SECȚIUNEA III

Sisteme de protecţie integrată a plantelor cu capacităţi de ameliorare fitosanitară a agrocenozelor şi obținerea produselor agricole competitive

CZU: 633.174:[631.811.98+632.954] https://doi.org/10.53040/ppap2023.37

PRODUCTIVITY OF CLEARFIELD OILSEED CANOLA (*Brassica napus* L.) BY INFLUENCE OF SOME HERBICIDES, HERBICIDE TANK MIXTURES AND HERBICIDE COMBINATIONS

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Summary: During the period 2018 - 2020 a field experiment was carried out with the winter Clearfield oilseed canola hybrid Phoenix CL (*Brassica napus* L). A total of 15 variants were investigated. They included untreated control, 2 combined herbicidesp 6 herbicide tank mixturesp 6 herbicide combinations. Foliar-applied herbicides were treated during 2-4 leaf canola stage. Soil-applied combined herbicides were treated during after sowing before emergence period of the canola. The lowest canola yields are obtained in untreated control as a result of the big weed infestation. The highest seed yields are obtained by use of combined herbicide Cleranda, followed by herbicide tank mixture Electron + Maza and combined herbicide Cleravo. High canola yields are also obtained by herbicide tank mixtures Butizan max + Maza, Springbok + Maza, Tanaris + Maza, as well as by herbicide combinations Caliph mega + Maza, Brasan + Maza, Bismarck + Maza. Increase in seed yields is due to the greatest degree of increase in indexes seeds number per pod, seed weight per pod and 1000 seeds weight. Plant height is greatest by use of combined herbicide Cleranda, followed by herbicide tank mixture Electron + Maza and combined herbicide Cleravo.

Keywords: *oilseed canola, herbicides, herbicide tank mixtures, herbicide combinations, seed yield, structural elements*

Introduction. Integrated weed control in oilseed canola is a combination of preventive, mechanical and chemical methods to reduce environmental pollution (Murawa and Warminski, 2004; Salimi et al., 2007; Zand et al., 2009). Cruciferous weeds are the most dangerous weeds in canola due to their difficult control in its crops (Oliveira Junior, 2001; Delchev, 2018 and 2020). At the conventional technology for oilseed canola growing some of the registered selective herbicides have no satisfactory efficacy against these weeds (Majchrzak et al., 2008; Majchrzak and Jarosz, 2010; Werner, 2014; Zotz et al., 2016). The fight against the weeds from *Brassicaceae* family in many countries is done by the use of GMO canola hybrids which are banned on the territory of the European Union, including in Bulgaria (McMullan et al., 1994). An alternative to solving this problem is Clearfield technology for oilseed canola growing (Pfenning et al., 2012; Delchev, 2021). This technology uses imidazolinone-tolerant canola hybrids (Schönhammer et al., 2010; Ádámszki et al., 2010).

The purpose of this investigation was to establish the changes in the seed yield and structural elements of yield by influence of some herbicides, herbicide tank mixtures and herbicide combinations in winter Clearfield oilseed canola under different meteorological condition.

Material and methods. The research was conducted during 2018 - 2020 with the imazamox-tolerant canola hybrid Phoenix CL (*Brassica napus* L). It was carried out a field experiment as a block method in 4 repetitions, on a 15 m^2 harvesting area, on pellic vertisol soil type, after durum wheat predecessor. A total of 15 variants were investigated. They included untreated control, 2 combined herbicides: Cleranda SC and Cleravo SC; 6 herbicide tank mixtures: Electron 500 SC + Maza 4 SL, Springbok + Maza 4 SL, Tanaris + Maza 4 SL, Butisan max + Maza 4 SL, Cliofar 600 SL + Maza 4 SL and Galera super + Maza 4 SL; 6 herbicide combinations: Caliph 480 EC + Maza 4 SL, Caliph mega + Maza 4 SL, Bismark CS + Maza 4 SL, Nero EC + Maza 4 SL, Brasan 540 EC + Maza 4 SL and Colsor trio EC + Maza 4 SL. The active substances, doses and periods of treatments of the investigated herbicides, herbicide tank mixtures and herbicide combinations are given in Table 1. Foliar-applied herbicides were treated during 2-4 leaf canola stage. Soil-applied combined herbicides were treated during after sowing before emergence period of the canola. All variants are applied with working solution consumption 200 l/ha. The mixing of the tank mixtures is done in tank of the sprayer. Due to of low

adhesion of the herbicides Cleranda, Cleravo and Maza were used in addition with adjuvant Dash HC – 1 l/ha.

Table 1. Investigated variants

№	Variants	Active substance	Doses	Treatment period
1	Control – untreated	-	-	-
Herbicides				
2	Cleranda SC	metazachlor + imazamox	2 l/ha	2-4 leaf
3	Cleravo SC	quinmerac + imazamox	1 l/ha	2-4 leaf
Herbicide tank mixtures				
4	Electron 500 SC + Maza 4 SL	metazachlor + quinmerac imazamox	2 l/ha 1.25 l/ha	2-4 leaf 2-4 leaf
5	Springbok + Maza 4 SL	metazachlor + dimethenamid-P imazamox	2.5 l/ha 1.25 l/ha	2-4 leaf 2-4 leaf
6	Tanaris + Maza 4 SL	dimethenamid-P + quinmerac imazamox	1.5 l/ha 1.25 l/ha	2-4 leaf 2-4 leaf
7	Butisan max + Maza 4 SL	metazachlor + quinmerac + dimethenamid-P imazamox	2.5 l/ha 1.25 l/ha	2-4 leaf 2-4 leaf
8	Cliofar 600 SL + Maza 4 SL	clopyralid imazamox	250 ml/ha 1.25 l/ha	2-4 leaf 2-4 leaf
9	Galera super + Maza 4 SL	clopyralid + picloram + aminopyralid imazamox	250 ml/ha 1.25 l/ha	2-4 leaf 2-4 leaf
Herbicide combinations				
10	Caliph 480 EC + Maza 4 SL	clomazone imazamox	200 ml/ha 1.25 l/ha	ASBE 2-4 leaf
11	Caliph mega + Maza 4 SL	clomazone + metazachlor imazamox	3 l/ha 1.25 l/ha	ASBE 2-4 leaf
12	Bismark CS + Maza 4 SL	clomazone + pendimethalin	1.5 l/ha 1.25 l/ha	ASBE 2-4 leaf

		imazamox		
13	Nero EC + Maza 4 SL	clomazone + petoxamide imazamox	3 l/ha 1.25 l/ha	ASBE 2-4 leaf
14	Brasan 540 EC + Maza 4 SL	clomazone + dimethachlor imazamox	2 l/ha 1.25 l/ha	ASBE 2-4 leaf
15	Colsor trio EC + Maza 4 SL	clomazone + dimethachlor + napropamide imazamox	4 l/ha 1.25 l/ha	ASBE 2-4 leaf
Herbicides Cleranda, Cleravo and Maza were used in addition with adjuvant Dash HC – 1 l/ha. ASBE – after sowing, before emergence				

At winter Clearfield oilseed canola maturity all plots were evaluated for seed yield and yield components – pod length, number of seeds per pod, seed weight per plant and 1000 seeds weight, to evaluate the influence of the herbicides, herbicide tank mixtures and herbicides combinations on canola seed yield and yield components. It was investigated and changes who made of the tested factors in the plant height. Analysis of variance method was used to study the influence of herbicide treatments on winter Clearfild oilseed canola.

Results and discussions. The weed flora present during the 3-year experiment was quite varied.

The first weeds in winter Clearfield canola crops are mainly late spring weeds *Amaranthus retroflexus* L., *Chenopodium album* L., *Polygonum aviculare* L, *.Abutilon theophrasti* Medic., *Xanthium strumarium* L., *Hibiscum trionim* L.

During October germinate winter-spring broadleaved weeds *Anthemis arvensis* L., *Chamomilla recutita* Rauchert, *Galium aparine* L., *Sinapis arvensis* L., *Raphanus raphanistrum* L., *Capsella bursa pastoris* L., *Descurainia sophia* Plantl., *Thlaspi arvense* L., *Falopia convolvulus* Leve, *Myagrum perfoliatum* L., *Lithospermum arvense* L., *Papaver rhoes* L., *Thlaspi arvense* L., *Consolida regalis* Gray, *Viola tricolor* L., *Lamium purpureum* L., *Veronica hederifolia* L., *Stellaria media* Cyr.

Winter-spring graminaceous weeds are represented by *Avena ludoviciana* Durien., *Alopecurus myosuroides* L., *Apera spica-venti* P.B., *Lolium multiflorum* L., *Lolium temulentum* L., *Bromus arvensis* L.

Self-sown plants are represented by durum wheat (*Triticum durum* Desf.), coriander (*Coriandrum sativum* L.) and milk thistle (*Silybum marianum* Gaertn.).

The results show that there is a positive correlation between biological efficacy of the herbicides, herbicide tank mixtures and herbicides combinations against weeds and canola seed yields (Table 2).

Table 2. Influence of some herbicides, herbicide tank mixtures and herbicide combinations on seed yield of canola (2018 - 2020)

Variants	2018		2019		2020		Mean	
	kg/ha	%	kg/ha	%	kg/ha	%	kg/ha	%
Control – untreated	3933	100	3630	100	3505	100	3689	100
Herbicides								
Cleranda	4727	120.2	4345	119.7	4276	122.0	4449	120.6
Cleravo	4688	119.2	4283	118.0	4245	121.1	4405	119.4
Herbicide tank mixtures								
Electron + Maza	4722	120.1	4320	119.0	4260	121.5	4434	120.2
Springbok + Maza	4672	118.8	4276	117.8	4213	120.2	4387	118.9
Tanaris + Maza	4590	116.7	4207	115.9	4171	119.0	4322	117.2
Butisan max + Maza	4657	118.4	4283	118.0	4206	120.0	4382	118.8
Cliofar + Maza	4330	110.1	3968	109.3	3926	112.0	4075	110.5
Galera super + Maza	4334	110.2	3822	105.3	3961	113.0	4040	109.5
Herbicide combinations								
Caliph + Maza	4370	111.1	4156	114.5	4000	114.2	4175	113.2
Caliph mega + Maza	4641	118.0	4273	117.7	4210	120.1	4375	118.6
Bismark + Maza	4602	117.0	4207	115.9	4171	119.0	4326	117.2
Nero + Maza	4491	114.2	4102	113.0	4080	116.4	4224	114.5
Brasan + Maza	4602	117.0	4214	116.1	4167	118.9	4328	117.3
Colsor trio + Maza	4370	111.1	3866	106.5	4000	114.2	4079	110.6
LSD 5 %	252	7.2	310	8.5	373	10.6		
LSD 1 %	303	7.7	382	10.5	469	13.4		
LSD 0.1 %	366	9.3	461	12.7	588	16.8		

The lowest seed yields are obtained in the untreated control, as a result of the high weed infestation with broadleaved and graminaceous weeds and self-sown plants of *Triticum durum* Desf., *Coriandrum sativum* L. and *Silybum marianum* Gaertn.

The highest seed yields are obtained by use of combined herbicide Cleranda – 120.6 % compared to the untreated control.

Almost the same seed yields are obtained by use of herbicide tank mixture Electron + Maza - 120.2% above the control. Obviously, the combination of three active substances - metazachlor and quinmerac (from herbicide Electron) and imazamox (from herbicide Maza) leads to high herbicide efficiency of the tank mixture, without any manifestations of phytotoxicity on canola plants. These results are confirmed by studies of Schönhammer and Freitag (2014). These authors studied the herbicides Vantiga D and Cleravis SC, which contain three active substances - metazachlor, quinmerac and imazamox. They also found high herbicidal efficacy and selectivity of the tested combined herbicides. Unfortunately, these herbicides have not yet been registered in Bulgaria.

Very high seed yields are obtained by use of combined herbicide Cleravo - 119.4 % above the untreated control. These yields are slightly lower than those of herbicide Cleranda and tank herbicide mixture Electron + Maza, due to the shorter duration of action of Cleravo due to the absence of the active substance metazachlor in this combined herbicide.

Very high canola yields were also obtained by herbicide tank mixtures Springbok + Maza and Butizan max + Maza, 118.9 % and 118.8 % above the control, respectively. High results from the combination of the active substances metazachlor, dimethenamid-P, quinmerac and imazamox have also been reported by Schönhammer et al. (2018). These authors combine herbicide Butizan combi (metazachlor + dimethenamid-P) with herbicide Clentiga SC (quinmerac + imazamox).

High seed yields are obtained by herbicide combinations Caliph mega + Maza, Brasan + Maza, Bismarck + Maza and by herbicide tank mixture Tanaris + Maza – from 118.6 % to 117.2 % above the untreated control.

Lower seed yields are obtained by herbicide combinations Nero + Maza, Caliph + Maza, Colsor trio + Maza and by herbicide tank mixtures Cliofar + Maza and Galera super + Maza. In all these variants, seed yields were also higher than in the untreated control. The reason for lower yields of Nero + Maza, Caliph + Maza and Cliofar + Maza is the lower herbicide efficacy of these variants. The reason for lower yields of Colsor trio + Maza and Galera super + Maza is their stronger phytotoxicity to oilseed canola. In herbicide tank mixture Galera super + Maza, the probable cause is the mixing of active substances clopyralid, aminopyralid and picloram on the

one hand with active substance imazamox on the other hand. In herbicide combination Colsor trio + Maza, the probable cause is the mixing of active substances clomazone, dimethachlor and napropamide on the one hand with active substance imazamox on the other hand.

To explain changes in winter Clearfield oilseed canola seed yield were investigated some of the components that determine it (Table 3). The results of structural analysis show, that the increase in seed yield is due to the greatest extent of the increase in the pod length, seed number per pod, the seed weight per pod and 1000 seed weight. The differences are mathematically proven. The greatest increase in the seed number per pod, the seed weight per pod and 1000 seed weight compared to untreated control is obtained by use of combined herbicide Cleranda followed by herbicide tank mixture Electron + Maza and herbicide Cleravo. It was established an increase in the pod length in the all variants. The increase in this index is less, but also has been proven mathematically. The pod length has a lesser influence on the yield value. More importantly for oilseed canola, the pods are filled with two rows of normally, well-fed and well ripened seeds.

Studied herbicides and herbicide combinations have an influence on plant height. It is lowest in the untreated control. This is due to competition between existing in the control weeds and canola plants. Eliminate the negative effect of weeds leads to an increase in plant height in all variants. The values of this index are the highest by use of combined herbicide Cleranda followed by herbicide tank mixture Electron + Maza and herbicide Cleravo. The canola plant height is lower in herbicide tank mixture Galera super + Maza and herbicide combination Colsor trio + Maza. As this reduction is accompanied by an increase in seed yield compared to untreated control, as a result of the high herbicide efficacy, these variants have a retardant effect rather than a phytotoxic effect. This is a further positive effect of their use as it reduces the risk of pulling down or breaking of the plants in a storm and downfall of the yield.

Table 3. Influence of some herbicides, herbicide tank mixtures and herbicide combinations on yield components of canola seeds (mean 2018 - 2020)

Variants	Pod length, cm	Seeds per pod, number	Seed weight per pod, g	1000 seed weight, g	Plant height, cm
Control – untreated	7.3	28.9	0.039	3.02	137.5
Herbicides					
Cleranda	8.6	34.8	0.111	3.44	145.3
Cleravo	8.6	34.4	0.106	3.42	145.0
Herbicide tank mixtures					
Electron + Maza	8.6	34.6	0.108	3.44	145.1
Springbok + Maza	8.6	34.2	0.100	3.42	144.7
Tanaris + Maza	8.8	33.6	0.098	3.42	144.0
Butisan max + Maza	8.6	34.2	0.100	3.42	144.7
Cliofar + Maza	8.7	33.0	0.086	3.33	144.4
Galera super + Maza	8.7	32.6	0.082	3.16	142.8
Herbicide combinations					
Caliph + Maza	8.8	33.4	0.090	3.40	144.8
Caliph mega + Maza	8.6	34.0	0.098	3.40	144.0
Bismark + Maza	8.6	33.8	0.094	3.38	144.7
Nero + Maza	8.8	33.6	0.098	3.42	144.0
Brasan + Maza	8.6	34.0	0.096	3.34	144.6
Colsor trio + Maza	8.8	33.0	0.086	3.34	142.9
LSD 5%	1.0	2.9	0.038	0.16	4.8
LSD 1%	2.2	4.3	0.046	0.30	8.1
LSD 0.1%	3.7	6.1	0.058	0.49	12.2

Conclusions

The lowest canola yields are obtained in untreated control as a result of the big weed infestation.

The highest seed yields are obtained by use of combined herbicide Cleranda, followed by herbicide tank mixture Electron + Maza and combined herbicide Cleravo.

High canola yields are also obtained by herbicide tank mixtures Butizan max + Maza, Springbok + Maza, Tanaris + Maza, as well as by herbicide combinations Caliph mega + Maza, Brasan + Maza, Bismarck + Maza.

Increase in seed yields is due to the greatest degree of increase in indexes seeds number per pod, seed weight per pod and 1000 seeds weight.

Plant height is greatest by use of combined herbicide Cleranda, followed by herbicide tank mixture Electron + Maza and combined herbicide Cleravo.

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