifica expert and Atlantis flex 20.25 WG – with adjuvant Biopower – 1 l/ha.

All herbicides were treated with working solution 200 l/ha. Due to the low adhesion of herbicide Zerrate it was used in addition with adjuvant Adigor – 1.5 l/ha, herbicides Palace 75 WG and Corello duo 85 WG –

with adjuvant Dasoil 26-2N – 500 ml/ha, and herbicides Pacifica expert and Atlantis flex 20.25 WG – with adjuvant Biopower – 1 l/ha.

To study the effects of herbicides only and to eliminate

the negative effects of weeds, they were removed by manual weeding throughout the growing season.

Temperatures during the growing season of durum wheat in 2017-2018 were around normal, and precipitation was above average for the period. During the vegetation period of the harvest year 2018-2019, the temperatures were above the average for the multiannual period, and the precipitation was around the norm. During the vegetation period of 2019-2020 the temperatures were above the average for the period and the precipitation was below the norm.

The grain gained from every variant was cleaned through a sieve with holes size 2.2 mm and the quantity of the waste grain was defined (siftings). All versions of seeds for sowing were defined for their germination energy and lab seed germination. Intensity of early growth of seeds, expressed by the length of primary roots and coleoptile defined on the eighth day after setting the samples was studied.

Each index was determined in two repetitions of the year. Averages in each of the years of experience were used as repetitions in mathematical data processing done according to the method of analysis of variance (Shanin, 1977; Barov, 1982; Lidanski, 1988).

Results and discussion

One of the important conditions for obtaining a normal crop and a good harvest is the use of quality seeds. Apart from the high-yield cultivar which is resistance to diseases and pests, it must have the necessary sowing properties, the main of which are high germination energy and seed germination. Germination energy is one of the most important characteristics of the sowing properties of the seed. The low germination energy is the reason for slower development of primary roots and coleoptile after seed germination and is associated with later germination in field conditions, less tempering of plants and higher risk of frost in the winter. It leads to lower grain yields. The obtained results showed that the soil application of the durum wheat with chlorotholuron containing combined herbicides Tolurex and Constell led to decreased germination energy (Table 2). Analysis of variance, in which the years have been taken for replications, showed that these increases were mathematically proven. A low decrease in germination energy was obtained at foliar treatment with mesosulfuron containing combined herbicides - Hussar max, Pacific expert and Atlantis flex, but this was not proved by analyses of variance.

Table 2. Influence of some antigraminaceous and combined herbicides on sowing characteristics of the seeds (mean 2018 - 2020)

Herbicides	Germinative energy, %	Germination, %	Length, cm		Waste grain, %
			Coleoptile	Root	
Control – hand weeded	85.5	97.0	10.98	15.94	8.3
Imaspro	84.5	98.0	9.87	13.23	8.9
Sword	85.0	94.5	9.95	13.34	8.8
Traxos	85.5	95.0	9.96	13.52	8.6
Axial	86.0	95.5	9.97	14.75	8.4
Axial one	86.0	95.5	9.87	14.68	8.4
Zerrate	85.5	95.0	9.86	13.62	8.5
Palace	85.5	96.5	10.10	14.56	8.4
Corello duo	85.5	96.0	10.08	14.50	8.4
Hussar max	82.5	96.0	10.20	15.43	8.3
Pacifica expert	82.0	96.5	10.09	15.35	8.3
Atlantis flex	83.0	96.5	10.23	15.51	8.3
Tolurex	78.5	92.0	8.33	7.97	9.3
Constell	79.0	92.6	8.97	8.28	9.1
Battle delta	84.5	96.5	9.91	12.34	9.0
Eagle	85.0	95.5	10.13	15.41	8.1
Prol aqua	85.5	97.5	10.15	14.26	8.8
Krum	85.5	95.5	10.86	12.17	8.8
LSD 0.5	6.2	4.4	2.0	3.2	1.1
LSD 0.1	8.3	6.1	4.7	5.8	2.5
LSD 0.01	10.5	8.3	7.1	8.0	4.1

Germination is the most important index characterizing the sowing properties of the seed. At low laboratory germination sowing should be done with higher sowing rate, which increases the cost production. Laboratory germination of the seeds in all variants during the three

years of study above the requirements of the standard for over 85% germination, although in different years, account for some variation of its values. This is the positive effect of use of antigraminaceous and combined herbicides, because it is not necessary to increase the sowing rate

(in kg/ha) and the cost of necessary seeds. At soil-applied herbicides Tolurex and Constell, seed germination was proved lower than hand weeded control. Durum wheat seeds germinate normally by influence of the herbicides Hussar max, Pacific expert and Atlantis flex, although the initial rate of development was lower due to lower germination energy. Other combined herbicides Axial one, Zerrate, Palace, Corello duo, Battle delta, Eagle, Prol aqua and Krum, as well as antigraminaceous herbicides Imaspro, Sword, Traxos and Axial did not change the proven indexes germination energy and seed germination. This means that they help for joint and fast germination of the durum wheat sowing-seeds.

The obtained results for germination energy and seed germination were a prerequisite to continue to test the effect of herbicides and their tank mixtures on initial intensity of the growth of seeds, expressed by the length of roots and coleoptiles. It was found that the length of coleoptiles of durum wheat was decreased by herbicides Tolurex and Constell. The length of primary roots of durum wheat was decreased only by herbicides Tolurex, Constell, Krum and Battle delta. This decreasing was proven by analysis of variants. These four herbicides hinder the development of young plants, reduce their resistance to cold and increase the risk of frost damages during winter months. Other combined herbicides Axial one, Zerrate, Palace, Corello duo, Hussar max, Pacific expert, Atlantis flex, Battle delta, Eagle, Prol aqua and Krum, as well as antigraminaceous herbicides Imaspro,

Sword, Traxos and Axial did have proven influence on the growth of the length of primary roots and coleoptiles of durum wheat and recommended for use in seed production crops of durum wheat.

At the evaluation of the sowing characteristics we have to consider not only the characteristics of the sowing seeds but also the quantity of the waste grain (siftings) which are gained at the preparation of these seeds. Bigger quantity screenings lead to higher cost of the seed and reduce the economic effect of seed production of durum wheat. None of the investigated 4 antigraminaceous herbicides and 13 combined herbicides led to mathematically proven increase in the quantity of waste grain. Other antigraminaceous herbicides, antibroadleaved herbicides and their tank mixtures led to decreasing the quantity of waste grain. Differences between them and hand weeded control were mathematically unproven. Only application of herbicides Tolurex, Constell and Battle delta showed a low increase in waste grain quantity, but it was not proven by the analysis of variance.

Decreases in the values of germination energy and laboratory seed germination, changes in the intensity of the initial growth, expressed by the length of the root and coleoptile at germination and changes in the quantity of waste grain by the influence of herbicides Tolurex, Constell, Krum and Battle delta were explained by the depressing effects on growth and development of durum wheat during its vegetative period.

Table 3. Influence of some antigraminaceous and combined herbicides on grain yield of durum wheat (mean 2018 - 2020)

Herbicides	2018		2019		2020		Mean	
	kg/ha	%	kg/ha	%	kg/ha	%	kg/ha	%
Control – hand weeded	5354	100	5286	100	5100	100	5247	100
Imaspro	5240	97.9	5036	95.3	5067	99.3	5114	97.4
Sword	5138	96.0	5161	97.6	5067	99.3	5122	97.6
Traxos	5240	97.9	5127	97.0	5049	99.0	5139	97.9
Axial	5331	99.6	5061	95.7	5033	98.5	5142	98.0
Axial one	5300	99.0	5022	95.0	4998	98.0	5107	97.3
Zerrate	5290	98.8	5075	96.0	4988	97.8	5118	97.5
Palace	5311	99.2	5085	96.2	5033	98.5	5143	98.0
Corello duo	5300	99.0	5085	96.2	4998	98.0	5128	97.7
Hussar max	5190	97.0	5161	97.6	5117	100.4	5156	98.2
Pacifica expert	5183	96.8	5127	97.0	5090	99.8	5133	97.8
Atlantis flex	5252	98.1	5170	97.8	5100	100	5174	98.6
Tolurex	5129	95.8	4937	93.4	4835	94.8	4967	94.7
Constell	5140	96.0	4995	94.5	4850	95.1	4995	95.2
Battle delta	5161	96.4	5127	97.0	4942	96.9	5077	96.8
Eagle	5194	97.1	5311	100.5	5133	100.7	5213	99.3
Prol aqua	5194	97.1	5261	99.5	4967	97.0	5141	97.9
Krum	5183	96.8	5211	98.6	4867	94.8	5087	97.0
LSD 5%	220	4.1	296	5.6	255	5.0		
LSD 1%	321	6.0	386	7.3	316	6.2		
LSD 0.1%	466	8.7	529	10.0	464	9.1		

To make a full evaluation of the sowing characteristics it is necessary to establish not only the quality of seeds, but also the quantity of grain which will be received from these seeds. Data about the influence of antigraminaceous and combined herbicides included in the experiment on grain yield (Table 3) showed that the greatest reduction in grain yield relative to the hand weeded control was registered by use of herbicide Tolurex on soil application during after sowing before emergence period - with 280 kg/ha or 5.3% on average for the period. Soil application of the herbicide Constell during the after sowing before emergence period also had a negative effect on grain yield. The yield reduction was 252 kg/ha or 4.8% on average over the period.

Reducing the percentage of active substance chlorotoluron in 1 kg of product and adding to it the active substance diflufenican in herbicide Constell increased the selectivity of the herbicide to grain yield compared to herbicide Tolurex containing chlorotoluron only.

High selectivity to durum wheat of the other herbicides included in the investigation was found: the antigraminaceous herbicides Imaspro, Sword, Traxos, Axial, the combined herbicides Axial one, Zerrate, Palace, Corello duo, Hussar max, Pacifica expert, Atlantis flex, treated during tillering stage of durum wheat and Battle delta, Eagle, Prol aqua, Krum, applied during after sowing before emergence period. In these, grain yields did not differ provenly from those in hand weeded control. Practically equal to the yields of the hand weeded control were the yields obtained by soil application of herbicide Eagle.

Conclusion

Combined herbicides Tolurex and Constell decreased significantly germination energy and laboratory seed germination of the durum wheat seeds. Length of coleoptile was decreased by influence of herbicides Tolurex and Constell. Lengths of primary roots are decreased by influence of herbicides Tolurex, Constell, Krum and Battle delta. The investigated 4 antigraminaceous and 13 combined herbicides did not prove influence on waste grain quantity. Application of combined herbicides Tolurex and Constell after sowing before emergence period led to obtaining the lowest grain yields of durum wheat. Soil-applied combined herbicide Eagle led to obtaining the highest grain yields.

References

- Abera D, Tamado T and Tadesse**, 2020. Effects of blended fertilizer rates on yield and grain quality of durum wheat (*Triticum turgidum* L.) varieties in Minijar Shenkora district, central Ethiopia. *Ethiopian Journal of Agricultural Sciences*, 30, 57-76.
- Barov V**, 1982. Analysis and schemes of the field experience. NAPO, Sofia, p. 668 (Bg).
- Buczek J, Tobiasz-Salach R, Szpunar-Krok E and Bobrecka-Jamro D**, 2007. Assessment of the effectiveness of application of selected herbicides on spring wheat. *Fragmenta Agronomica*, 24, 48-57.
- Campagna C and Rueegg W**, 2006. Pinoxaden: new herbicide for post emergence application in wheat and barley [*Triticum aestivum* L.; *Triticum durum* Desf.; *Hordeum vulgare* L.; Italy; France; Germany]. *Atti delle Giornate Fitopatologiche*, (pt.1), 285-290.
- Campiglia E**, 2015. The long-term effects of conventional and organic cropping systems, tillage managements and weather conditions on yield and grain quality of durum wheat (*Triticum durum* Desf.) in the Mediterranean environment of Central Italy. *Field Crops Research*, 176, 34-44.
- Delchev G**, 2018. Mixability of herbicides with growth regulators and foliar fertilizers. Monograph, ISBN: 978-613-6-64820-0, LAP LAMBERT Academic Publishing, Saarbrücken, Germany, p. 329.
- Delchev G**, 2018a. Late use of herbicides in durum wheat crop (*Triticum durum* Desf.). Monograph, ISBN: 978-613-8-26945-8, LAP LAMBERT Academic Publishing, Saarbrücken, Germany, p. 141.
- Delchev G**, 2020. Winter resistance of oilseed canola and reseeding with spring crops. Monograph, ISBN: 978-620-2-68306-7, LAP LAMBERT Academic Publishing, Saarbrücken, Germany, p. 129.
- Gerba L, Belay G and Worku W**, 2013. Nitrogen fertilization effects on grain quality of durum wheat (*Triticum turgidum* L. var. *durum*) varieties in central Ethiopia. DOI: 10.4236/as.2013.43019
- Giuliani M**, 2011. Relationships between nitrogen utilization and grain technological quality in durum wheat: II. Grain yield and qualities. *Agronomy Journal*, 103, 1668-1675.
- Hassan G, Khan I, Bibi S and Shah N**, 2008. To

- investigate the efficacy of different herbicides alone or in mixtures for controlling weeds in wheat. *Pakistan Journal of Plant Sciences*, 14, 59-65.
- Houshmand S, Arzani A and Mirmohammadi S**, 2014. Effects of salinity and drought stress on grain quality of durum wheat. *Communications in Soil Science and Plant Analysis*, 45, 297-308.
- Ierna A, Lombardo G and Mauromicale G**, 2016. Yield, nitrogen use efficiency and grain quality in durum wheat as affected by nitrogen fertilization under a Mediterranean environment. *Experimental Agriculture*, 52, 314-329.
- Jat S**, 2014. Effect of nitrogen and weed management on productivity and quality of durum wheat (*Triticum durum*). *Indian Journal of Agronomy*, 59, 281-285.
- Lidanski T**, 1988. *Statistical methods in biology and agriculture*, Sofia, p. 376 (Bg).
- Magallanes-López A**, 2017. Grain quality traits of commercial durum wheat varieties and their relationships with drought stress and glutenins composition. *Journal of Cereal Science*, 75, 1-9.
- Nazco R**, 2012. Can Mediterranean durum wheat landraces contribute to improved grain quality attributes in modern cultivars? *Euphytica*, 185, 1-17.
- Pagnani G**, 2019. Effect of soil tillage and crop sequence on grain yield and quality of durum wheat in Mediterranean areas. *Agronomy*, 9, 480-488.
- Rapparini G, Paci F, Bartolini D and Romagnoli S**, 2004. Further study of miscibility between clodinafop-propargyl and tralkoxydim with broad-leaf herbicides applied in post-emergence of wheat [*Triticum aestivum* L.; *Triticum durum* Desf.; Emilia-Romagna]. *Atti delle Giornate Fitopatologiche*, (pt.1), 357-362.
- Shanin Yo**, 1977. Methodology of the field experience. *Bulgarian Academy of Science*, p. 384 (Bg).
- Toukabri W**, 2021. Improvements of durum wheat main crop in weed control, productivity and grain quality through the inclusion of fenugreek and clover as companion plants: effect of N fertilization regime. *Agronomy*, 11, 78.
- Woźniak A and Stępniewska A**, 2017. Yield and quality of durum wheat grain in different tillage systems. *Elem Journal*, 22, 817-829.
- Wozniak A**, 2013. The effect of tillage systems on yield and quality of durum wheat cultivars. *Turkish Journal of Agriculture and Forestry*, 37, 133-138.