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Impact of some herbicides, herbicide combinations and herbicide tank mixture on sowing characteristics of chickpea (*Cicer arietinum* L.)

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Abstract

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The research was conducted during 2016 – 2018 on pellic vertisol soil type. Under investigation was chickpea cultivar Kabule (*Cicer arietinum* L.). Factor A included untreated control and 4 soil-applied herbicides – Dual gold 960 EC (S-metolachlor) – 1.5 l.ha^{-1}, Stomp aqua (pendimethalin) – 3 l.ha^{-1}, Merlin flex 480 SC (isoxaflutole) – 420 g.ha^{-1} and Pelican 50 SC (diflufenikan) – 250 ml.ha^{-1}. Factor B included untreated control, 3 foliar-applied herbicides – Pulsar 40 (imazamox) – 1.2 l.ha^{-1}, Challenge 600 SC (aclonifen) – 4 l.ha^{-1} and Shadow 3 EC (clethodim) – 1.6 l.ha^{-1} and 1 herbicide tank mixture – Challenge 600 SC (aclonifen) – 4 l.ha^{-1} + Shadow 3 EC (clethodim) – 1.6 l.ha^{-1}. Soil herbicides were applied during the period after sowing before emergence. Foliar herbicides were applied during 6 – 8 real leaf stage of the chickpea. Alone use of foliar-applied herbicide Pulsar and its combinations with soil-applied herbicides Dual gold, Stomp aqua, Merlin flex and Pelican proven decrease germination energy of the chickpea seeds. Laboratory seed germination proves decreasing by herbicide combination Pelican + Pulsar only. Length of primary germ is decreased by alone use of foliar-applied herbicide Pulsar and its combinations with soil-applied herbicides Dual gold, Stomp aqua, Merlin flex and Pelican. Length of primary root is decreased by herbicide combination Pelican + Pulsar only. Herbicide combination Pelican + Pulsar proven increases waste grain quantities. Alone uses of herbicides Pelican and Pulsar do not proven decreases waste grain quantities. The highest yields of chickpea seeds are obtained by foliar treatment with herbicide tank-mixture Challenge + Shadow after soil-applied herbicides Pelican and Merlin flex. High yields are obtained also by foliar treatment with herbicide tank-mixture Challenge + Shadow after soil-applied herbicides Stomp aqua and Dual gold.

Keywords: chickpea; herbicides; herbicide combinations; seed yield; sowing characteristics

Introduction

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 (Velasquez & Alonso, 1993; Soltero-Díaz et al., 2010; Delchev, 2018). The experience of their widespread use shows how important it is borne in mind all the factors that determine the effective application of these complex organic compounds. The main accent in the study of herbicides in chickpea is on their efficacy against the dominant weeds, selectivity in relation of crop and their influence on the seed quality as regards the use as a raw material in the food industry (Skrobakova, 1998 & 1999; Vaissi & Shimi, 2003; Şanlı et al., 2009; Ratnam & Rao, 2011).

A part of the seeds, however, is used as a seed for sowing. The realization of the biological potential of chickpea is closely related to the creation of well-topped and highly productive crops that require high-quality seeds. Herbicides are a systemic environmental stressor and besides direct action, they can also have a specific effect on next-generation plants (Khan et al., 2006; Tanveer et al., 2010; Hoseiny-Rad

& Jagannath, 2011). The question of the influence of herbicidal use in the seed production on the quality of the obtained chickpea seeds has not yet been clarified.

Considering these achievements, we set the aim of this investigation to establish the influence of some herbicides, herbicide combinations and an herbicide tank mixture on sowing characteristics of the chickpea seeds and the quantity of waste grain.

Materials and Methods

The research was conducted during 2016 – 2018 on pellic vertisol soil type. Under investigation was chickpea cultivar Kabule (*Cicer arietinum* L.). Two factors experiment was conducted under the block method, in 4 repetitions; the size of the crop plot was 15 m^2. Factor A included untreated control and 4 soil-applied herbicides – Dual gold 960 EC (S-metolachlor) – 1.5 $l.ha^{-1}$, Stomp aqua (pendimethalin) – 3 $l.ha^{-1}$, Merlin flex 480 SC (isoxaflutole) – 420 $g.ha^{-1}$ and Pelican 50 SC (diflufenikan) – 250 $ml.ha^{-1}$. Factor B included untreated control, 3 foliar-applied herbicides – Pulsar 40 (imazamox) – 1.2 $l.ha^{-1}$, Challenge 600 SC (aclonifen) – 4 $l.ha^{-1}$ and Shadow 3 EC (clethodim) – 1.6 $l.ha^{-1}$ and 1 herbicide tank mixture – Challenge 600 SC (aclonifen) – 4 $l.ha^{-1}$ + Shadow 3 EC (clethodim) – 1.6 $l.ha^{-1}$. Active substances of herbicides and their doses are shown in Table 1.

Soil herbicides were applied during the period after sowing before emergence. Foliar herbicides were applied during 6 – 8 real leaf stage of the chickpea. All of herbicides, herbicide combinations and herbicide tank-mixture were applied in a working solution of 200 $l.ha^{-1}$. Mixing of foliar-applied herbicides was done in the tank on the sprayer. Due to of low adhesion of the herbicide Pulsar 40 was used in addition with adjuvant Dash HC – 1 $l.ha^{-1}$.

Table 1. Investigated variants

№	Variants	Active substance	Doses
After sowing, before emergence			
1	Control	–	–
2	Dual gold 960 EC	S-metolachlor	1.2 $l.ha^{-1}$
3	Stomp aqua	pendimethalin	3 $l.ha^{-1}$
4	Merlin flex 480 SC	isoxaflutole	420 $g.ha^{-1}$
5	Pelican 50 SC	diflufenikan	250 $ml.ha^{-1}$
6 – 8 real leaf stage			
1	Control	–	–
2	Pulsar 40	imazamox	1.2 $l.ha^{-1}$
3	Challenge 600 SC	aclonifen	4 $l.ha^{-1}$
4	Shadow 3 EC	clethodim	1.6 $l.ha^{-1}$
5	Challenge 600 SC + Shadow 3 EC	aclonifen + clethodim	4 $l.ha^{-1}$ + 1.6 $l.ha^{-1}$

Herbicides Pulsar 40 was used in addition with adjuvant Dash HC – 1 $l.ha^{-1}$.

The grain obtained after every variant was cleaned through a sieves and the quantity of the waste grain was defined (siftings). All version seeds for sowing were defined for their germination energy and lab seed germination. It was studied intensity of early growth of seeds, expressed by the lengths of primary germ and primary root definite on the eighth day after setting the samples. Each index was determined in two repetitions of the year. Averages in each of the years of experiment were used as repetitions in mathematical data processing were done according to the method of analysis of variance.

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 germ and primary root after seed germination and is associated with later germination in field conditions, slower plant growth in spring and higher risk of early drying in the summer. Its lead to lower seed yields. The obtained results show that the treatment of the chickpea with foliar-applied herbicide Pulsar and its combinations with soil-applied herbicides Dual gold, Stomp aqua, Merlin flex and Pelican lead to the decrease in the germination energy (Table 2). Analysis of variance, in which the years have taken for replications, shows that these decreases are mathematically proven.

Germination is the most important index who characterizing the sowing properties of the seeds. At low laboratory germination sowing should be done with higher sowing rate, which increases the cost production. Laboratory germination of the seeds at all variant during the three years of study is higher compared to the requirements of the standard, although in different years account for some variation of its values. This is the positive effect of their use, because it is not necessary to increase the sowing rate (in $kg.ha^{-1}$) and the cost of necessary seeds. At herbicide combination Pelican + Pulsar seed germination is lower than untreated control. The chickpea seeds germinate normally by influence of the herbicide combinations Dual gold + Pulsar, Stomp aqua + Pulsar and Marlin flex + Pulsar, and although the initial rate of development is lower due to lower germination energy. Other soil-applied herbicides, foliar-applied herbicides and their combinations increase the indexes germination energy and seed germination. This means that they help for joint and fast germination of the chickpea sowing-seeds.

Table 2. Influence of some herbicides, herbicide combinations and herbicide tank mixture on sowing characteristics of the chickpea seeds (mean 2016 – 2018)

Herbicides		Germinative energy, %	Germination, %	Length, cm		Waste grain, %
Soil-applied	Foliar-applied			Primary germ	Primary root	
–	–	60.7	72.8	3.7	4.7	18.4
	Pulsar	56.1	77.7	2.3	5.8	16.9
	Challenge	69.0	78.5	5.1	5.8	15.2
	Shadow	64.5	778.0	4.8	5.4	15.8
	Challenge + Shadow	69.3	78.3	5.3	5.5	15.3
Dual gold	–	65.1	78.0	5.0	6.0	15.6
	Pulsar	56.5	77.7	2.3	6.0	18.2
	Challenge	67.9	80.5	5.3	6.6	14.7
	Shadow	64.8	77.8	5.7	5.9	15.4
	Challenge + Shadow	69.3	80.2	5.2	6.6	14.5
Stomp aqua	–	68.2	82.7	5.0	7.2	15.3
	Pulsar	56.4	81.8	2.3	7.0	17.9
	Challenge	66.3	802	5.5	6.8	14.1
	Shadow	66.6	78.0	5.0	5.9	15.0
	Challenge + Shadow	67.0	77.5	5.6	7.1	14.9
Merlin flex	–	66.8	72.1	3.8	5.8	15.1
	Pulsar	56.4	77.8	2.4	5.8	18.2
	Challenge	70.0	81.3	5.8	6.7	14.6
	Shadow	67.1	77.3	4.9	7.0	15.2
	Challenge + Shadow	71.3	82.2	5.7	6.8	14.3
Pelican	–	65.1	79.5	3.9	5.8	17.8
	Pulsar	54.5	66.2	1.9	2.9	21.1
	Challenge	69.8	82.2	5.7	6.6	14.5
	Shadow	67.0	77.8	5.0	5.9	15.3
	Challenge + Shadow	69.8	82.7	5.6	6.7	14.6
LSD 0.5		3.7	4.3	0.9	1.1	2.5
LSD 0.1		4.6	5.4	1.8	2.0	3.7
LSD 0.01		5.8	6.6	2.9	3.1	5.3

The obtained results for germination energy and seed germination are a prerequisite continue to investigate the effect of herbicides, herbicide combinations and herbicide tank mixture on initial intensity of the growth of seeds, expressed by the lengths of primary germs and roots. It was found that the lengths of primary germ of chickpea is decreased by alone use of herbicide Pulsar and its combinations with soil-applied herbicides Dual gold, Stomp aqua, Merlin flex and Pelican. The length of primary root is only decreased by herbicide combination Pelican + Pulsar. These decreasing are proven by analysis of variants. This five variants depress young plants developments, reduces their resistance to drought and increase risk of plant dying during the summer months. Other combinations between soil-applied and foliar-applied herbicides led to increase of the lengths of primary germ and primary root of the chickpea and recommended for use in seed production chickpea crops.

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 chickpea. Herbicide combination Pelican + Pulsar lead to mathematically proven increase of the quantity of waste grain. Alone uses of soil-applied herbicide Pelican and foliar-applied herbicide Pulsar don not decrease the quantity of waste grain. Other herbicides, herbicide combinations and herbicide tank mixture lead to mathematically proven decrease of the quantity of waste grain. Differences between these variants and untreated control are mathematically proven.

Decreases in the values of germination energy and laboratory seed germination, decreases in the intensity of the initial growth, expressed by the lengths of the primary root and

Table 3. Influence of some herbicides, herbicide combinations and herbicide tank mixture on seed yield of chickpea (2016 – 2018)

Herbicides		2016		2017		2018		Mean	
Soil-applied	Foliar-applied	kg.ha^{-1}	%	kg.ha^{-1}	%	kg.ha^{-1}	%	kg.ha^{-1}	%
–	–	2077	100	1211	100	1760	100	1683	100
	Pulsar	2278	109.7	1291	106.3	1880	106.8	1816	107.9
	Challenge	2353	113.3	1345	111.1	1955	111.0	1884	112.0
	Shadow	2125	102.3	1245	102.8	1822	103.5	1731	102.8
	Challenge + Shadow	2397	115.4	1389	114.7	1989	113.0	1925	114.4
Dual gold	–	2191	105.5	1284	106.0	1971	107.7	1815	107.9
	Pulsar	2289	110.2	1321	109.1	1918	109.0	1843	109.4
	Challenge	2399	115.5	1393	115.0	2049	116.4	1947	115.7
	Shadow	2247	108.2	1326	109.5	1918	109.0	1830	108.7
	Challenge + Shadow	2436	117.3	1405	116.0	2054	116.7	1965	116.8
Stomp aqua	–	2216	106.7	1303	107.6	1917	108.9	1812	107.7
	Pulsar	2303	110.9	1339	110.6	1989	111.1	1877	111.5
	Challenge	2410	116.0	1399	115.5	2024	115.0	1944	115.5
	Shadow	2264	109.0	1332	110.0	1941	110.3	1846	109.7
	Challenge + Shadow	2453	118.1	1423	117.5	2059	117.0	1978	117.5
Merlin flex	–	2233	107.5	1308	108.0	1932	109.8	1824	108.4
	Pulsar	2337	112.5	1368	113.0	1969	111.9	1891	112.4
	Challenge	2453	118.1	1425	117.7	2068	117.2	1982	117.8
	Shadow	2264	109.0	1339	110.6	1955	111.1	1853	110.1
	Challenge + Shadow	2517	121.2	1460	120.8	2094	119.0	2024	120.2
Pelican	–	2250	108.3	1322	109.2	1955	111.1	1842	109.5
	Pulsar	2195	105.7	1241	102.5	1833	104.2	1756	104.4
	Challenge	2467	118.8	1441	119.0	1091	118.8	1957	116.3
	Shadow	2274	109.5	1340	110.7	1964	111.6	1859	110.5
	Challenge + Shadow	2513	121.0	1465	121.1	2107	119.7	2028	120.5
LSD 0.5		106	5.1	48	4.0	83	4.7		
LSD 0.1		137	6.6	68	5.6	107	6.1		
LSD 0.01		170	8.2	88	7.3	134	7.6		

primary germ at germination and changes in the quantity of waste grain by the influence of the relevant herbicides, herbicide combinations and herbicide tank mixture are explained by the their depressing effects on growth and development of the chickpea during its vegetative period.

To done a complete evaluation of the sowing characteristics needed to establish not only the quality of seeds, but also the quantity of grain which will be received this seeds. Data for the influence of investigated herbicides, herbicide combinations and the herbicide tank mixture on seed yield of chickpea (Table 3) show that the lower yield is obtained by alone use of antigraminaceous herbicide Shadow, especially during wet years. The increase in yield is unproven compared to untreated control, due to the low efficacy of Shadow over the annual and perennial broadleaved weeds that are dominant in the experiment.

The yield increase in relative to the control is also unproven by herbicide combination the Pelican + Pulsar. This is due to the strong phytotoxicity of this herbicide combination to chickpeas, despite its high efficacy against weeds.

Treatment with herbicide Pulsar showed higher yields over the untreated control during the three years. Chickpea is lagging poorly in its development, the maturing stage is delayed by 4-5 days, but however seed yields are not significantly reduced, as weeding is significantly lower than untreated control, because Pulsar destroys all available weeds and self-sown plants.

It is important to note that herbicide Pelican has an initial phytotoxic effect on chickpea, which is to inhibit plant growth during the first 20-30 days after treatment. Subsequently, chickpeas overcome this negative effect and at the vegetation end in this variant high seed yields have been ob-

tained, which is proven mathematically. This is due to the good chemical control of herbicide Pelican against existing weeds.

The alone use of soil-applied herbicides Dual gold, Stomp aqua and Merlin flex increases less the see yields than the alone use of foliar-applied herbicide Challenge and the herbicide tank mixture Challenge + Shadow, because these herbicides cannot control the perennial weeds and part of the annual weeds.

The highest yields of chickpea seeds are obtained by foliar treatment with herbicide tank-mixture Challenge + Shadow after soil-applied herbicides Pelican and Merlin flex – respectively 120.5% and 120.2% relative to the untreated control. High yields also are obtained also by foliar treatment with herbicide tank-mixture Challenge + Shadow after soil-applied herbicides Stomp aqua and Dual gold – respectively 116.8 % and 117.5%.

Combinations of soil-applied herbicides Dual gold, Stomp aqua, Merlin flex and Pelican with foliar-applied herbicides Challenge, Pulsar and Shadow always leads to higher yields compared to the alone use of the respective herbicides during the three years of the investigation.

Conclusion

Alone use of foliar-applied herbicide Pulsar and its combinations with soil-applied herbicides Dual gold, Stomp aqua, Merlin flex and Pelican proven decrease germination energy of the chickpea seeds. Laboratory seed germination proves decreased by herbicide combination Pelican + Pulsar only. Length of primary germ is decreased by alone use of foliar-applied herbicide Pulsar and its combinations with soil-applied herbicides Dual gold, Stomp aqua, Merlin flex and Pelican. Length of primary root is decreased by herbicide combination Pelican + Pulsar only. Herbicide combination Pelican + Pulsar proven increases waste grain quantities. Alone uses of herbicides Pelican and Pulsar do not proven decreases waste grain quantities. The highest yields of chickpea seeds are obtained by foliar treatment with herbicide tank-mixture Challenge + Shadow after soil-applied herbicides Pelican and Merlin flex. High yields are obtained also by foliar treatment with herbicide tank-mixture Challenge + Shadow after soil-applied herbicides Stomp aqua and Dual gold.

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