

## Efficacy of herbicide Lentagran WP for control of annual dicotyledonous weeds in cabbage crop

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In 2007–2008 at the Lithuanian Institute of Horticulture there were carried out the investigations of herbicide Lentagran WP (a. i. pyridate 45 %) efficiency in cabbage crop.

The investigated herbicide effectively decreased weed number in cabbage crop. Annual dicotyledonous weeds were sensitive to herbicide Lentagran WP 0.5–2.0 l ha<sup>-1</sup>. Total number of weeds 14 days after application of herbicide decreased by 51.6–82.3 %, number of annual dicotyledonous weeds decreased by 58.3–82.5 %, air dry weight of weeds decreased by 34.9–67.6 %. The number of annual dicotyledonous weeds in Lentagran WP 0.5–2.0 l ha<sup>-1</sup> treatments was essentially lower to compare with untreated and also there was found essentially lower number of annual dicotyledonous weeds in Lentagran WP (a. i. pyridate 45 %) 2.0 l ha<sup>-1</sup> treatment to compare with Butizan 400 2.0 l ha<sup>-1</sup> treatment. Especially sensitive to Lentagran WP 0.5–2.0 l ha<sup>-1</sup> there was *Galinsoga parviflora* Cav. (80.4–100 %). Very sensitive to Lentagran WP 2.0 l ha<sup>-1</sup> were *Matricaria inodora* L. (93.7 %), *Stellaria media* L. (87.3 %).

**Key words:** cabbage, herbicides, Lentagran WP, pyridate, yield, weeds.

**Introduction.** Broadleaf weeds continue to be significant problem in cabbage production fields. Until recently only two herbicides were registered for postemergence broadleaf weed control in transplanted cabbage. With the recent registration of Lentagran WP the possibility of developing postemergence weed management strategies for both direct-seeded and transplanted cabbages exists. Herbicide Lentagran WP now registered for use in onion, leek and cabbage in the Lithuania, controls or suppresses redroot pigweed (*Amaranthus retroflexus* L.), common lambsquarters (*Chenopodium album* L.), nightshade spp. (*Solanum* spp.) and small flowered galinsoga (*Galinsoga parviflora* Cav.). Lentagran WP is postemergence contact herbicide and has no residual soil activity. Its mode of action involves hydrolysis to 3-phenyl-4-hydroxy-6-chloropyridazine, which then inhibits photosystem II electron transport (Zohner, 1987).

Effective weed management must also have good crop tolerance. Pyridate injury, which occurs as distinctive, blotchy chlorosis of treated leaves, has frequently been reported in cabbage (Bullen et al., 1993; Miller, Hopen, 1991; Orfanedes, Masiunas, 1990; Wallace, Bellinder, 1992). Four-leaf cabbage tolerated pyridate when applied at

1x and 2x rates (1.0 and 2.0 kg/ha, respectively) however, when applied at earlier growth stages, significantly injury has been reported phytotoxicity. Injuring is usually transitory with nonchlorotic leaves emerging subsequent to application. There have been no reported instances of yield reductions in cabbage where pyridate was applied.

The aim of the study – to investigate the effect of herbicide Lentagran WP (a. i. pyridate 45 %) efficiency in cabbage crop.

**Object, methods and conditions.** Investigations were carried out at the Lithuanian Institute of Horticulture in 2007–2008. Soil – sandy loam on light loam, calcareous epihypogleyic luvisol (IDg 8-k, / *Calc(ar)i – Epihypogleyc Luvisolls – LVg-p w cc*). Ploughing layer was of 22–25 cm in thickness, of little humus (1.58 %), neutral ( $\text{pH}_{\text{KCL}}$  7.0). There was big amount of agile phosphorus (354 mg kg<sup>-1</sup> of the soil), potassium (146 mg kg<sup>-1</sup> of the soil) and calcium (4 500 mg kg<sup>-1</sup> of the soil) in the soil, but small amount of nitrogen (in the layer of 0–40 cm – 56.6 kg ha<sup>-1</sup> N-NH<sub>4</sub> + N-NO<sub>3</sub>). Before planting 200 kg ha<sup>-1</sup> N, 150 kg ha<sup>-1</sup> P, 200 kg ha<sup>-1</sup> K were poured. There was grown cabbage cultivar ‘Langedijker Dauer’. Investigations were carried out according to the mechanized technology of cabbage growing created at the Lithuanian Institute of Horticulture. Cabbage experimental area was 600 m<sup>2</sup>. Record plot – 5 × 5 = 25 m<sup>2</sup>. Experiment was carried out in 4 replications.

Herbicides in cabbage crop were sprayed two weeks after planting according to the s c h e m e:

- 1) Control (without herbicides, weeded);
- 2) Butizan 400 (standard) 2.0 l ha<sup>-1</sup>;
- 3) Lentagran WP 0.5 l ha<sup>-1</sup>;
- 4) Lentagran WP 1.0 l ha<sup>-1</sup>;
- 5) Lentagran WP 1.5 l ha<sup>-1</sup>;
- 6) Lentagran WP 2.0 l ha<sup>-1</sup>.

Herbicides were sprayed with back sprayer. Water rate – 400 l ha<sup>-1</sup>. Weeds were counted in four places of every plot, in areas of 0.25 m<sup>2</sup>, diagonally through the plot, once after the month from the last spraying. After weed calculation, they were weeded once. The data of crop weediness and cabbage yield were calculated by dispersion analysis method. Before carrying out statistical analysis, the number of weeds was recounted according to the formula:  $y = (x + 1)$ :  $x$  – real weed date;  $y$  – transformed weed date (Tarakanovas, Raudonius, 2003).

**Results.** In 2007–2008 the average total number of weeds after application of herbicide Lentagran WP 0.5–2.0 l ha<sup>-1</sup> decreased by 51.6–82.3 % to compare with untreated. The number of total weeds in Lentagran WP 0.5–2.0 l ha<sup>-1</sup> treatments was found essentially lower to compare with untreated and there was found essentially lower total number of weeds in Lentagran WP 1.5–2.0 l ha<sup>-1</sup> treatments to compare with Butizan 400 2.0 l ha<sup>-1</sup> standard treatment. The efficacy of Lentagran WP 1.5–2.0 l ha<sup>-1</sup> was bigger in 13.3–18.0 % to compare with standard treatment. Total weed number was lower in 2007 than in 2008, but herbicide efficacy was similar in both years of investigation (Table 1).

**Table 1.** Efficiency of herbicide Lentagran WP for control of total number of weed in cabbage

**1 lentelė.** Herbicido Lentagran WP įtaka bendram piktžolių skaičiui kopūstų pasėlyje

Babtai, 2007–2008

Treatments Variantai	Total number of weeds (pcs. m <sup>-2</sup> ) Bendras piktžolių skaičius, vnt. m <sup>-2</sup>		
	2007	2008	2007–2008 average vidurkis
Untreated Nepurkšta	36.5	79.0	57.7
Butizan 400 2.0 l ha <sup>-1</sup> (standard standartas)	18.2*	23.0*	20.6*
Lentagran WP 0.5 l ha <sup>-1</sup>	27.2*	28.7*	27.9*
Lentagran WP 1.0 l ha <sup>-1</sup>	19.0*	23.7*	21.3*
Lentagran WP 1.5 l ha <sup>-1</sup>	8.2**	17.7*	12.9**
Lentagran WP 2.0 l ha <sup>-1</sup>	6.2**	14.2**	10.2**

Note: \* – essentially less than in the untreated treatment (LSD<sub>05</sub>),

\*\* – essentially less than in the Butizan 400 2.0 l ha<sup>-1</sup> (standard) treatment (LSD<sub>05</sub>)

Pastaba: \* – iš esmės mažiau negu nepurkštame variante (R<sub>05</sub>), \*\* – iš esmės mažiau negu herbicidu Butizan 400 2,0 l ha<sup>-1</sup> nupurkštame standartiniame variante (R<sub>05</sub>).

Average number of annual dicotyledonous weeds in 2007–2008 in herbicide Lentagran WP 0.5–2.0 l ha<sup>-1</sup> treatment decreased by 58.3–82.5 % to compare with untreated. There was found essentially lower number of annual dicotyledonous weeds in Lentagran WP 0.5–2.0 l ha<sup>-1</sup> treatments to compare with untreated and also there was found essentially lower number of annual dicotyledonous weeds in Lentagran WP 1.5–2.0 l ha<sup>-1</sup> treatments to compare with Butizan 400 2.0 l ha<sup>-1</sup> standard treatment. The efficacy of Lentagran WP 1.5–2.0 l ha<sup>-1</sup> in post emergence dicotyledonous weed management was bigger in 14.8–16.7 % to compare with standard treatment. Number of annual dicotyledonous weeds was lower in 2007 and efficacy of Lentagran WP 2.0 l ha<sup>-1</sup> was bigger by 5 % in that year than in 2008 (Table 2).

Total air-dry weight of weeds in Lentagran WP 0.5–2.0 l ha<sup>-1</sup> treatments decreased by 34.9–67.6 % to compare with untreated in both year of investigation. There was found essentially lower air-dry weight of weeds in Lentagran WP 0.5–2.0 l ha<sup>-1</sup> treatments to compare with untreated and there was found essentially lower air-dry weight of weeds in Lentagran WP 2.0 l ha<sup>-1</sup> treatment to compare with Butizan 400 2.0 l ha<sup>-1</sup> treatment. Lentagran WP 2.0 l ha<sup>-1</sup> decreased air-dry weight of weeds in 27.6 % (Table 3).

**Table 2.** Efficiency of herbicide Lentagran WP for control of annual dicotyledonous weed number in cabbage

**2 lentelė.** Herbicido Lentagran WP įtaka vienmečių dviskilčių piktžolių skaičiui kopūstų pasėlyje

Babtai, 2007–2008

Treatments Variantai	Number of annual dicotyledonous weeds, (pcs. m <sup>-2</sup> ) Vienmečių dviskilčių piktžolių skaičius, vnt. m <sup>-2</sup>		
	2007	2008	2007–2008 average vidurkis
Untreated Nepurkšta	33.5	78.5	55.6
Butizan 400 2.0 l ha <sup>-1</sup> (standard standartas)	16.2*	22.7*	19.0*
Lentagran WP 0.5 l ha <sup>-1</sup>	23.2*	25.2*	23.2*
Lentagran WP 1.0 l ha <sup>-1</sup>	13.2*	19.7*	16.5*
Lentagran WP 1.5 l ha <sup>-1</sup>	6.2**	15.5*	10.8**
Lentagran WP 2.0 l ha <sup>-1</sup>	4.0**	12.7**	9.7**

*Note:* \* – essentially less than in the untreated treatment (LSD<sub>05</sub>), \*\* – essentially less than in the Butizan 400 2.0 l ha<sup>-1</sup> (standard) treatment (LSD<sub>05</sub>).

*Pastaba:* \* – iš esmės mažiau negu nepurkštame variante (R<sub>05</sub>), \*\* – iš esmės mažiau negu herbicidu Butizan 400 2,0 l ha<sup>-1</sup> nupurkštame standartiniame variante (R<sub>05</sub>).

**Table 3.** Efficiency of herbicide Lentagran WP for control of weed air-dry weight in cabbage

**3 lentelė.** Herbicido Lentagran WP įtaka piktžolių orasausei masei kopūstų pasėlyje

Babtai, 2007–2008

Treatments Variantai	Total air-dry weight of weeds Orasausė piktžolių masė (g m <sup>-2</sup> )		
	2007	2008	2007–2008 average vidurkis
Untreated Nepurkšta	81.2	105.0	96.7
Butizan 400 2.0 l ha <sup>-1</sup> (standard standartas)	51.2*	63.5*	57.7*
Lentagran WP 0.5 l ha <sup>-1</sup>	49.2*	77.0*	62.9*
Lentagran WP 1.0 l ha <sup>-1</sup>	44.0*	67.0*	57.0*
Lentagran WP 1.5 l ha <sup>-1</sup>	44.0*	65.7*	51.7*
Lentagran WP 2.0 l ha <sup>-1</sup>	20.0**	45.7**	31.3**

*Note:* \* – essentially less than in the untreated treatment (LSD<sub>05</sub>), \*\* – essentially less than in the Butizan 400 2.0 l ha<sup>-1</sup> (standard) treatment (LSD<sub>05</sub>).

*Pastaba:* \* – iš esmės mažiau negu nepurkštame variante (R<sub>05</sub>), \*\* – iš esmės mažiau negu herbicidu Butizan 400 2,0 l ha<sup>-1</sup> nupurkštame standartiniame variante (R<sub>05</sub>).

The number of *Chenopodium album* L. decreased by 74.8 % in treatments with Lentagran WP 2.0 l ha<sup>-1</sup> and decreased by 49.8–67.7 % in Lentagran WP 0.5–1.5 l ha<sup>-1</sup> treatment and –44.7 % in Butizan 400 2.0 l ha<sup>-1</sup> standard treatment during investigation year. The number of *Galinsoga parviflora* Cav. decreased by 80.4–100 % in treatments with Lentagran WP 0.5–2.0 l ha<sup>-1</sup> and decreased by 68.2 % in Butizan 400 2.0 l ha<sup>-1</sup> treatment. The number of *Capsella bursa-pastoris* L. decreased by 66.0–73.1 % in treatments with Lentagran WP 1.5–2.0 l ha<sup>-1</sup> and – by 27.7–46.4 in treatments with Lentagran WP 0.5–1.0 l ha<sup>-1</sup> and Butizan 400 2.0 l ha<sup>-1</sup> treatment. The number of *Stellaria media* L. decreased by 87.3 % in treatments with Lentagran WP 2.0 l ha<sup>-1</sup> and decreased by 100 % in treatment with Butizan 400 2.0 l ha<sup>-1</sup> treatments. The number of *Matricaria inodora* L. decreased in Lentagran WP 2.0 l ha<sup>-1</sup> treatment by 93.7 %, in Lentagran WP 1.0 l ha<sup>-1</sup> – by 79.7 % and in Butizan 400 2.0 l ha<sup>-1</sup> treatment – by 17.2 % during investigation year (Table 4).

**Table 4.** Efficiency of Lentagran WP for reduction (%) of main dicotyledonous weed species in cabbage

**4 lentelė.** Kai kurių vienmečių dviskilčių piktžolių rūšių skaičiaus sumažėjimas (%) panaudojus herbicidą Lentagran WP kopūstų pasėlyje

Babtai, 2007–2008

Treatments Variantai	<i>Chenopodium album</i> L.	<i>Galinsoga parviflora</i> Cav.	<i>Stellaria media</i> L.	<i>Matricaria inodora</i> L.	<i>Capsella bursa-pastoris</i> L.
Untreated Nepurkšta	0	0	0	0	0
Butizan 400 2.0 l ha <sup>-1</sup> (standard / standartas)	44.7	68.2	100	17.2	34.6
Lentagran WP 0.5 l ha <sup>-1</sup>	49.8	96.5	64.7	14.0	27.7
Lentagran WP 1.0 l ha <sup>-1</sup>	57.6	80.4	50.0	79.7	46.4
Lentagran WP 1.5 l ha <sup>-1</sup>	67.7	96.5	64.7	48.4	66.0
Lentagran WP 2.0 l ha <sup>-1</sup>	74.8	100	87.3	93.7	73.1

There was not found significant differences between treated with herbicides Lentagran WP 0.5–2.0 l ha<sup>-1</sup>, Butizan 400 2.0 l ha<sup>-1</sup> treatments and untreated in cabbage yield in both year of investigation. Negative direct effect on crop, cabbage yield and exterior quality of yield was no observed during investigation year (Table 5).

**Table 5.** Yield of cabbage after application of herbicide Lentagran WP  
**5 lentelė.** Kopūstų derlius panaudojus herbicidą Lentagran WP

Babtai, 2007–2008

Treatments Variantai	Total yield Bendras derlius (t ha <sup>-1</sup> )	Marketable yield Prekinis derlius	
		t ha <sup>-1</sup>	% from total yield % nuo bendro derliaus
Untreated Nepurkšta	39.8	39.0	97.9
Butizan 400 2.0 l ha <sup>-1</sup> (standard standartas)	43.1	42.8	99.3
Lentagran WP 0.5 l ha <sup>-1</sup>	46.3	43.9	94.8
Lentagran WP 1.0 l ha <sup>-1</sup>	43.8	42.5	97.0
Lentagran WP 1.5 l ha <sup>-1</sup>	45.6	44.6	97.8
Lentagran WP 2.0 l ha <sup>-1</sup>	44.7	44.1	98.6
LSD <sub>05</sub> / R <sub>05</sub>	6.81	6.47	-

**Discussion.** According to the data by Kathleen et al. (1990), herbicide pyridate applied postemergence on direct-seeded broccoli. According to Henderson and Cairns (2002), pyridate kills weeds in broccoli, Chinese cabbage, cabbage, or cauliflower with minimal crop damage. Stall and Hensel (1994) reports about pyridate spraying in onion. Applying 450 g ha<sup>-1</sup> pyridate caused **chlorotic spotting of the sprayed vegetable leaves**, but did not affect marketable yields of broccoli, cabbage or cauliflower. This rate controlled deadnettle (*Lamium amplexicaule*), reduced sowthistle (*Sonchus oleraceus*) growth by only 30–50 % compared with an unweeded control. Cabbage and cauliflower yields were unaffected by spraying 900 g ha<sup>-1</sup> pyridate. This rate improved sowthistle control to a commercially acceptable level (Henderson, Cairns, 2002). In our investigation Lentagran WP (a. i. pyridate 45%) 1.0–1.5 l ha<sup>-1</sup> showed the biggest efficient in cabbage. The number of annual dicotyledonous weeds decreased by 58.3–82.5 %. The number of *Chenopodium album* L. decreased by 74.8 % after spraying of Lentagran WP 2.0 l ha<sup>-1</sup>. The number of *Galinsoga parviflora* Cav. decreased by 80.4–100 % after Lentagran WP 0.5–2.0 l ha<sup>-1</sup>. The number of *Capsella bursa-pastoris* L. decreased by 66.0–73.1 % after Lentagran WP 1.5–2.0 l ha<sup>-1</sup>. The number of *Stellaria media* L. decreased by 87.3 % after Lentagran WP 2.0 l ha<sup>-1</sup>. The number of *Matricaria inodora* L. decreased in Lentagran WP 2.0 l ha<sup>-1</sup> treatment by 93.7 %, in Lentagran WP 1.0 l ha<sup>-1</sup> – by 79.7 %. Negative effect of Lentagran WP 1.0–1.5 l ha<sup>-1</sup> on crop and cabbage yield was no observed. Orfanedes and Masiunas (1990) also reported, that four leaf cabbage tolerate pyridate when applied 1.0 and 2.0 kg/ha. Bellinder et al. (1997) reported about sethoxydim and crop oil concentrate increase pyridate phytotoxicity in transplanted cabbage.

**Conclusions.** 1. Lentagran WP (a. i. pyridate 45 %) 1.0–1.5 l ha<sup>-1</sup> was most effective to control small dicotyledonous weeds in cabbage.

2. Negative effect of Lentagran WP (a. i. pyridate 45 %) 1.0–1.5 l ha<sup>-1</sup> on crop, cabbage yield and exterior quality was not observed.

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## **Herbicido Lentagran WP veiksmingumas kopūstų pasėlyje naikinant vienametės dviskiltės piktžolės**

### **D. Kavaliauskaitė**

#### *Santrauka*

2007–2008 m. Lietuvos sodininkystės ir daržininkystės institute buvo atlikti herbicido Lentagran WP (v. m. pyridate 45 %) veiksmingumo tyrimai kopūstų pasėlyje.

Tirtas herbicidas veiksmingai sumažino bendrą piktžolių skaičių kopūstų pasėlyje. Vienametės dviskiltės piktžolės buvo jautrios herbicidui Lentagran WP 0,5–2,0 l ha<sup>-1</sup>. Bendras piktžolių skaičius po herbicido purškimo praėjus 14 dienų sumažėjo 51,6–82,3 %, vienamečių dviskilčių piktžolių skaičius – 58,3–82,5 %, orasausė piktžolių masė – 34,9–67,6 %. Vienmečių dviskilčių piktžolių skaičius buvo iš esmės mažesnis nupurškus Lentagran WP 0,5–2,0 l ha<sup>-1</sup> negu nupurškstame variante, o Lentagran WP 2,0 l ha<sup>-1</sup> – iš esmės mažesnis negu herbicidu Butizan 400 2,0 l ha<sup>-1</sup> nupurškstame standartiniame variante.

Herbicidui Lentagran WP 0,5–2,0 l ha<sup>-1</sup> ypač jautri buvo smulkiažiedė galinsoga (*Galinsoga praviflora* Cav.) (80,4–100 %). Lentagran WP 2,0 l ha<sup>-1</sup> labai jautrus buvo bekvapis šunramunis (*Matricaria inodora* L.) (93,7 %) ir daržinė žliūgė (*Stellaria media* L.) (87,3 %).

**Reikšminiai žodžiai:** derlius, herbicidai, kopūstai, Lentagran WP, piktžolės, pyridate.