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EFFECTS OF CULTIVAR AND MULCHING ON THE POTATO YIELD

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ABSTRACT

Plant growing technology involves usage of complex agrotechnical operations aimed at creating favorable conditions for plant growth and development, that is, for better exploitation of cultivar genetic potential. Effects of mulching with white and black polyethylene foil, and organic mulch (straw) were studied in three, drip-irrigated potato cultivars: Carrera (early), Laura (medium early) and Agria (medium late). Treatments were arranged in a randomized complete block design with four replications at the site of Zemun Polje, Serbia (44°88ʾN, 20°35ʾE, 79 m a.s.l.) in three consecutive years (2011–2013). Results obtained on the variants with different mulch materials were compared with results attained on the plot with bare soil (control). The highest average number of tubers per plant was determined in cv. Laura's control variant (12.0), while the lowest average number of tubers was determined in the cv. Agria with white mulch (8.2). The highest average tuber mass (146.3 g) and total tuber yield (59.6 t ha^{-1}) was determined in cv. Carrera subjected to the straw mulch treatment. The lowest average tuber mass and tuber yield was found in the cv. Agria on the variant with black polyethylene foil (83 g and 27.8 t ha^{-1}). The results obtained in our study indicate positive effect of the combination of straw mulch and irrigation on the productivity of potato. Modern growing technology, which includes the regulation of temperature in the surface soil layer by combination of soil mulching, drip irrigation system, and the use of adequate genotypes, can result in high potato yield.

Key words: *mulching, potato, potato yield, tuber mass.*

INTRODUCTION

The average area under potatoes in Serbia is 73.000 ha with a small average yield of 14.5 t ha^{-1} (Statistical Yearbook of Serbia, 2016). Wider application of intensive agrotechnology is lacking in potato production in Serbia, especially considering small and economically poor agricultural holdings (Broćić and Stefanović 2012).

Plant growing technology involves usage of complex agrotechnical operations aimed at creating favorable conditions for plant growth and development, that is, for better exploitation of the genetic potential of cultivars. Term agronomic variety relates to variety specific requirements regarding particular agrotechnical measures. Detailed monitoring of important morphological characteristics, such as fertility, yield quantity and quality, disease resistance and abiotic stress tolerance, must be a basic prerequisite for assessing the suitability of a particular breeding variety to specific agroecological conditions (Momirović et al., 2000). Agrotechnical procedures applied in modern potato production are selection of plots, basic and additional soil cultivation, fertilization of crops, selection of assortments and preparation for planting, crop protection measures (hoeing, sheltering, protection from diseases and pests, feeding, mellowing of compacted soils, irrigation), extraction of potato tubers, tuber storage and preparation for the market.

Mulching is an agrotechnical technique that directly determines the microclimate of plants in several ways. It reduces evaporation (Gao and Li, 2005; Zhao et al., 2012), warms the surface soil layer after sowing (Wang et al., 2003; Zhao et al., 2012), increases the microbiological activity (Yang et al., 2003; Agüero et al., 2008) and inhibits the development of most one-year and perennial weeds (Jodaugiene et al., 2006a, b). Soil covering with mulch also reduces the destructive action of rain drops, prevents formation of crust and maintains favorable air regime of the land. Through greater heat accumulation, as well as the photo-physiological effect of reflected diffused light, soil mulching significantly affects potato yield quantity and quality, the bulk density and marketability of the tubers, as well as the greater content of protective, colorful compounds (Momirović et al., 2011). Since the application of a plastic mulch technique most often involves irrigation with the "drop by drop" system, the loss of nutrients is minimal. Nutritional substances can be introduced into the irrigation system and thus, if necessary, precisely directed into the soil root zone.

For soil mulching, differently colored polychloropenic foils and organic mulch are used. White/black foil is characterized by extremely high reflection which allows cultivation of crops in the warmer part of the vegetation season. Black mulch foils are used for vegetable cultivation in general; the advantages are mainly related to water savings (up to 50% in drip-irrigation system), successful weed control, better phytosanitary conditions and directed carbon dioxide emissions from soil to photosynthetic area (chimney effect). Dark foil can be considered as absolutely non-toxic herbicide, harmless to plants, land and man (Kovačević and Momirović, 2008). Straw is the most commonly used material for ground covering in the crop and vegetable production because of its good thermal insulation properties. The temperature of the soil under the straw can be 5-8 ^{o}C lower than the temperature of bare soil which is especially important in the summer. The aim of the present paper was to evaluate effects of different mulch materials (organic and plastic mulch) and cultivar/genotype on productive characteristics of potato grown in the lowland region of Serbia.

MATERIALS AND METHODS

Effects of mulching with white and black polyethylene foil, and organic mulch (straw) on productive characteristics of three drip-irrigated potato cultivars: Carrera (early), Laura (medium early) and Agria (medium late) were investigated. Treatments were arranged in a randomized complete block design with four replications at the site of Zemun Polje, Belgrade (44°88′N, 20°35′E, 79 m a.s.l.) in the period 2011–2013. Experimental field was divided into four blocks with unit size of 7 m^2 (cultivar x mulch combination). Standard tillage treatment for potato crop was used. Irrigation tapes were placed in the middle of a shallow bank and incorporated into the soil (sub-irrigation) and soil moisture maintained at about 75% of FWC.

The variants with different mulch materials were established, as well as control plot with bare soil. In plots with plastic mulch, ridges were formed firstly and then covered by the polyethylene film. Tubers were hand-planted in previously prepared holes in the plastic mulch. In the variant with organic mulch, straw was layered to 25 mm thickness directly after planting and the formation of ridges.

In the years of study the planting of tubers (planting density: 80 x 30 cm) was carried out in the first decade of April. Potato harvesting was carried out at the stage of full maturity in the second ten days of September and number of tubers per plant, tuber mass and total yield were determined for all cultivar/treatment variants and averaged.

The climate conditions during potato growing season are presented in the Table 1. The average air temperatures during potato vegetation period in 2011, 2012 and 2013 were significantly higher (for 2.1-3.6 ^oC) than 1961-1990 multi-year average (18.4 ^oC); this was mostly result of average temperature increase in June, July and August. Temperature increase in June and July were especially significant, considering that this period is important for tuber bulking. Precipitations were below limits of multiple-year average with an uneven distribution during the growing season in all three years of investigation.

Climate conditions during potato growing season

Table 1. The average monthly air temperatures and monthly precipitation sums at Belgrade, Serbia during the growing seasons 2011, 2012 and 2013 and multi-year average

Month	2011		2012		2013		1961-1990	
	^oC	mm	^oC	mm	^oC	mm	^oC	mm
April	14.7	14.1	14.6	66.9	15.2	21.3	12.4	58.8
May	18.3	66.8	18.0	127.9	19.3	104.4	17.2	70.7
June	21.9	41.1	24.6	16.0	21.1	50.1	20.1	90.4
July	24.3	95.0	27.0	39.0	24.1	2.9	21.8	66.5
August	24.6	14.0	26.0	4.5	25.5	44.3	21.4	51.2
September	23.0	47.7	22.0	30.7	17.6	58.7	17.7	51.4
Average/Sum	**21.1**	**278.7**	**22.0**	**285.0**	**20.5**	**281.7**	**18.4**	**389.0**

Statistical analysis was performed using STATISTICA 10 (StatSoft, Inc. 1984-2011, USA). The data concerning tuber number, tuber mass and total yield were subjected to two-factor analysis of variance (ANOVA) with Cultivar and Mulch-Type as factors, followed by Fisher's-LSD test at significance levels of 0.05 and 0.01.

RESULTS AND DISCUSSION

The results of investigation given in Table 2. show that the highest average number of tubers per plant (all three cultivars/genotypes) was recorded in the variant with white plastic mulch and control (10.0), somewhat smaller was determined on variants with black mulch (9.9), while the lowest number of tubers per plant (9.5) was recorded on variant with straw.

Considering cultivar/genotype factor, cv. Laura was forming the highest average number of tubers per plant (10.8), followed by Carrera (10.2), while the lowest number of tubers per plant was recorded for cv. Agria (8.6).

Considering both investigated factors (Table 2.), Mulch and Cultivar, cv. Carrera grown on white foil mulch has shown significantly higher number of tubers per plant (11.2) compared to straw mulch (10.1), black foil mulch (10.0) and control (9.4) variants. Cv. Laura formed the highest number of tubers on bare soil (12.0), followed by variants with black and white foil mulch, and significantly the lowest number on variant with straw mulch (9.1).

Tuber size and mass are traits primarily determined by potato genotype. Nevertheless, these traits depend also on ecological factors, agrotechnical practices, size of seed tuber, number of primary shoots, number of tubers per plant, etc. (Poštić et al., 2015; Momirović et al 2016). Significant difference was determined between tuber mass on organic, straw mulch and other investigated mulches (Table 2.). The highest average tuber mass was recorded on organic mulch (134 g), followed by control (126 g), variant with black plastic mulch (102 g), while the lowest tuber mass was determined on variant with white plastic mulch (95 g).

Comparison between cultivars/genotypes has revealed that cv. Carrera forms significantly heavier tubers (130 g) compared to cvs. Agria (111 g) and Laura (101 g).

Considering both investigated factors (Table 2.), Mulch and Cultivar, cv. Agria grown on straw mulch and bare soil formed significantly heavier tubers (134 g and 129 g, respectively) compared with white and black foil mulch (98 g and 83 g, respectively). Tuber mass of two other cultivars, Carrera and Laura, did not significantly differ between investigated mulch variants.

Table 2. Impacts of mulch and cultivar on potato status

Mulch (polyethylene foil A1=white, A2=black; organic mulch A3=straw; bare soil A4), cultivar (B1= Carrera, B2=Laura, B3=Agria) and potato status (3-year averages 2011-2013)

	Tuber number per plant				**Tuber mass** (g)				**Tuber yield** (t ha^{-1})			
	B1	B2	B3	**xA**	B1	B2	B3	**xA**	B1	B2	B3	**xA**
A1	11.2	10.7	8.2	**10.0**	103	83	98	**95**	48.0	34.7	33.1	**38.6**
A2	10.0	11.5	8.2	**9.9**	127	96	83	**102**	53.9	45.6	27.8	**42.5**
A3	10.1	9.1	9.3	**9.5**	146	122	134	**134**	59.6	44.5	48.2	**50.7**
A4	9.4	12.0	8.5	**10.0**	142	105	129	**126**	55.1	51.8	45.1	**50.7**
x B	**10.2**	**10.8**	**8.6**	**x B**	**130**	**101**	**111**	**x B**	**54.2**	**44.1**	**38.6**	
LSD	A	B	AxB		A	B	AxB		A	B	AxB	
0.05	0.57	0.38	1.50		34.5	29.9	45.8		12.1	10.8	19.1	
0.01	0.97	0.79	2.57		41.5	30.6	55.5		16.2	14.0	25.0	

The highest average yield of three cultivars (Table 2.) was determined in variant with organic mulch (50.7 t ha-1), followed by yield of potato plants treated with black plastic mulch (42.5 t ha-1), while the lowest yield was determined in variant white plastic mulch (38.6 t ha-1). Similar results were obtained in research on cvs. Marabel (medium early), Desiree (medium late) and Jelly (medium late) where significant difference in tuber yield was determined between organic mulch and two plastic mulch treatments (Oljača et al., 2016a). Beneficial effect of plastic foil mulches on potato yield is usually observed in cold climate regions (Singh and Ahmed 2008), while in Serbia plastic foil mulching can be useful in production of new potato during spring (Oljača 2016. b).

Considering cultivar/genotype factor, cv. Carrera has shown the highest average yield (54.2 t ha^{-1}), followed by Laura (44.1 t ha^{-1}), while the lowest tuber yield was recorded for cv. Agria (38.6 t ha^{-1}). However, significant difference in yield was detected only between Carrera and two other cultivars, Laura and Agria.

Considering both investigated factors, Mulch and Cultivar, cv. Agria has shown significantly higher tuber yield on straw mulch (48.2 t ha^{-1}) and bare soil (45.1 t ha^{-1}) compared with white (33.1 t ha^{-1}) or black (27.8 t ha^{-1}) plastic foil mulch. Similarly to tuber mass parameter, Carrera and Laura tuber yield on different mulch variants did not significantly differ. Also, no significant difference was observed between mulch treatments and control (bare soil).

CONCLUSIONS

The results obtained in our study indicate positive effect of the combination of straw mulch and irrigation on the productivity of potato. Considering production potential of particular cultivars/genotypes, the highest average tuber mass all three varieties were achieved in treatments with organic mulch or bare soil. Cultivars Carrera and Agria was showing the highest yield on variant with organic mulch,

while the Laura variety achieved the highest yield on bare soil. Conversely, the lowest yield of each particular cultivar was determined in treatment with white and black plastic mulch indicating that this mulch type is not appropriate for potato growing under agroecological conditions of southern Srem, Serbia. Modern growing technology, which includes the regulation of temperature in the surface soil layer by combination of straw mulching, drip irrigation system, and the use of adequate genotypes, can result in high potato yield.

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