

## EFFICACY OF HERBICIDES, HERBICIDE COMBINATIONS AND HERBICIDE TANK MIXTURE ON CHICKPEA (*Cicer arietinum* L.)

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### Abstract

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, Stomp aqua (pendimethalin) - 3 l/ha, Merlin flex 480 SC (isoxaflutole) - 420 g/ha and Pelican 50 SC (diflufenikan) - 250 ml/ha. Factor B included untreated control, 3 foliar-applied herbicides – Pulsar 40 (imazamox) - 1.2 l/ha, Challenge 600 SC (aclonifen) - 4 l/ha and Shadow 3 EC (clethodim) - 1.6 l/ha and 1 herbicide tank mixture – Challenge 600 SC (aclonifen) - 4 l/ha + Shadow 3 EC (clethodim) - 1.6 l/ha. Soil-applied herbicides were treated during the period after sowing before emergence. Foliar-applied herbicides were treated 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. Mixing of foliar-applied herbicides was done in the tank on the sprayer. Combinations of soil-applied herbicides Dual gold, Stomp aqua, Merlin flex and Pelican with foliar-applied herbicides Challenge and Shadow, as well as with herbicide tank mixture Challenge + Shadow exhibit an additive effect on herbicidal efficacy. Foliar-applied herbicide Pulsar destroys all annual and perennial broadleaved and graminaceous weeds and self-sown plants. Herbicide Challenge is the only herbicide that successfully controls Clearfield and ExpressSun sunflower self-sown plants in chickpea crops. Treatment with foliar-applied herbicide Pulsar leads to high phytotoxicity in chickpea – rate 3 according to the scale of EWRS. Herbicide combination Pelican + Pulsar leads to even higher phytotoxicity in chickpea – rate 5 according to the scale of EWRS. Soil-applied herbicide Pelican used alone or combined with foliar-applied herbicides Challenge and Shadow and herbicide tank-mixture Challenge + Shadow leads to pure phytotoxicity in chickpea – rate 2 according to the scale of EWRS. 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.

**Key words:** chickpea, herbicides, herbicide combinations, efficacy, selectivity, seed yield.

### INTRODUCTION

Chickpea is a crop that grows slowly in the first days after germination and is easily oppressed by weeds. In its crops mainly early spring weeds develop - *Sinapis arvensis* L., *Falopia convolvulus* Leve, *Raphanus raphanistrum* L., and more limited late spring weeds develop - *Chenopodium album* L., *Amaranthus retroflexus* L., etc. From perennial weeds with the widest distribution and highest density are *Convolvulus arvensis* L. and *Cirsium arvense* Scop. An important measure in pea cultivation is the removal of weeds that carry diseases - *Anthemis arvensis* L., *Cirsium arvense* Scop., *Papaver rhoes* L., as well as those weeds that are poisonous - *Solanum nigrum* L., self-sown potatoes *Solanum tuberosum* L., *Datura stramonium* L. (Velasquez and Alonso, 1993; Soltero-Díaz et al., 2010).

It has made a huge progress in weed control during recent years. Conditions for complete elimination of manual labor were created (Marwat et al., 2004). Weed control is most successful in complex application of agro-technical and chemical methods (Şanlı et al., 2009; Ratnam and Rao, 2011). World experience shows that the possibilities for biological weed control are still small (Vaissi and Shimi, 2003). Agro-technical methods include: crop rotation – sowing of legumes after cereals; plowing and pre-sowing tillage adjusted to character and degree of weed infestation; adherence to the chickpea sowing period, etc. Chemical control is carried out with selective herbicides – soil-applied and foliar-applied. They should be selected according to the nature of the weed associations accompanying the chickpea crop (Skrobakova,

1998 and 1999; Khan et al., 2010; Tanveer et al., 2010; Delchev, 2018 and 2020). The purpose of this investigation was to establish the efficacy and selectivity of some herbicides, herbicide combinations and a herbicide tank mixture on the chickpea by influence of different meteorological conditions.

## 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<sup>2</sup>. Factor A included untreated control and 4 soil-applied herbicides – Dual gold 960 EC, Stomp aqua, Merlin flex 480 SC and Pelican 50 SC. Factor B included untreated control, 3 foliar-applied herbicides – Pulsar 40, Challenge 600 SC and Shadow 3 EC and 1 herbicide tank mixture – Challenge 600 SC + Shadow 3 EC. Active substances of herbicides and their doses are shown in Table 1. Soil-applied herbicides were treated during the period after sowing before emergence.

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
3	Stomp aqua	pendimethalin	3 l/ha
4	Merlin flex 480 SC	isoxaflutole	420 g/ha
5	Pelican 50 SC	diflufenikan	250 ml/ha
6 - 8 real leaf stage			
1	Control	-	-
2	Pulsar 40	imazamox	1.2 l/ha
3	Challenge 600 SC	aclonifen	4 l/ha
4	Shadow 3 EC	clethodim	1.6 l/ha
5	Challenge 600 SC + Shadow 3 EC	aclonifen + clethodim	4 l/ha + 1.6 l/ha
Herbicide Pulsar 40 was used in addition with adjuvant Dash HC – 1 l/ha.			

Foliar-applied herbicides were treated 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. 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.

It was investigated efficacy and selectivity of herbicides, herbicide combinations and herbicide tank mixture. It was established their influence on seed yield. Efficacy of herbicides against weeds and self-sown durum wheat was

appointed according to 100 % scale of EWRS (European Weed Research Society). Selectivity of herbicides to chickpea plants was followed according to the 9-rate scale of EWRS (rating 1 - without damages, rating 9 - crop is completely destroyed). The mathematical processing is done with analysis of variance method.

## RESULTS AND DISCUSSION

Annual broadleaved weeds in the experiment are represented by *Anthemis arvensis* L., *Chamomilla recutita* Rauchert, *Galium aparine*

L., *Sinapis arvensis* L., *Amaranthus retroflexus* L., *Falopia convolvulus* Leve, *Papaver rhoes* L., *Consolida regalis* Gray, *Lamium purpureum* L., *Veronica hederifolia* L., also single plants of *Capsella bursa-pastoris* L., *Lithospermum arvense* L., *Chenopodium album* L., *Viola tricolor* L., *Myagrum perfoliatum* L., *Stellaria media* Cyr.

Annual graminaceous weeds are *Avena fatua* L., *Alopecurus myosuroides* L., *Lolium multiflorum* L., *Bromus arvensis* L., also single plants of *Avena ludoviciana* Durien., *Apera spica-venti* P.B., *Lolium temulentum* L.

Perennial broadleaved weeds are *Cirsium arvense* Scop. and *Convolvulus arvensis* L. Perennial graminaceous weeds are *Sorghum helepense* Pers. and *Cynodon dactylon* Pers.

Cereal self-sown plants are represented by durum wheat (*Triticum durum* Desf.), was grown as precrop.

Broadleaved self-sown plants are Clearfield and ExpressSun sunflower hybrids (*Helianthus annuus* L.), grown two years ago as precrop of wheat.

Soil-applied herbicide Dual gold controls 100 % of *Galium aparine* L., *Sinapis arvensis* L., *Raphanus raphanistrum* L., *Anthemis arvensis* L., *Lamium purpureum* L., *Amaranthus retroflexus* L., *Chenopodium album* L. (Table 2). It controls 85 - 95 % of weeds such as *Galium aparine* L. and *Papaver rhoes* L. This herbicide has low efficacy of 30 % against *Falopia convolvulus* Leve and *Veronica hederifolia* L. and is inefficacy against *Consolida regalis* Gray.

Soil-applied herbicide Stomp aqua controls 100 % of annual broadleaved weeds such *Galium aparine* L., *Sinapis arvensis* L., *Amaranthus retroflexus* L., *Chenopodium album* L., *Anthemis arvensis* L. and *Veronica hederifolia* L. It controls 85 % of *Galium aparine* L. and *Papaver rhoes* L. This herbicide has a low efficacy of 35 - 40 % against *Falopia convolvulus* Leve and *Lamium purpureum* L.

Herbicide Merlin flex controls successfully almost all annual broadleaved weeds. This herbicide has a lower efficacy only against *Papaver rhoes* L. - 95 %.

Of the soil-applied herbicide group, the largest percentage of destruction of annual weeds was reported in herbicide Pelican. It controls successfully all early-spring and late-spring broadleaved weeds including *Amaranthus retroflexus* L. and *Chenopodium album* L.

Foliar-applied herbicide Pulsar completely controls all annual broadleaved weeds available in the experiment.

The herbicide Challenge, applied alone or as herbicide tank mixture with antigraminaceous herbicide Shadow, also completely controls all annual broadleaved weeds available in the experiment.

The seed coat of sunflower hybrids has a thick armored layer consisting of several rows of carbon cells to protect from *Homoeosoma nebulella* D. & S. For this reason, some of these seeds do not germinate next year in cereal crops, but in the year later in chickpea crops and become a major problem during the chickpea vegetation and the chickpea harvest. Herbicide Merlin flex is the only herbicide that successfully controls Clearfield and ExpressSun sunflower self-sown plants in chickpea crops.

Soil-applied herbicides Dual gold, and applied during the period after sowing before germination (ASBE) of chickpea, are inefficacy against perennial broadleaved weeds *Cirsium arvense* Scop. and *Convolvulus arvensis* L. (Table 3). Dual gold and Stomp aqua are inefficacy also against perennial graminaceous weeds *Sorghum helepense* Pers. and *Cynodon dactylon* Pers. Herbicide Merlin flex is partially efficacy only against *Sorghum helepense* Pers. (60%) - its plants become white and their growth slows significantly.

Of the soil-applied herbicide group, only herbicide Pelican has a satisfactory efficacy against perennial broadleaved and graminaceous weeds. It controls these weeds from 60 to 75 %.

Foliar-applied herbicide Pulsar completely controls all annual broadleaved weeds. Herbicide Challenge is ineffective against these weeds.

Table 2. Efficacy of some herbicides, herbicide combinations and herbicide tank mixture against annual broadleaved weeds and self-sown plants at chickpea according to the 100 % visual scale of EWRS (mean 2016 - 2018)

Herbicides		Weeds									
Soil-applied	Foliar-applied	<i>Gdium aparine</i>	<i>Chamomilla recutita</i>	<i>Papaver rhoeas</i>	<i>Consolida regalis</i>	<i>Amaranthus retroflexus</i>	<i>Anthemis arvensis</i>	<i>Falopia convolvulus</i>	<i>Veronica hederifolia</i>	<i>Lamium purpureum</i>	<i>Helianthus annuus</i> *
	-	0	0	0	0	0	0	0	0	0	0
	Pulsar	100	100	100	100	100	100	100	100	100	0
	Challenge	100	100	98	98	100	100	90	95	100	0
	Shadow	0	0	0	0	0	0	0	0	0	0
	Challenge + Shadow	100	100	98	98	100	100	90	95	100	0
	-	85	100	90	0	100	100	30	30	100	0
	Pulsar	100	100	100	100	100	100	100	100	100	0
Dual gold	Challenge	100	100	98	98	100	100	90	95	100	0
	Shadow	85	100	90	0	100	100	30	30	100	0
	Challenge + Shadow	100	100	98	98	100	100	90	95	100	0
	-	85	100	85	30	100	100	40	100	35	0
	Pulsar	100	100	100	100	100	100	100	100	100	0
Stomp aqua	Challenge	100	100	98	98	100	100	90	100	100	0
	Shadow	85	100	85	30	100	100	40	100	35	0
	Challenge + Shadow	100	100	98	98	100	100	90	100	100	0
	-	100	100	95	100	100	100	100	100	100	100
	Pulsar	100	100	100	100	100	100	100	100	100	100
Merlin flex	Challenge	100	100	100	100	100	100	100	100	100	100
	Shadow	100	100	95	100	100	100	100	100	100	100
	Challenge + Shadow	100	100	100	100	100	100	100	100	100	100
	-	100	100	100	100	100	100	100	100	100	0
	Pulsar	100	100	100	100	100	100	100	100	100	0
Pelican	Challenge	100	100	100	100	100	100	100	100	100	0
	Shadow	100	100	100	100	100	100	100	100	100	0
	Challenge + Shadow	100	100	100	100	100	100	100	100	100	0

\* - self-sown plants of ClearField and ExpressSun sunflower

Foliar-applied herbicides Pulsar, Shadow and herbicide tank mixture Challenge + Shadow successfully control perennial graminaceous weeds.

Soil-applied herbicide Dual gold is inefficacy against annual graminaceous weeds *Bromus arvensis* L., *Avena fatua* L. and *Avena ludoviciana* Durien. It has a low efficacy of

Table 3. Efficacy of some herbicides, herbicide combinations and herbicide tank mixture against perennial weeds, annual graminaceous weeds and self-sown plants at chickpea according to the 100 % visual scale of EWRS and selectivity according to the 9-rate scale of EWRS (mean 2016 - 2018)

Herbicides		Weeds									
Soil-applied	Foliar-applied	<i>Cirsium arvense</i>	<i>Convolvulus arvensis</i>	<i>Sorghum halepense</i>	<i>Cynodon dactylon</i>	<i>Avena fatua</i>	<i>Lolium multiflorum</i>	<i>Alopecurus myosuroides</i>	<i>Bromus arvensis</i>	<i>Triticum durum*</i>	Selectivity
-	-	0	0	0	0	0	0	0	0	0	1
	Pulsar	98	100	97	100	100	100	100	98	100	3
	Challenge	0	0	0	0	40	65	80	0	70	1
	Shadow	0	0	100	100	100	100	100	100	100	1
	Challenge + Shadow	0	0	100	100	100	100	100	100	100	1
Dual gold	-	0	0	0	0	0	100	100	0	40	1
	Pulsar	98	100	97	100	100	100	100	98	100	3
	Challenge	0	0	0	0	40	100	100	0	70	1
	Shadow	0	0	100	100	100	100	100	100	100	1
	Challenge + Shadow	0	0	100	100	100	100	100	100	100	1
Stomp aqua	-	0	0	0	0	95	100	100	0	0	1
	Pulsar	98	100	97	100	100	100	100	98	100	3
	Challenge	0	0	0	0	95	100	100	0	70	1
	Shadow	0	0	100	100	100	100	100	100	100	1
	Challenge + Shadow	0	0	100	100	100	100	100	100	100	1
Merlin flex	-	0	0	60	0	100	100	100	0	55	1
	Pulsar	98	100	100	100	100	100	100	98	100	3
	Challenge	0	0	0	0	100	100	100	0	70	1
	Shadow	0	0	100	100	100	100	100	100	100	1
	Challenge + Shadow	0	0	100	100	100	100	100	100	100	1
Pelican	-	70	60	75	65	0	0	0	0	0	2
	Pulsar	98	100	100	100	100	100	100	98	100	5
	Challenge	70	60	75	75	40	65	80	0	70	2
	Shadow	70	60	100	100	100	100	100	100	100	2
	Challenge + Shadow	70	60	100	100	100	100	100	100	100	2

\* - self-sown plants of durum wheat

40 % against self-sown plants of durum wheat (*Triticum durum* Desf.).

Herbicides Stomp aqua and Merlin flex are efficacy against all annual graminaceous

weeds, except for *Bromus arvensis* L. The herbicides are inefficacy against self-sown plants of *Triticum durum* Desf.

Soil-applied herbicide Pelican is inefficacy against annual graminaceous weeds and self-sown plants of *Triticum durum* Desf.

In vegetation treatment, the herbicide Challenge is poorly efficacy against annual graminaceous weeds. In soil application this herbicide provides good control of these weeds. Herbicides Pulsar, Shadow and herbicide tank mixture Challenge + Shadow successfully control annual graminaceous weeds.

Combinations of soil-applied herbicides Dual gold, Stomp aqua, Merlin flex and Pelican with foliar-applied herbicides Challenge and Shadow, as well as with herbicide tank mixture Challenge + Shadow exhibit an additive effect on herbicidal efficacy.

Soil-applied herbicides Dual gold, Stomp aqua, and Merlin flex, treated after sowing before emergence and also foliar-applied herbicide Shadow, treated during 6 - 8 real leaf stage of the chickpea, have very high pea selectivity - rating 1 by scale of EWRS (Table 3).

During later vegetative treatment with herbicide Challenge, weak phytotoxicity is possible - bleaching and discoloration on the periphery of chickpea leaves. It overcomes quickly and has no effect on seed yield.

Soil-applied herbicide Pelican used alone or combined with foliar-applied herbicides Challenge and Shadow and herbicide tank-mixture Challenge + Shadow have pure phytotoxicity in chickpea – rate 2 according to the scale of EWRS. It is overcome by the 30th day after Pelican treatment.

Soil-applied herbicide Pulsar used alone or combined with soil-applied herbicides Dual gold, Stomp aqua and Merlin flex have phytotoxicity in chickpea – rate 3 according to the scale of EWRS. Although there are no strong visible signs, it overcomes slowly and leads to a reduction in seed yield.

Herbicide combination Pelican + Pulsar leads to high phytotoxicity in chickpea – rate 5 according to the scale of EWRS. It overcomes very slowly, slows the growth of chickpeas and leads to a significant reduction in seed yield compared to the alone uses of herbicides Pelican and Pulsar.

Data for the influence of investigated herbicides, herbicide combinations and the

herbicide tank mixture on seed yield of chickpea (Table 4) 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 obtained, 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

Table 4. Influence of some herbicides, herbicide combinations and herbicide tank mixture on seed yield of chickpea (2016 - 2018)

Soil-applied	Herbicides	2016		2017		2018		Mean		
		Foliar-applied	kg/ha	%	kg/ha	%	kg/ha	%	kg/ha	%
-	-		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 5 %		106	5.1	48	4.0	83	4.7		
	LSD 1 %		137	6.6	68	5.6	107	6.1		
	LSD 0.1 %		170	8.2	88	7.3	134	7.6		

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.

## CONCLUSIONS

Combinations of soil-applied herbicides Dual gold, Stomp aqua, Merlin flex and Pelican with foliar-applied herbicides Challenge and Shadow, as well as with herbicide tank mixture Challenge + Shadow exhibit an additive effect on herbicidal efficacy.

Foliar-applied herbicide Pulsar destroys all annual and perennial broadleaved and graminaceous weeds and self-sown plants.

Herbicide Challenge is the only herbicide that successfully controls Clearfield and ExpressSun sunflower self-sown plants in chickpea crops.

Treatment with foliar-applied herbicide Pulsar leads to high phytotoxicity in chickpea – rate 3 according to the scale of EWRS. Herbicide combination Pelican + Pulsar leads to even higher phytotoxicity in chickpea – rate 5 according to the scale of EWRS.

Soil-applied herbicide Pelican used alone or combined with foliar-applied herbicides Challenge and Shadow and herbicide tank-mixture Challenge + Shadow leads to pure phytotoxicity in chickpea – rate 2 according to the scale of EWRS.

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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