Differences in the Ripening of Two Clover Species and the Effect of Pre-harvest Desiccation

Razlike u sazrijevanju dviju vrsta djeteline i utjecaj desikacije prije žetve

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DIFFERENCES IN THE RIPENING OF TWO CLOVER SPECIES AND THE EFFECT OF PRE-HARVEST DESICCATION

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SUMMARY

Experiments were focused on differences in the ripening of crimson clover (Trifolium incarnatum L.) and red clover (Trifolium pratense L.) and on the influence of the pre-harvest treatment with desiccants. The drying of leaves, stems and heads during ripening, regrowing, breakdown of heads and yield parameters including seed were compared. The crimson clover exhibited the natural drying of leaves, stems and heads faster than the red clover. In crimson clover, the drying of leaves, stems and heads before the harvest was 80 - 100%, 50– 95%, and 100 %, respectively. In red clover, the drying of leaves, stems and heads was 25 - 84 %, 20–72% and 45–99%, respectively. There were also differences in the regrowing and in the breakdown of heads. In the pre-harvest treatments of crimson clover and red clover, the effect of diquat was compared with the efficiency of other herbicide substances (pyraflufen-ethyl, carfentrazone-ethyl and pelargonic acid) and with the efficiency of a high dose of DAM fertilizer (liquid fertilizer, urea-ammonium nitrate). Compared with diquat, the drying was slower with the other active substances. Significant effects of tested active substances on yield, WTS (weight of thousand seeds) and germination were not recorded.

***Keywords*: Trifolium incarnatum L., Trifolium pratense L., ripening, desiccation**

INTRODUCTION

Clover crops are an important part of crop rotation by enriching the soil with nitrogen and having a favorable influence on soil properties (Graham and Vance 2003, Brtnický et al. 2021). They are grown for fodder and green matter, and this is why they have not been primarily bred for seeds. Being cultivated for seeds, they exhibit great differences among individual species in the physiology of ripening and seed production. The most significant clover species grown in the Czech Republic for seeds are crimson clover and red clover. Crimson clover (*Trifolium incarnatum* L.) is a winter, single-cut species which is maturing rapidly (fodder quality decreases) during the bud formation and at the beginning of bloom. It is harvested for seed from the end of June to mid-July some 30 days after the end of bloom. The timing of harvest is important because mature heads become crumbling and considerable losses may occur.

Red clover (*Trifolium pratense* L.) is a perennial species readily regrowing after the cut. For seed, it is harvested in the first utility year, usually from the second cut. The seeds ripen about six weeks after pollination. According to the first cut date, the seed harvest usually falls to the second half of August or to September.

Seed stands of clovers are often harvested directly. When using the method of direct harvest, it is recommended to treat the stands with desiccants before the harvest, which terminate the vegetation, accelerate the stand drying, and facilitate harvesting. Active substance used to be diquat, but its approval was not renewed by the EU Commission Directive no. 2018/1532 of 12 October 2018 (European Commission, 2018). The prohibition of diquat brings a necessity to solve the issue of its substitution. Inhibitors most suitable for desiccation from 27 groups of herbicides classified according to their effects (Mallory-Smith and Retzinger 2003) are those of PS I system—that is, diquat and paraquat. Their advantages include versatility, fast action and wide spectrum of effect. Also, they work by contact, so do not cause permanent damage to the crop and have only a minor influence on soybean seed quality of (Zanatta et al., 2018). Their high toxicity is a disadvantage though. From the other active substances, for example carfentrazone, flumioxazin, pyraflufen-ethyl, fluroxypyr or glyphosate were tested in beans (Soltani et al., 2013, McNaughton

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et al., 2015, Parreira et al., 2015), red lentil (Subedi et al., 2017), cowpea seeds (Raisse et al., 2020), castor (Costa et al., 2018) or in red and white clover (Havstad et al. 2022). The use of glyphosate may result in limited germination and longevity of seeds in some crops (Subedi et al., 2017, Raisse et al., 2020). Loux (2019) studied the use of dicamba for the pre-harvest treatment and active substance 2,4-D was tested by Costa et al. (2018). Organic acids can be used for desiccation, too, for example pelargonic acid (Fabbri et al., 2018, Zotarelli et al., 2020, Havstad et al. 2022), whose 7% - 10% solution is used to desiccate potato tops (Hutchinson and Stall, 2007).

A great advantage of diquat was the well-developed technology verified during tens of years of its use. The action of other substances is different, and this is why experiments were established with crimson clover and red clover in order to evaluate the course of their ripening and a possibility of using alternative active substances for desiccation.

MATERIAL AND METHODS

Small plot experiments (plot size 12.5 m^2) were made in triplicates and in random order. The stand of crimson clover was situated in Nová Ves near Oslavany, the stand of red clover was situated in Javůrek near Domašov (2019), in Březejc (2020) and in Troubsko (2021). As the sites of Nová Ves and Domašov are in the vicinity of Troubsko, they are allocated weather data from the Troubsko meteorological station. The site of Březejc is allocated average temperatures and precipitation amounts for the Vysočina Region (ČHMÚ, 2020) (as shown in Table 1). Both clover species were cultivated according to the common management used for the given species. The following agrotechnical interventions were carried out on the researched crops: Sowing (crimson clover: 20/8/2018, 29/8/2019, 25/8/2020, variety Inkara, sowing rate 17 kg ha^{-1}; red clover: 3/4/2018, 11/4/2019, 8/4/2020, variety Vendelín, sowing rate 12 kg ha^{-1}), the herbicide treatment (crimson clover: 10/10/2018, 8/10/2019, 13/10/2020, Corum 1,1 l ha^{-1} + Dicopur 0,5 l ha^{-1}; red clover: no herbicides was applied, mowing was used to weed control in the first-year), the insecticide treatment (crimson clover: no insecticide treatment was necessary; red clover: 8/7/2019, 30/7/2020, 20/7/2021, Bicaya 0,3 l ha^{-1}, clover seed weevil protection). Row width was 12.5 cm. No fertilizer was applied.

The two clover species were tested in seven variants (Table 2): 1. Untreated control, 2. Diquat; 3. Pyraflufen-ethyl, 4. Carfentrazone-ethyl, 5. Pelargonic acid, 6. Liquid DAM fertilizer (ammonium nitrate with urea) 1:1 with water and wetting agent, 7. (in crimson clover) Diquat with the DAM fertilizer and wetting agent; 7. (in red clover) Carfentrazone-ethyl with pyraflufen-ethyl.

The active substances of pyraflufen-ethyl, carfentrazone-ethyl and pelargonic acid were combined in order to increase their efficiency with the DAM fertilizer at 10 l ha^{-1} and wetting agent Dash HC (active substances: oleic acid 5 %, palmitic acid, methyl ester; oleic acid, methyl ester 37.5 %, phosphoric acid polyalkoxy ester 22.5 %) at 1 l ha^{-1}. The spray fluid dose was 400 l ha^{-1}. There were two terms of application (T1, T2). The application on crimson clover was made in the following terms: T1 - 17/6/2019, 16/6/2020, 23/6/2021; T2 - 20/6/2019, 23/6/2020, 25/6/2021. The application on red clover was made in the following terms: T1 – 12/8/2019, 3/9/2020, 19/8/2021; T2 – 19/8/2019, 10/9/2020, 27/8/2021. The drying of clovers separately for leaves, stems and heads (in % of dry tissues), regrowth (in % of regrowth coverage), and breakdown of heads (in % of dropped parts of head) were evaluated. The plots were harvested using the small combine made by Sampo (crimson clover: 28/6/2019, 1/7/2020, 1/7/2021; red clover: 23/8/2019, 16/9/2020, 3/9/2021). Parameters determined were yield, WTS (weight of thousand seeds), and seed germination. In 2020 and 2021, the moisture content in the harvested matter was determined during the harvest. Results were processed in the Statistica 12 program using the analysis of variance and by the following Tukey's test at a level of α 0.05.

Table 1. Temperatures and precipitation amount in the growing seasons (2019, 2020, 2021) and the long-term normal (1981–2010)

Tablica 1. Srednje mjesečne temperature i mjesečne količine oborina (2019., 2020., 2021.) i višegodišnji prosjek (1981. –2010.)

Site / *year* Lokalitet / *godina*	Month *Mjesec*	January / *Siječanj*	February / *Veljača*	March / *Ožujak*	April / *Travanj*	May / *Svibanj*	June / *Lipanj*	July / *Srpanj*	August / *Kolovoz*	September / *Rujan*
Troubsko 2019	Temperature (°C)	-0.9	2.4	6.7	11.1	12.2	22.0	20.3	20.8	14.6
	Precipitation (mm)	23	17	27	17	78	65	60	56	72.6
Březejc 2020	Temperature (°C)	-0.5	3.1	3.7	9.1	10.6	15.9	17.3	18.5	13.7
	Precipitation (mm)	18	70	33	26	79	187	82	128	68
Troubsko 2020	Temperature (°C)	-0.2	4.6	5.3	9.9	12.6	18.0	19.1	20.7	15.0
	Precipitation (mm)	9	27	26	20	64	87	68	105	81.6
Troubsko 2021	Temperature (°C)	-0.1	0.0	3.5	7.1	12.7	20.2	20.8	17.9	15.6
	Precipitation (mm)	36	31	21	16	58	67	100	130	15.0
Troubsko 1981-2010	Temperature (°C)	-1,7	-0,3	3,8	9,5	14,6	17,4	19,5	18,8	14,1
	Precipitation (mm)	25.0	23.9	31.5	32.0	60.5	68.7	71.6	63.7	48.2
Březejc 1981-2010	Temperature (°C)	-2,6	-1,5	2,2	7,4	12,6	15,4	17,3	16,9	12,4
	Precipitation (mm)	44	38	48	41	71	75	87	80	56

Table 2. Pre-harvest treatment variants

Tablica 2. Varijante tretmana prije žetve

Variant / *Varijanta*		Shortcut / *Skraćenica*	Species / *Vrsta*	Application term / *Datum primjene*	Rate / *Doza primjene*
1	Control without treatment	Unt.	Crimson/red clover	-	-
2	Diquat	Diq.	Crimson/red clover	T2	700 g ae ha^{-1} *
3	Pyraflufen-ethyl surfactant DAM	Pyr.	Crimson/red clover	T1	21.5 g ae ha^{-1} 1 l ha^{-1} 10 l ha^{-1}
4	Carfentrazone-ethyl surfactant DAM	Car.	Crimson/red clover	T1	60 g ae ha^{-1} 1 l ha^{-1} 10 l ha^{-1}
5	Pelargonic acid surfactant DAM	Pel. ac.	Crimson/red clover	T1	10,880 g ae ha^{-1} 1 l ha^{-1} 10 l ha^{-1}
6	DAM surfactant	DAM	Crimson/red clover	T2	200 l ha^{-1} 1 l ha^{-1}
7	Diquat surfactant DAM	Diq.+	Crimson clover	T2	600 g ae ha^{-1} 0.5 l ha^{-1} 100 l ha^{-1}
7	Carfentrazone-ethyl Pyraflufen-ethyl surfactant DAM	Car.+Pyr.	Red clover	T1	60 g ae ha^{-1} 21.5 g ae ha^{-1} 1 l ha^{-1} 10 l ha^{-1}
	*grams of acid equivalent per ha				

RESULTS AND DISCUSSION

Differences in ripening and yield parameters between crimson and red clovers

Differences were recorded between the two species in the drying of leaves, stems and heads during the ripening. The natural drying of leaves in crimson clover ranged from 81% to 100%. The drying of stems was worse than the drying of leaves, ranging from 53% to 92% (Table 3). The natural drying of heads before harvest was 100% in all years. In red clover, the natural drying of plants was slower than in crimson clover (Table 3), and variability was greater. The natural drying of leaves, stems, and heads before harvest ranged from 17% to 84%, from 20% to 72%, and from 53% do 97%, respectively, in dependence on year and weather. Similarly, as in crimson clover, the best drying was exhibited by heads while stems and leaves were drying worse. McNaughton et al. (2015) studied the drying of tissues in edible beans, and in this crop, the drying of leaves and fruits was more rapid than the drying of stems too. The best drying of tissues in crimson and red was observed in 2019, which was a very dry year (Table 1). In wetter years of 2020 and 2021, the drying of tissues was slower. In both species, the drying of tissues was affected by temperature and particularly by the amount of rain during ripening. Precipitation also affected the regrowth of stands where great differences were recorded between crimson and red clovers. In crimson clover, the regrowing ranged from 0% to 10% of the leaf area of regrown plants per plot just before harvesting. In red clover, the regrowth showed a great variability and ranged from 10% to 95%, depending on the amount of precipitation. The least regrowth was in both species recorded in the dry year 2019 and the largest regrowth was recorded in 2020 (Table 3). Differences were observed between the two species in the breakdown of heads. In crimson clover, the heads were intensively disintegrating during the drying, and their breakdown reached 18–41 % before the harvest. The effect of weather showed in the breakdown of heads too. The greatest breakdown of heads was recorded in 2019 when a storm and heavy torrential rain just before harvest caused an intensive breakdown of clover heads. In red clover, the breakdown of heads hardly occurred during the ripening (Table 3).

The differences in yield parameters were recorded between the two clover species (Table 4). The average yield of crimson clover was 335–589 kg ha^{-1}. Duke (1981) mentions yields to be 340 to 410 kg ha^{-1}, but the yields of crimson clover can be 500–750 kg ha^{-1} (Hackney et al., 2007). The average yield of red clover was lower and ranged from 196 to 277 kg ha^{-1}. The yields of red clover were relatively low in our experiments. Bender and Tamm (2018) claim the yield of red clover to be 345–413 kg ha^{-1}

in dependence on cultivar, sowing rate and dose of fertilizer. Boller et al. (2010) mention even yields ranging from 400 to 600 kg ha^{-1} and Havstad et al. (2022) report yields ranging from 265 to 1013 kg ha^{-1}. A reason for the low yields could have been low precipitation amounts which adversely affect the production of red clover seeds (Oliva et al., 1994). Compared to red clover, crimson clover did not only have higher yields but also a higher WTS. In crimson and red clovers, WTS was 3.92–4.47 g and 1.35–2.49 g, respectively. Kirk and colleagues (2017a) state the WTS in red clover to range from 1.42 to 1.96 g and Havstad et al. (2022) report values ranging from 1.83 to 1.94 g. The higher values in red clover ranging from 2.8 to 3.05 g were detected by Bender and Tamm (2018). The moisture content of harvested matter was lower in crimson clover than in red clover, but the difference was not statistically significant (Table 4). A significant difference was found in the germination of the two clover species. In crimson clover, seeds were germinating in heads, especially in the wet year of 2020. This is why the number of dead seeds and damaged young seedlings of crimson clover ranged from 37% to 50%, depending on the year. The highest number of damaged young seedlings was recorded in 2020. In the red clover, the number of dead seeds and damaged young seedlings reached max. 9.3%. A higher number of dead seeds and damaged young seedlings ranging from 16 to 30% in red clover were detected by Havstad et al. (2022). The proportion of hard seeds was high (26% and 51%) in red clover. Havstad et al. (2022) report the number of hard seeds in the range from 25 to 34%. In crimson clover, the proportion of hard seeds was 4–9.5 %. The highest numbers of hard seeds occurred in both clover species in the dry year 2019 (Table 4).

Effect of pre-harvest treatment

The natural drying of ripening plants is usually insufficient for harvesting seeds and the matter moisture content is relatively high in the naturally dried stands, up to 30% in crimson clover and nearly 40% in red clover (Table 4). This is why an artificial termination of vegetation is necessary before the harvest in both clover species. In this study, we tested seven variants of pre-harvest treatment. A favorable effect on drying was demonstrated in both clover species. The active substance of diquat exhibited the best efficiency in the two clover species, the effect showed after four to seven days. The onset of effect came slower, and the overall efficiency was lower in the other active substances. The higher efficiency of diquat as compared with other active substances were recorded also by Kirk et al. (2017a, b). In their studies, the effect of diquat began to show after two to six days and the overall efficiency was higher than in the other tested variants. Havstad et al. (2022) compared the effect of diquat with other active substances in red clover and white clover. The drying of plants as compared with the diquat control was worse in all other tested variants, similarly as in our experiments. McNaughton et al. (2015) and Soltani et al. (2013) compared the effect of diquat, carfentrazone and flumioxazin on the ripening of edible beans. Similarly, as in our research, diquat and carfentrazone accelerated the ripening and drying of plants as compared with the untreated control. The desiccation effect of diquat was higher, similarly as in our experiments. Unlike in diquat, greater differences between the years and clover species were in the other variants. In crimson clover, the most efficient variant except diquat (var. 2) was the variant with pelargonic acid combined with the wetting agent and DAM fertilizer (var. 5) and the variant with a high dose of DAM fertilizer (var. 6). On the contrary, in red clover the efficiency of these variants was low, and the most efficient variants were those with carfentrazone-ethyl (var. 4 and var. 7). In the research of Havstad et al. (2022), the efficiency of carfentrazone-ethyl was relatively low. The most efficient variant except diquat was pelargonic acid, but it was used in a higher dose than in our experiments. The difference compared with our results could be also due to different conditions. The difference between the two diametrically different years showed the effect of weather on the efficiency of individual variants. Under moist weather, the natural drying of clover stands was slower, but the efficiency of desiccation was higher in those years (Table 5). In the studies conducted by Kirk et al. (2017a, b), the effect of year showed similarly as in our research. Desiccation effects in red and alsike clovers were the lowest in dry years too. In wet years, the regrowth of stands was more intensive, which was a great problem particularly in red clover. The effect of desiccants on the regrowth showed in both clover species, and the treatment with desiccants caused reduced regrowing (Table 5). The regrowing was most suppressed by diquat and carfentrazone-ethyl, namely in red clover. As to yield parameters, a significant difference as compared with the untreated control was found only in the harvest moisture content of red clover in 2021. The significantly reduced moisture content was due to the active substance of diquat (Table 6). Effects of the treatment on the seed yield, WTS (weight of thousand seeds) and germination were not observed.

Table 3. Differences in the natural drying of tissues, regrowing and breakdown of heads

Tablica 3. Razlike u prirodnome sušenju tkiva, ponovnome rastu i sušenju cvati

Species / *Vrsta*	Year / *Godina*	Drying of tissues before harvest (%) / *Sušenje tkiva prije žetve (%)*			Regrowing (% of regrowth coverage) / *Ponovni porast (% pokrivenosti usjeva)*	Head breakdown / *Otvaranje plodova*
		Leaves *Listovi*	Stems *Stabljike*	Heads *Glavice*		
Crimson clover / Inkarnatka	2019	100c	92d	100c	0a	41c
	2020	81b	70c	100c	10a	20b
	2021	83b	53bc	100c	3a	18b
Red clover / Crvena djetelina	2019	84b	56bc	97c	13a	0a
	2020	25a	40b	83b	95b	0a
	2021	17a	22a	53a	85b	0a
Mean values for the specific species / *Prosječne vrijednosti za vrste*						
	Crimson clover	88b	72b	100b	4a	26b
	Red clover	42a	39a	78a	64b	0a
Mean values for the specific years / *Prosječne vrijednosti za godine*						
	2019	92b	74c	99c	7a	20b
	2020	53a	55b	92b	52b	10a
	2021	50a	38a	77a	44b	9a

Legend: Shown are the average values (n=3) of natural drying of tissues, regrowing, and breakdown of heads in the respective experimental years, in the respective species, and the means of all years for the specific species (n=9) and means of all species for the specific years (n=6). Different letter indices illustrate statistical differences at a level of α 0.05 (ANOVA, post-hoc Tukey´s HSD test). / *Prikazane su prosječne vrijednosti prirodnoga sušenja tkiva, ponovnoga rasta i sušenje cvati u pojedinim godinama i vrstama te prosječne vrijednosti svih godina za pojedinačne vrste (n=9) te prosječne vrijednosti vrsta za pojedinačne godine (n=6). Različita slova prikazuju statističke razlike na razini 0,05 (ANOVA, Tukyjev post-hoc HSD test).*

Table 4. Comparison of yield parameters in crimson and red clovers

Tablica 4. Usporedba komponenti prinosa inkarnatke i crvene djeteline

Species / *Vrsta*	Year / *Godina*	Yield (kg ha^{-1}) / *Prinos*	Harvest moisture (%) / *Vlaga u žetvi*	WTS (g) / *Masa tisuću zrna (g)*	Germination (%) / *Klijavost (%)*	Death seeds and abnormal seedlings (%) / *Neklijavo sjeme i abnormalni klijanci (%)*	Hard seeds (%) / *Nalivene sjemenke (%)*
Crimson clover / *Inkarnatka*	2019	589b	-	3.9207d	59.2ab	40.8bc	9.5a
	2020	578b	22.5a	4.4682e	49.3a	50.3c	4.0a
	2021	335ab	29.4ab	3.9525d	63.0b	37.0b	5.0a
Red clover / *Crvena djetelina*	2019	277a	-	1.3474a	93.2c	7.0a	51.0d
	2020	277a	24.7ab	1.8328b	96.0c	2.7a	37.7c
	2021	196a	37.6b	2.4884c	90.3c	9.3a	26.3b
Mean values for the specific species / *Prosječne vrijednosti za vrste*							
	Crimson clover	501b	26.0a	4.1138b	57.2a	42.7b	6.2a
	Red clover	250a	31.1a	1.8895a	93.2b	6.3a	38.3b
Mean values for the specific years / *Prosječne vrijednosti za godine*							
	2019	433b	-	2.6341a	76.2a	23.9a	30.3c
	2020	427b	23.6a	3.1505b	72.7a	26.5a	20.8b
	2021	266a	33.5b	3.2204b	76.7a	23.2a	15.7a

Legend: Shown are the average values (n=3) of yield parameters the respective experimental years, species and means of all years for the specific species (n=9) and means of all species for the specific years (n=6). Different letter indices illustrate statistical differences at a level of α 0.05 (ANOVA, post-hoc Tukey´s HSD test). / *Prikazane su prosječne vrijednosti komponenti prinosa tijekom godina, i vrstama te prosječne vrijednosti svih godina za pojedinačne vrste (n=9) te prosječne vrijednosti vrsta za pojedinačne godine (n=6). Različita slova prikazuju statističke razlike na razini 0,05 (ANOVA, Tukyjev post-hoc HSD test).*

Table 5. Drying of tissues and regrowing after the treatment with desiccants

Tablica 5. Sušenje tkiva nakon tretmana desikantima

Year/ variant *Godina/ varijanta*		Crimson clove / *Inkarnatka*				Red clover / *Crvena djetelina*			
		Drying of tissues before harvest (%) / *Sušenje biljnih tkiva prije žetve (%)*			Regrowth coverage before harvest (%) / *Pokrivenostusjeva i prije žetve (%)*	Drying of tisues before harvest (%) / *Sušenje biljnih tkiva prije žetve (%)*			Regrowth coverage before harvest (%) / *Ponovni rast pokrivenosti prije žetve (%)*
		Leaves *Listovi*	Stems / *Stabljike*	Heads / *Cvati*		Leaves *Listovi*	Stems *Stabljike*	Heads *Glavice*	
2019	1 Unt.	100a	92a	100a	0,0a	84a	56a	97ab	13,0a
	2 Diq.	100a	98cd	100a	0,0a	100c	99b	100b	11,0a
	3 Pyr.	100a	96abc	100a	0,0a	91ab	80ab	99b	8,0a
	4 Carf.	100a	95abc	100a	0,0a	86a	63a	98ab	13,3a
	5 Pel. ac.	100a	94ab	100a	0,0a	95bc	76ab	99ab	10,0a
	6 DAM	100a	96abc	100a	0,0a	91ab	65a	94a	17,3a
	7 Diq+/ Car.+Pyr.	100a	100d	100a	0,0a	86a	67a	99ab	8,3a
2020	1 Unt.	81a	70a	100a	10,0b	25a	40a	83a	94,7c
	2 Diq.	100d	95de	100a	1,3a	90c	82c	96b	46,7b
	3 Pyr.	90b	78b	100a	8,3b	75b	60abc	91ab	80,0c
	4 Carf.	89b	78b	100a	4,0ab	90c	65bc	90ab	16,3a
	5 Pel. ac.	98d	88cd	100a	6,0ab	68b	57ab	90ab	80,7c
	6 DAM	94c	80bc	100a	5,3ab	72b	68bc	91ab	71,7c
	7 Diq+/ Car.+Pyr.	100d	98e	100a	0,0a	94c	78bc	94b	13,3a
2021	1 Unt.	83a	53a	100a	2,7b	17a	22a	53a	85,0c
	2 Diq.	97d	80cd	100a	0,6a	93c	90c	95c	12,7a
	3 Pyr.	91bc	67abc	100a	0,7a	43b	41ab	75b	71,7bc
	4 Carf.	88ab	63ab	100a	0,0a	95c	86c	94c	15,0a
	5 Pel. ac.	98d	85de	100a	0,0a	43b	45b	65ab	63,3b
	6 DAM	95cd	72bcd	100a	0,3a	35ab	35ab	62a	65,0b
	7 Diq+/ Car.+Pyr.	100d	94e	100a	0,0a	96c	87c	96c	6,7a
2019	-	100b	96c	100a	0,0a	90c	72b	98c	11,6a
2020	-	93a	84b	100a	5,0b	73b	64a	91b	57,6c
2021	-	93a	73a	100a	0,6a	60a	58a	77a	45,6b

Legend: Shown are the average values (n=3) of drying of tissues and regrowing in the respective experimental years, in the respective variants, and totals of all variants for the specific years (n=21). Different letter indices illustrate statistical differences at a level of α 0.05 (ANOVA, post-hoc Tukey´s HSD test). / *Prikazane su prosječne vrijednosti sušenja tkiva i ponovnoga rasta u godinama i tretmanima varijantama, te prosječni iznosi svih tretmana za pojedinačne godine (n=21). Različita slova prikazuju statističke razlike na razini 0,05 (ANOVA, Tukyjev post-hoc HSD test).*

Table 6. Effect of the treatment with desiccants on yield parameters

Tablica 8. Učinak tretmana desikantima na komponente prinosa

Year/ variant *Godina/ varijanta*		Yield parameters in crimson clover / *Komponente prinosa inkarnatke*				Yield parameters in red clover / *Komponente prinosa crvene djeteline*			
		Yield (kg ha^{-1}) / *Prinos (kg ha^{-1})*	Harvest moisture (%) / *Vlaga u žetvi (%)*	WTS (g) / *Masa tisuću zrna (g)*	Germination (%) / *Klijavost (%)*	Yield (kg ha^{-1}) / *Prinos (kg ha^{-1})*	Harvest moisture (%) / *Vlaga u žetvi (%)*	WTS (g) / *Masa tisuću zrna (g)*	Germination (%) / *Klijavost (%)*
2019	1 Unt.	589ab	-	3.9207a	59.0a	277ab	-	1.3474a	93.2ab
	2 Diq.	757b	-	3.9345a	70.7a	309ab	-	1.3635a	96.0ab
	3 Pyr.	720b	-	3.9246a	71.0a	242ab	-	1.3736a	96.7ab
	4 Carf.	771b	-	4.0076a	68.7a	314ab	-	1.3604a	94.7ab
	5 Pel. ac.	727b	-	3.9784a	75.0a	358b	-	1.3789a	98.3b
	6 DAM	676ab	-	4.0376a	62.0a	212a	-	1.4138a	91.7a
	7 Diq+/ Car.+Pyr.	435a	-	3.8859a	71.3a	291ab	-	1.3414a	94.8ab
2020	1 Unt.	578a	22.5a	4.4682a	49.7a	277a	24.7a	1.8328a	96.0a
	2 Diq.	506a	15.8a	4.5394a	41.0a	314a	15.3a	1.8493a	93.9a
	3 Pyr.	581a	15.9a	4.3443a	38.7a	291a	18.9a	1.8433a	95.3a
	4 Carf.	530a	15.7a	4.4931a	43.0a	329a	17.8a	1.8500a	95.0a
	5 Pel. ac.	684a	16.2a	4.6083a	43.7a	210a	21.7a	1.8600a	92.9a
	6 DAM	531a	17.5a	4.3993a	39.0a	254a	21.9a	1.9028a	97.4a
	7 Diq+/ Car.+Pyr.	431a	10.2a	4.6340a	53.0a	254a	12.5a	1.8700a	96.5a
2021	1 Unt.	335a	29.4a	3.9525a	63.0a	196a	37.6b	2.4884a	90.3a
	2 Diq.	366a	16.0a	3.8529a	61.3a	239a	18.3a	2.5051a	95.3a
	3 Pyr.	351a	19.3a	3.8531a	63.7a	230a	31.0ab	2.4644a	85.0a
	4 Carf.	361a	24.0a	3.8944a	58.0a	250a	32.9ab	2.5193a	90.7a
	5 Pel. ac.	353a	25.1a	3.9794a	54.7a	202a	38.2b	2.5641a	89.7a
	6 DAM	380a	19.4a	3.9480a	59.0a	290a	29.6ab	2.5216a	89.0a
	7 Diq+/ Car.+Pyr.	373a	13.1a	4.0253a	65.0a	264a	25.0ab	2.5571a	92.7a
2019	-	668c	-	3.9556a	68.2c	286b	-	1.3684a	95.0b
2020	-	549b	16.3a	4.4981b	44.0a	275ab	19.0a	1.8583b	95.3b
2021	-	360a	20.9b	3.9294a	60.7b	239a	30.4b	2.5171c	90.4a

Legend: Shown are the average values (n=3) of yield parameters in the respective experimental years, in the respective variants, and means of all variants for the specific years (n=21). Different letter indices illustrate statistical differences at a level of α 0.05 (ANOVA, post-hoc Tukey´s HSD test). / *Prikazane su prosječne vrijednosti (n=3) parametara prinosa u pojedinim pokusnim godinama, u pojedinim varijantama, i ukupni iznosi svih varijanata za pojedinačne godine (n=21). Različita slova prikazuju statističke razlike na razini 0,05 (ANOVA, Tukyjev post-hoc HSD test).*

CONCLUSION

Significant differences were recorded in the ripening of crimson and red clovers. Crimson clover dries out more intensively when ripening and does not show regrowing; however, its heads are crumbly. Red clover does not have crumbling heads but shows a very intensive regrowth. The ripening and drying of plants are relatively greatly affected by the course of weather. Under less favorable conditions with rains in the period of ripening and harvest, the natural drying of stand is insufficient, and before the harvest the vegetation has to be terminated when harvested for seed. The most suitable active substance of all active substances tested for the desiccation of the stands of both clover species was diquat which acted most rapidly and exhibited the highest efficiency. Other tested active substances are less effective compared to it. In crimson clover, the most proven active substance in addition to diquat was pelargonic acid and the variant with a high dose of DAM fertilizer. In red clover, the most efficient active substance in addition to diquat was carfentrazone-ethyl, either alone or in combination with pyraflufen-ethyl.

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REFERENCES

1. Bender, A., & Tamm, S. (2018). Seed yield of tetraploid red clover as influenced by cover crop management. *Zemdirbyste-Agriculture*, *105*(2), 133–140. DOI 10.13080/z-a.2018.105.017
2. Boller, B., Schubiger, F. X., & Kölliker, R. (2010). Red clover. In: Boller B, Posselt UK, Veronesi F (eds) *Fodder crops and amenity grasses, handbook of plant breeding,* vol 5. Springer, New York, 439–455. https://doi.org/10.1007/978-1-4419-0760-8_18
3. Brtnický, M., Kintl, A., Hammerschmiedt, T., Mustafa, A., Elbl, J., Kucerik, J., Vyhnanek, T., Skladanka, J., Hunady, I., Holatko, J. (2021), Clover Species Specific Influence on Microbial Abundance and Associated Enzyme Activities in Rhizosphere and Non-Rhizosphere Soils. *Agronomy, 11*, 2214. https://doi.org/10.3390/agronomy11112214
4. Costa, A. G. F., Severino, L. S., Sofiatti, V., Freitas, J. G., Gondim, T. M. S., & Cardoso, G. D. (2018). Pre-harvest desiccation of castor crop using 2,4-D and glyphosate. *Industrial Crops and Products, 122*, 261-265. https://doi.org/10.1016/j.indcrop.2018.05.070
5. ČHMU, (2020): *Měsíční a roční data dle zákona 123/1998 Sb*. https://www.chmi.cz/historicka-data/pocasi/mesicni-data/mesicni-data-dle-z.-123-1998-Sb
6. Duke, J. A. (1981). *Handbook of legumes of world economic importance.* Plenum Press, New York, USA, 345 p. https://doi.org/10.1007/978-1-4684-8151-8
7. European commission (2018): Official Journal of the European Union. L 125/10, 15.10.2018. Retrieved from https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32018R1532&from=PL
8. Fabbri, M., Casagrandi, F., Paganelli, M., Campagna, G., & Maffioli, G. (2018). Desiccation trials on potato with pelargonic acid. *Atti, Giornate Fitopatologiche, Chianciano Terme* (SI), Italia, 6-9 marzo 2018, Volume primo 2018, 493-498
9. Graham, P. H., & Vance, C. P. (2003). Legumes: Importance and Constraints to Greater Use. *Plant Physiol. 131*, 872-877. https://doi.org/10.1104/pp.017004
10. Hackney, B., Crocker, G., & Dear, Br. (2007): Crimson clover. *PRIMEFACT 382*, https://www.dpi.nsw.gov.au/__data/assets/pdf_file/0009/155466/crimson-clover.pdf
11. Havstad L. T., Øverland J. I., Aamlid T. S., Gunnarstorp T., Knudsen G. K. & Sæland J. (2022) Evaluation of pre-harvest desiccation strategies in red clover (*Trifolium pratense* L.) and white clover (*Trifolium repens* L.) seed crops, Acta Agriculturae Scandinavica, Section B — Soil & Plant Science, *72*:1, 818-834, DOI: 10.1080/09064710.2022.2089223
12. Hutchinson, C., & Stall, W. (2007). *Potato Vine Killing or Desiccation*, EDIS, 2007(20). Retrieved from https://journals.flvc.org/edis/article/view/117045
13. Kirk, S., Yoder, C., & Gauthier, T. (2017a). A three year comparative study of desiccant use on red clover seed crops in the Peace River region. *The Seed Head Fact sheet, 14*, 1-4.
14. Kirk S., Yoder C., & Gauthier T. (2017b). A three year comparative study of desiccant use on alsike clover seed crops in the Peace River region. *The Seed Head Fact sheet,* 15, 1-4.
15. Loux, M. (2019). Reminders about pre-harvest herbicide treatment. *Ohio's country journal 09.* www.ocj/2019/09/reminders-about-pre-harvest-herbicide-treatment.
16. Mallory-Smith, C. A., & Retzinger, E. J. (2003). Revised Classification of Herbicides by Site of Action for Weed Resistance Management Strategies. *Weed Technology*, *17*, 605–619. https://doi.org/10.1614/0890-037X(2003)017[0605:RCOHBS]2.0.CO;2
17. McNaughton, K. E., Blackshaw, R. E., Waddell, K. A., Gulden, R. H., Sikkema, P. H., & Gillard, Ch. L. (2015). Effect of application timing of glyphosate and saflufenacil as desiccants in dry edible bean (*Phaseolus vulgaris* L.). *Canadian Journal of Plant Science, 95*, 369-375. https://doi.org/10.4141/cjps-2014-157
18. Oliva, R.N., Steiner, J.J., & Young, W.C., III (1994). Red Clover Seed Production: II. Plant Water Status on Yield and Yield Components. *Crop Science, 34*, 184-192 https://doi.org/10.2135/cropsci1994.0011183X003400010033x
19. Parreira, M. C., Lemos, L. B., Portugal, J., & da Costa Aguiar Alves, P. L. (2015): Effect of desiccation with glyphosate on two common bean cultivars: physiology and cookung quality of the harvested product. *Australian Journal of Crop Science*, *9*(10), 925-930. ISSN:1835-2707
20. Raisse, E. R., Assis, M. D. O., Araujo, E. F., de Freitas, F. C. L., & Araujo, R. F. (2020). Chemical desiccants for anticipation of harvest and physiological quality of cowpea seeds. *Revista Caatinga 33*(4), 878-887. https://doi.org/10.1590/1983-21252020v33n402rc
21. Soltani, N., Blackshaw, R. E., Gulden, R. H., Gillard, C. L., Shropshire, Ch., & Sikkema, P. H. (2013). Desiccation in dry edible beans with various herbicides. *Canadian Journal of Plant Science,* 93, 871-877. https://doi.org/10.4141/cjps2013-061
22. Subedi, M., Willenborg, C.J., & Vandenberg, A. (2017). Influence of harvest aid herbicides on seed germination, seedling vigor and milling quality traits of red lentil (*Lens culinaris* L.). *Frontiers in Plant Science, 8*, 311. https://doi.org/10.3389/fpls.2017.00311
23. Zanatta, E., Szareski, V. J., Carvalho, I. R., Koch, F., Pimentel, J. R., Troyjack, C., Dellagostin, S. M., Demari, G. H., Lautenchleger, F., de Souza, V. Q., Martinazzo, E. G., Villela, F. A., Pedó, T., & Aumonde, T. Z. (2018). Pre-harvest Desiccation: Productivity and Physical and Physiological Inferences on Soybean Seeds During Storage. *Journal of Agricultural Science, 10*(6), 354-362. Doi:10.5539/jas.v10n6p354
24. Zotarelli, L., Sargent, S., Dittmar, P., & Makani, M. (2020). *Potato Vine Killing or Desiccation.* EDIS, https://edis.ifas.ufl.edu/publication/HS181

RAZLIKE U SAZRIJEVANJU DVIJU VRSTA DJETELINE I UTJECAJ DESIKACIJE PRIJE ŽETVE

SAŽETAK

Cilj ovog istraživanja bio je utvrditi razlike između sazrijevanja djeteline inkarnatke (Trifolium incarnatum L.) i crvene djeteline (Trifolium pratense L.) ovisno o primjeni desikanata prije žetve. Određena je razlika ovisno o vrsti tijekom više godina za odabrane pokazatelje: sušenje listova, stabljike i cvati tijekom sazrijevanja te ponovni porast usjeva, otvaranje plodova i prinos sjemena. Listovi, stabljike i cvati su se prirodno brže sušili kod djeteline inkarnatke negoli kod crvene djeteline. Kod inkarnatke je sušenje listova, stabljike i cvati je prije žetve iznosilo 80 – 100%, 50 – 95%, odnosno 100%, a kod crvene djeteline 25 – 84%, 20 – 72%, odnosno 45 – 99%. Također su utvrđene razlike u pokrovnosti usjeva nakon retrovegetacije i sušenje cvati. U predžetvenim tretmanima inkarnatke i crvene djeteline uspoređena je učinkovitost dikvata s učinkovitošću drugih herbicida (piraflufen-etil, karfentrazon-etil i pelargonska kiselina) te s učinkovitošću visoke doze DAM gnojiva (tekuće gnojivo, urea-amonij nitratom). U usporedbi s dikvatom, kod ostalih djelatnih tvari sušenje je bilo sporije. Nije utvrđen utjecaj korištenih djelatnih tvari na prinos, masu tisuću zrna i klijavost sjemena.

Ključne riječi: Trifolium incarnatum L., Trifolium pratense L., dozrijevanje, tretman desikantom

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