INFLUENCE OF EARLY POTATOES GROWING UNDER FLOATING ROW COVER ON STRUCTURE OF YIELD COMPONENTS*

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During 2000–2002 the influence of white polypropylene textile (NT) Pegas-agro 17 UV on the dynamics of yield formation in early irrigated potatoes (Adora and Impala varieties) has been investigated in precise field experiment in an early potatoes growing region of the Czech Republic. Modified micro-climatic conditions under the row cover (NT) statistically significantly increased marketable tubers mass under hill (in variety Adora it was by 7.7%, in the variety Impala it was by 12.3%), tubers mass in total (in variety Adora by 7.2%, in variety Impala by 11.8%), average tuber mass (in variety Adora by 12.6%, in variety Impala by 12.3%), number of marketable tubers (in variety Impala by 6.0%), haulm mass (in variety Adora by 8.0%, in variety Impala by 14.0%), length of the longest stem in the hill (in variety Adora by 6.6%, in variety Impala by 6.95%) during an average of the years 2000–2002 in comparison with the control variant without textile. In variant with NT has been found tendency to higher number of marketable tubers in variety Adora (by 0.85%), to higher number of stems per plant (in variety Adora by 4.1%, in variety Impala by 3.97%). Use of row cover did not influence number of tubers in total.

early potatoes; row cover; yield components; varieties; term of harvest

INTRODUCTION

In production of early potatoes for the earliest harvests there is a tendency to reach the earliest and high tubers yield with marketable size and standard consumer quality of tubers. For very early varieties a vegetation period (from planting to physiological maturity of new tubers) lasts from 90 to 100 days. In crops for early harvests the harvest starts after 60 up to 65 days, when potatoes are sold for higher prices. In this case the yield must be formed during relatively short period.

This task solution is partially on breeders – to breed a variety with fast formation of biomass at the beginning of vegetation, with fast transition to maximum growth and to its early termination, with early tubers formation – according to Zrůst (1991), and partially on growers – variety selection for existing growing conditions, proper tubers chitting, early planting in dense spacing and irrigation. The rows covering with row cover have been promoted in the CR since the 1990s (Dvořák et al., 2004).

Similarly, as in other crops also in potatoes it is necessary to monitor and record large number of data about plants and their environment for crop analysis (yield components) (Zrůst, Čepl, 1991). Structure of tubers yield comes from a number of stems and tubers per plant, from tubers mass per plant and from average tuber mass (Zrůst, cit. Petr et al., 1980).

Monitoring of growth dynamics and the factors during ontogenesis shows, that formation of yield components (and also of yield) is very variable. Based on the yield components number of the stems per hill (or per area) is created first (Zrůst, cit. Rybáček, 1988). The number of main stems of a seed tuber or seed piece is very important and depends on the number of eyes per tuber, the number of sprouts developing from the eyes and the proportion of sprouts developing into main stems. The number of eyes is determined by the tuber size. Large tubers have more eyes than smaller tubers, because as tubers grow larger the number of eyes increases, since new lateal buds are continuously initiated. The number of sprouts is also affected by chitting regime and the physiological age of tubers (Struik, Wiersema, 1999). Secondly, the number of stems is also influenced by density (number) of planted tubers and by their emergence (Zrůst, cit. Rybáček, 1988). In case of variety reaction to mineral fertilization and crop organization, reaction to increased fertilization in very early and early varieties in row culture was not observed in experiments of Zrůst and Dobiáš (1988) and the number of stems had the lowest average variability.

In field experiments of Zrůst (1991) his previous finding has been confirmed, that very early varieties with lower number of stems prove to be more productive varieties (not only in early harvest).

Number of tubers per hill (or per stem) depends on genetic base of a variety, on number of stems (in varieties with the same number of stems, the number of tubers per stem varies slightly). Number of tubers per hill ranges from 9 to 25 (number of tubers per stem ranges from 1.5 to 5). Number of tubers is a yield limiting factor

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in case that its value is so low, that it is not possible to compensate it with tubers mass (Zrůst, cit. Rybáček, 1988). Number of tubers is influenced by a variety and also it is highly influenced by a year (i.e. due to weather during tubers setting) and by seed tubers size. This monitored indicator has not been influenced (or very slight tendency was observed) by graded nitrogen fertilization and planting depth (Čepl, Vokál, 1996). Number of tubers is also influenced by decrease of giberelines synthesis (Wang et al., 1985), and also application of synthetic growth regulators influences the number of tubers in individual size classes (Košík, 1992).

Results of Josipović et al. (2005) show that tubers production and formation of other yield components are mainly influenced by a site and variety selection. Variety Impala in comparison with other three very early potato varieties (Krystala, Koruna and Ukama) in trials by Zrůst and Jůzl (1996) dominated in tubers growth (probably due to more favourable course of leaf area index) and in photosynthesis rate. Average tuber mass determinates an economic yield. Dobiáš and Radek (1988) proved in their experiments close relation (correlation) between total tubers yield and average tuber mass. Optimum growing conditions and yield formation components in suitable structure (e.g. variety genotype) are a prerequisite for full realization of this trait (Zrůst, cit. Rybáček, 1988).

It is always necessary to take into account, that many characteristics of production rate are interdependent, there are interactions between them and that there are interactions in yield formation. In the earliest varieties fast formation of the hill, early tubers initiation and their fast formation are required, which enable early assimilates to outlet into forming tubers, so they would reach possible consumer size and corresponding quality as well (Zrůst, Jůzl, 1996).

Due to positive correlation between longer growing period and higher yield performance (Avratovščuková, 1967), it is difficult to reach required yield performance in very early varieties. Furthermore, the required yield performance does not have to be in compliance with economic characteristics – good consumer quality, tuber size and shape uniformity, resistance to variable climatic conditions during vegetation, year, plant diseases and availability to mechanized harvest in lower stage of tubers maturity – mechanical damage (Zrůst, Jůzl, 1996).

The crops covering with row cover have been widely used in the CR since the 1990s, and it influences microclimate under the textile. The aim of our study is to investigate, how these altered microclimatic conditions influence growth and development of crops and structure of yield formation components in early potatoes.

MATERIAL AND METHODS

The precise field experiments were established at a site in Přerov nad Labem (at the variety test plot of the Central Institute for Supervising and Testing in Agriculture – CISTA). The site in Přerov nad Labem – 178 m above sea level, annual average temperature 8.8 °C, total annual precipitations 622 mm, sugar beet-growing area, typical brown soil, sandy soil, the high content of phosphorus in soil (134 ppm), good K and Mg content (201 ppm, 73 ppm) and pH 5.1.

The trials were established according to the methodology of CISTA for irrigated early potatoes in tetra blocks, when in every repeating the varieties were hand-planted in two rows, 25 tubers per row for each of the variants. The control variant (without covering with NT) and the experimental variant differed from the methodology of CISTA for irrigated early potatoes in covering with NT Pegas-agro 17 UV. The seed tubers of very early variety Adora and Impala (in grade C2) were used in the trials. The seed tubers of both variants were chitting during 4 to 5 weeks before planting. The tubers had sprouts of size 10 to 15 mm before planting, they were hand planted in spacing of 62.5 x 25 cm and immediately after preemergence herbicide Sencor (70% metribuzin) application they were covered with NT in terms showed in Table 1. In our experiments we used white polypropylene textile of type Pegas-agro 17 UV (weight of 17 g/m^2). It was removed from crops in dependence on weather (Table 1). Fertilization (commercial compost Organic of 12 t/ha, mineral fertilizers of 120 kg N, 120 kg P and 120 kg K in pure nutrients/ha) and treatment during vegetation were the same for both variants. To replenish water requirements we used eight irrigation rates in 2000 (total of 102 mm), five irrigation rates in 2001 (total of 83 mm) and seven irrigation rates in 2002 (total of 95 mm).

Plant samples (potato hills) for analyses were collected approximately in ten days intervals, the first samples harvest by 60 days after planting (the last decade of May and the beginning of June). Monitored yield formation components (number of tubers, mass of tubers, number of marketable tubers, mass of marketable tubers, number of stems, mass of potato haulm) were analysed

Table 1. Terms planting, removed textile and dates of harvest

Year	Planting	Removed textile (Textile variant)	First term of harvest	Second term of harvest	Third term of harvest
2000	4. 4.	4. 5.	31. 5.	15. 6.	28. 6.
2001	5. 4.	10. 5.	7. 6.	14. 6.	27. 6.
2002	28. 3.	4. 5.	31. 5.	6. 6.	26. 6.

and evaluated in each hill from each repeating. In marketable tubers yield they were investigated in each repeating. After primary data classification we evaluated them statistically using SAS 6.12 programme and analysis of variance method (ANOVA). For more detailed evaluation of differences and for statistical significance determination we used Tukey's method.

RESULTS AND DISCUSSION

Table 2 shows basic average data about yield formation components from all sample harvests and years. The highest marketable tubers mass per the hill on average of years had the variant with NT in both cultivars. In cultivar Impala it was statistically confirmatively higher by 55.5 g, in cultivar Adora it was statistically confirmatively higher by 35.9 g in comparison with the control without NT. Similar results in variant with NT were found also for number of marketable tubers under the hill (total number of tubers for both variants differed minimally). Numbers of stems per potato hill were not statistically significant.

Considering earliness evaluation it is necessary to monitor development of individual yield formation components during successive sample harvests and to evaluate influence of NT on their formation. Comparison of their values including statistical significance is showed in Tables 3 and 4.

Marketable tubers mass

Results from precise field experiments proved significantly positive influence of row cover on marketable tubers mass under the hill in the earliest harvest terms. Level of this trait in experimental variant with textile achieved in average of years 2000–2002 and cultivars during the first harvest terms (approx. 60 days after planting) statistically significantly higher values (by 22.9%) compared to the control variant. Also during the second sample harvest (approx. 75 days after planting) statistically confirmatively higher growth of marketable tubers mass due to NT was found (by 19.1%). In the third harvest term the mass of marketable tubers in experimental variant with NT reached the control variant.

Table 2. Level of the yield formation components in of experimental variants average of harvest terms years 2000–2002

Varieties	Adora			Impala		
	Control	Textile		Control	Textile	
Indicator	Mean	Mean	$LSD_{0.05}$	Mean	Mean	$LSD_{0.05}$
Mass of marketable tubers / hill (g)	466.13	502.04*	28.30	449.86	505.34*	35.48
Total tubers mass / hill (g)	478.36	512.94*	28.13	470.61	526.04*	34.66
Number of marketable tubers / hill	5.91	5.96	0.53	6.53	6.92*	0.33
Total number of tubers / hill	7.27	7.00	0.38	9.00	9.00	0.44
Number of stems / hill	3.42	3.56	0.20	5.12	5.22	0.27
Potato haulm mass / hill (g)	231.27	249.77*	17.22	248.79	283.66*	20.37
Length of the longest stem per hill (cm)	52.97	56.47*	1.16	54.56	58.35*	1.57
Average tuber mass (g)	71.11	80.05*	4.87	56.33	63.24*	4.70

* significant difference between variant with NT and control

Table 3. Structure of the yield formation components in cultivar Adora in individual terms of harvest in average of years 2000–2002

Harvest	First term of harvest				Second term of harvest				Third term of harvest			
Indicator	Control	Textile	$LSD_{0.05}$	Signif.	Control	Textile	$LSD_{0.05}$	Signif.	Control	Textile	$LSD_{0.05}$	Signif.
Mass of marketable tubers / hill (g)	286.26	350.27	22.53	*	450.85	498.09	30.40	*	661.28	657.77	44.95	ns
Total tubers mass / hill (g)	302.61	364.73	24.38	*	462.98	507.79	29.94	*	669.49	666.30	45.06	ns
Number of marketable tubers / hill	5.20	5.59	0.47	ns	6.07	6.41	1.42	ns	6.47	5.87	0.49	*
Total number of tubers / hill	6.90	7.06	0.69	ns	7.43	7.23	0.65	ns	7.49	6.72	0.63	*
Number of stems / hill	3.44	3.68	0.33	ns	3.48	3.70	0.37	ns	3.33	3.29	0.34	ns
Potato haulm mass / hill (g)	294.47	316.92	28.33	ns	256.53	284.04	22.77	*	142.83	148.34	21.32	ns
Length of the longest stem per hill (cm)	56.87	59.07	2.04	*	55.63	60.06	1.97	*	46.41	50.29	3.40	*
Average tuber mass (g)	48.42	55.27	4.25	*	68.62	77.74	6.86	*	96.03	107.14	8.31	*

Signif. – significance, * – significant / ns – not significant

Table 4. Structure of the yield formation components in cultivar Impala in individual terms of harvest in average of years 2000–2002

Harvest	First term of harvest				Second term of harvest				Third term of harvest			
Indicator	Control	Textile	$LSD_{0.05}$	Signif.	Control	Textile	$LSD_{0.05}$	Signif.	Control	Textile	$LSD_{0.05}$	Signif.
Mass of marketable tubers / hill (g)	213.26	294.13	17.85	*	404.31	471.25	36.73	*	732.03	750.66	43.09	ns
Total tubers mass / hill (g)	243.95	325.20	18.45	*	423.63	487.11	36.21	*	744.26	765.82	43.17	ns
Number of marketable tubers / hill	5.13	6.16	0.45	*	6.58	6.93	0.49	ns	7.88	7.66	0.618	ns
Total number of tubers / hill	8.48	8.56	0.76	ns	9.20	9.23	0.79	ns	9.33	9.22	0.76	ns
Number of stems / hill	5.09	5.08	0.47	ns	5.63	5.66	0.50	ns	4.64	4.93	0.41	ns
Potato haulm mass / hill (g)	323.08	364.75	30.94	*	273.87	314.31	34.28	*	149.43	171.92	21.75	*
Length of the longest stem per hill (cm)	57.45	60.07	2.14	*	56.82	60.97	2.11	*	49.42	54.03	3.34	*
Average tuber mass (g)	31.46	40.59	3.02	*	51.63	59.63	7.08	*	85.91	89.80	7.26	ns

Signif. – significance, * – significant / ns – not significant

Crops with the row cover had faster emergence, growth and development due to more favourable temperature, soil and air moisture. But later they had lower vitality because of favourable soil moisture under the NT they rooted less deeply, under favourable conditions under the textile they became more delicate and so they were reached or overtaken by more vital crops of the control variant. The results concerning impact of the textile on air temperature and on soil temperature were published in late works of Dvořák et al. (2004) and Kožnarová et al. (2000). In total tubers mass (Tables 3 and 4) was also proved influence of NT on the level of this trait.

Number of marketable tubers

This indicator is very important for determination of correct term of the first harvest, because it is desirable to achieve the highest possible percentage rate of marketable size tubers. Influence of the textile on a number of tubers varied during the experimental years. The row cover caused average increase in the number of marketable tubers during the first sample harvests by 7.0% in cultivar Adora, in cultivar Impala by 16.7% (higher numbers of marketable tubers under NT were not statistically confirmative except for the first harvest term in cultivar Impala and it was even opposing during the third harvests in both cultivars).

Number of marketable tubers corresponds with the total number of tubers. Higher numbers of tubers (higher set of tubers) differed in dependence on cultivar, variant and sample harvest (Tables 3 and 4).

Number of stems per hill

The influence of the row cover on the number of stems has not been definitely proved during the monitored years. In most cases it was moderate, statistically non-significant increasement of the number of stems in option with NT.

Significant differences in the number of stems could be seen in comparison of both cultivars, when possible explanation could be the different temperature requirements of varieties, but especially genetic qualities of the varieties. Adora forms less stems and lower number of tubers under the hill, but with higher average tuber mass (Tables 3 and 4). Impala with higher number of stems and tubers under the hill (Table 4) has lower average tuber mass. Higher tubers set in Impala together with higher stems number confirm the correlation between the number of stems and tubers set. Similar relations between yield formation components and yield were found also by other authors (Hruška, 1977) and were confirmed by growing under the row cover (Hamouz et al., 2005).

Potato haulm mass

Conditions under the NT and following development of crops after the textile removal statistically significantly increased potato haulm mass in cultivar Impala in all three evaluated sample harvests (Table 4). In variety Adora (Table 3) tendency to higher potato haulm mass in variant with NT was found (statistically significantly higher only in the second harvests). Higher potato haulm mass in option with NT (in average of years and harvests in the cultivar Adora it was by 8.0%, in the cultivar Impala it was by 14.0% compared to the control with NT) and negative correlation of tubers mass found by many authors in case of using the NT did not appear in tubers mass result.

Length of the longest stem

In both monitored cultivars and in all sample harvests the length of the longest stem was statistically signifi-

cantly higher (Tables 3 and 4) in option with NT (in average in the cultivar Adora it was by 6.6% and in the cultivar Impala it was by 7.0%).

Average tuber mass

It is necessary to remember that full realization of a trait (in case of marketable tubers maximum production the average tuber mass is crucial) is possible only under optimum ecological conditions and with suitable structure of other yield formation components (determined by genetic background of particular cultivar) or by crop organization.

Comparing both cultivars cultivated under the NT, the higher average tuber mass was found in the cultivar Adora (by 21%), but higher impact of NT on tubers mass growth compared to the control was found in cultivar Impala (by 37.6% in comparison with the cultivar Adora). Finding of Zrůst and Čepl (1991) was thus confirmed saying that the most efficient types of cultivars prove to be varieties with lower number of stems and higher average mass of tubers.

By comparing increasement of average tuber mass during first harvests, we can find that the NT increased average tuber mass in cultivar Adora from 48.4 g to 55.3 g and in cultivar Impala from 31.5 g to 40.6 g (Tables 3 and 4). Favourable influence of the NT on earliness of harvest is related to artificially created microclimatic conditions of the crop, which accelerated emergence (approx. by 7 up to 10 days compared to the control) and accelerated further growth and development of the crops in term, when there were less favourable weather conditions for early potatoes (Kožnarová et al., 2000).

From this result we can see the different reaction of cultivars on growth under the row cover, and so it is necessary to choose a suitable cultivar for the earliest harvests.

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Vliv pěstování raných brambor pod nakryvem netkané textilie na strukturu výnosotvorných prvků.

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V letech 2000–2002 byl sledován vliv bílé netkané textilie Pegas-agro 17 UV na dynamiku tvorby výnosotvorných prvků u raných zavlažovaných brambor na stanovišti Přerov nad Labem v ranobramborářské oblasti ČR. Pokusy byly založeny podle metodiky ÚKZÚZ pro rané zavlažované brambory ve čtyřech blocích, kdy v opakování byly odrůdy ručně vysázeny ve dvou řádcích po 25 hlízách u každé varianty – kontrolní (bez nakrytí) a pokusné (s nakryvem netkané textilie Pegas-agro 17 UV). Sadba byla před výsadbou jednotně předkličována, při ruční výsadbě sázena do sponu 62,5 x 25 cm. Netkaná textilie byla natažena bezprostředně po aplikaci preemergentního herbicidu (Tab. 1) a sejmuta v závislosti na počasí cca do poloviny května. Odběry rostlin (trsů) pro rozbory byly prováděny přibližně v 10denních intervalech, první odběr cca do 60 dní po výsadbě (poslední dekáda května, počátek června). Byly sledovány výnosotvorné prvky (počet hlíz, počet stonků, hmotnost hlíz, hmotnost natě a délka nejdelšího stonku). Použití bílé netkané textilie zvýšilo statisticky průkazně hmotnost hlíz konzumní velikosti pod trsem v časných termínech sklizně na konci května a počátku června (v průměru let 2000–2002 u odrůdy Adora o 22,4 %, u odrůdy Impala o 37,9 % v porovnání s kontrolní variantou bez textilie). Při porovnání obou odrůd se tak vyšší efekt textilie projevil u odrůdy Impala v porovnání s odrůdou Adora. Nejvyšší průměrnou hmotnost hlíz konzumní velikosti pod trsem vykázala varianta s netkanou textilií u obou odrůd (u odrůdy Impala 505,34 g, u odrůdy Adora 502,04 g). Dále se ukázal příznivý vliv bílé netkané textilie na teplotu půdy a vzduchu v přízemní vrstvě.

rané brambory; nakryv netkané textilie; výnosotvorné prvky; odrůda; ročník

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