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<i>Ivica Djalović, Vuk Radojević, Vojislav Mihailović, Sanja Vasiljević, Bojan Mitrović:</i> GENOTIPSKI ODGOVOR NS HIBRIDA KUKURUZA NA POVEĆANU GUSTINU USEVA.....	11
<i>Ana Marjanović Jeromela, Federica Zanetti, Johann Vollmann, Barbara Alberghini, Arianna Borghesi, Sandra Cvejić, Ankica Kondić Špika, Andrea Monti, Dragana Miladinović:</i> COMPARISON OF CAMELINA SEED YIELD AND BIOMASS PRODUCTION IN CONTRASTING ENVIRONMENTS.....	19
<i>Ankica Kondić Špika, Dragana Trkulja, Sanja Mikić, Ljiljana Brbaklić:</i> COMPARISON OF AGRONOMICAL PERFORMANCE OF SERBIAN WHEAT CULTIVARS AND NILS WITH DIFFERENT PPD ALLELES.....	25
<i>Borislav Petković, Novo Pržulj, Vojo Radić, Darko Aćimović:</i> POTENCIJAL PRINOSA GENOTIPOVA CRVENE DJETELIENE (<i>Trifolium pratense</i> L.).....	31
<i>Dalibor Tomić, Vladeta Stevović, Dragan Đurović, Milomirka Madić, Miloš Marijanović, Aleksandar Simić, Jasmina Knežević:</i> ZNAČAJ PRAVILNE ISHRANE KRMNIH LEGUMINOZA FOSFOROM NA KISELIM ZEMLJIŠTIMA.....	37
<i>Vojin Đukić, Jegor Miladinović, Zlatica Miladinov Mamlić, Gordana Dozet, Marija Bajagić, Marijana Jovanović, Vojin Cvijanović:</i> PRINOS SOJE U ZAVISNOSTI OD VREMENA PRIMENE NPK ĐUBRIVA	43
<i>Duško Brković, Dalibor Tomić, Snežana Branković:</i> DIVERZITET I ANALIZA KVALITATIVNOG SASTAVA BILJNE ZAJEDNICE STRNIŠTA KAO POTENCIJALNE KRME.....	49
<i>Gordana Dozet, Vojin Đukić, Zlatica Miladinov Mamlić, Nenad Đurić, Gorica Cvijanović, Marijana Jovanović Todorović, Dimitrije Dozet:</i> UTICAJ SORTE I MIKROBIOLOŠKIH PREPARATA NA BROJ I MASU NODULA KOD ORGANSKE PROIZVODNJE PASULJA	55
<i>Gorica Cvijanović, Eltreki Abduladim, Nenad Đurić, Vojin Đukić, Gordana Dozet, Zlatica Miladinov Mamlić, Asija Abduladim:</i> UTICAJ PRIMENE NPK ĐUBRIVA I EFEKTIVNIH MIKROORGANIZAMA NA MASU I VISINU BILJAKA SOJE.....	61
<i>Kristina Luković, Veselinka Zečević, Vladimir Perišić, Milivoje Milovanović, Kamenko Bratković, Vera Rajčić:</i> STABILNOST PRINOSA ZRNA LINIJA PŠENICE CENTRA ZA STRNA ŽITA KRAGUJEVAC.....	67
<i>Ljiljana Bošković-Rakočević, Gorica Paunović, Goran Dugalić, Jelena Mladenović:</i> POGODNOST ZEMLJIŠTA ZA GAJENJE MALINE	73
<i>Marijana Dugalić, Ljiljana Bošković Rakočević, Vera Rajčić, Dragan Terzić:</i> UTICAJ NAČINA PRIMENE MINERALNIH ĐUBRIVA NA PRINOS KROMPIRA	79
<i>Milena Simić, Vesna Dragičević, Željko Dolijanović, Milan Brankov, Života Jovanović:</i> ZNAČAJ PREDUSEVA ZA PRODUKTIVNOST KUKURUZA	85
<i>Milomirka Madić, Dalibor Tomić, Aleksandar Paunović, Vladeta Stevović, Dragan Đurović:</i> PRINOS ZRNA HIBRIDA KUKURUZA RAZLIČITIH FAO GUPA ZRENJA.....	93

COMPARISON OF AGRONOMICAL PERFORMANCE OF SERBIAN WHEAT CULTIVARS AND NILs WITH DIFFERENT *PPD* ALLELES

Ankica Kondić Špika¹, Dragana Trkulja¹, Sanja Mikić¹, Ljiljana Brbaklić¹

Abstract: Photoperiod response (*Ppd*) genes are very important for adaptation of wheat to different agro-climatic conditions, but also have influence on crop yield. The aim of this study was to compare agronomic traits of 10 Serbian wheat cultivars and 54 NILs of cv. Paragon with single, double and triple doses of *Ppd-1* alleles. The results showed that the NILs with introgressed single early *Ppd-1* alleles (Set 2), as well as the NILs with introgressed *Ppd-1* null alleles, knock-outs and late alleles (Set 4) had significantly longer stems and spikes than Serbian cultivars (Set 1). The lines with introgressed double early *Ppd-1* alleles (Set 3) were very similar to the Serbian cultivars. Some promising lines with good potential for breeding programs were identified.

Key words: agronomical traits, NILs, *Ppd* alleles, wheat cultivars

Introduction

According to photoperiod susceptibility, wheat cultivars can be classified into photoperiod sensitive (PS) or photoperiod insensitive (PI) types. In PS wheat cultivars, flowering occur earlier under long-day conditions (LD), while under short-day conditions (SD) flowering is delayed (Zhao *et al.*, 2015). These cultivars are often distributed at high latitudes, while PI cultivars predominate in low-latitude regions with SD, such as Southern Europe (Worland 1996, Lobell and Field 2007).

Photoperiodic response, a trait important for wheat adaptability to various environments, is controlled by three major genes, namely, *Ppd-D1* (previously designated *Ppd1*), *Ppd-B1* (*Ppd2*) and *Ppd-A1* (*Ppd3*), located on homeologous group 2 chromosomes (Scarath and Law 1983, 1984, Welsh *et al.*, 1973). The sequence analyses revealed that the photoperiod-insensitive *Ppd-D1a* allele is associated with a 2,089-bp deletion upstream of the coding region (Beales *et al.*, 2007). Recent data show that the photoperiod-insensitive *Ppd-A1a* and *Ppd-B1a* alleles are associated with a 1085-bp deletion and a 308-bp insertion, respectively (Nishida *et al.*, 2013, GenBank sequence accessions are [AB646973](https://www.ncbi.nlm.nih.gov/nuccore/AB646973) and [AB646974](https://www.ncbi.nlm.nih.gov/nuccore/AB646974)), both of which share the common region with a deletion of *Ppd-D1a*. Besides the photoperiodic response, these alleles may have the effect on many other important agronomical traits, including yield.

The objective of this study was to identify the effect of different *Ppd* alleles on important agronomical traits (stem height, peduncle and spike length) by using

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near-isogenic lines (NILs) of wheat cultivar Paragon in comparison to Serbian well adapted cultivars.

Material and methods

The experiment was carried out at Rimski šančevi, Serbia (45°20'N, 19°51'E) during the growing season 2014/15. Four sets of specific genetic material were used for the study:

Set 1 - Ten modern Serbian wheat cultivars (Simonida, Zvezdana, Dika, Ljiljana, Dragana, NS 40S, Rapsodija, Pobeda, Renesansa, NS Gora),

Set 2 - NILs of cv. Paragon with single changes in *Ppd* alleles (insensitivity and early alleles)

Set 3 - NILs of cv. Paragon with double changes in *Ppd* alleles (insensitivity and early alleles),

Set 4 - NILs of cv. Paragon with single, double or triple changes in *Ppd* alleles (null, knock-outs or late alleles)

The plot size was 2 m² (2x1) with six rows per plot in three replications. The following traits were measured on sample plants from each replication: whole stem height (cm), peduncle length (cm), and spike length (cm). Statistical data analysis using Tukey test to compare means was carried out in STAR-Statistical Tool for Agricultural Research v. 2.0.1.program.

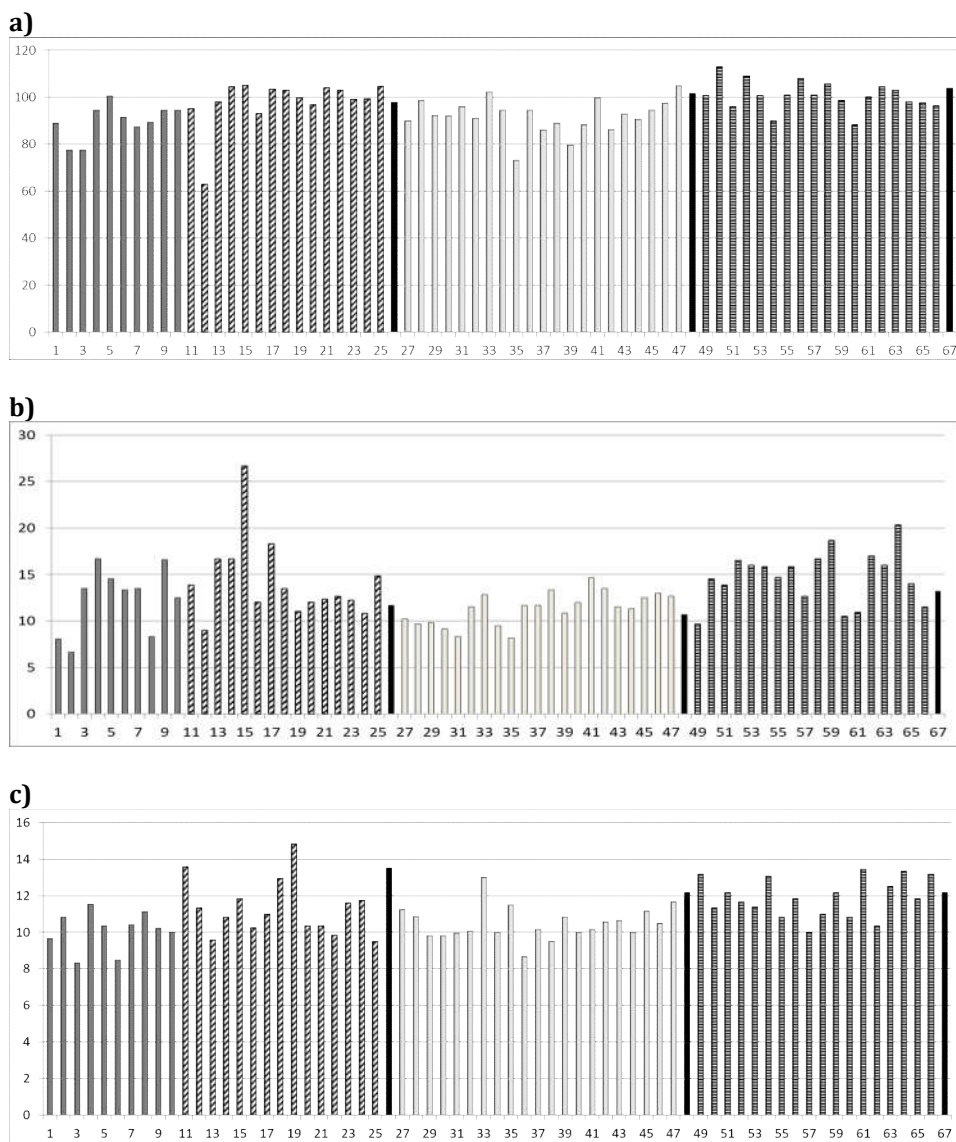
Results and discussion

The results showed significant differences among the sets of the genotypes concerning analyzed traits. Among Serbian cultivars (Set 1) the whole stem height varied from 77 cm to 101 cm, among NILs of the Set 2 from 63 cm to 105 cm, in the Set 3 of NILs from 73 cm to 105 cm, while in the Set 4 of NILs they varied from 88 cm to 113 cm (Graph. 1a). Coefficient of variation (CV) for all the genotypes was 9%. Regarding the peduncle length, variations among lines within and among the sets were significantly higher. Serbian cultivars had peduncle length from 7 cm to 17 cm, the Set 2 from 9 cm to 27 cm, the Set 3 from 8 cm to 15 and the Set 4 from 10 cm to 20 cm (Graph 1b). The overall CV was 25%. The spike length varied in the Serbian cultivars in the range 8.3-11.5 cm, in the Set 2 9.5-14.8 cm, in the Set 3 8.7-13 cm, while in the Set 4 10-13.4 cm (Graph 1c). Coefficient of variation for this trait was 12%.

From the Graph 1 some interesting lines could be identified, such as the lines 12 (Set 2), 35 (Set 3) and 61 (Set 4). These NILs with different *Ppd* alleles had very short stem and peduncle, but relatively long spikes, indicating a high harvest index, good translocation of assimilates and indirectly good yield potential. These lines could be potentially used in breeding programs for simultaneous improvement of wheat adaptability and yield.

Graf. 1. Dužina stabljike (a), vršne internodije (b) i klasa (c) u setovima genotipova pšenice sa različitim *Ppd* alelima: 1-10 Set1, 11-25 Set 2, 27-47 Set 3, 49-66 Set 4, 26, 48 i 67 sorta Paragon. Sve vrednosti su u cm.

Graph 1. Whole stem height (a), peduncle length (b), and spike length (c) for the sets of wheat genotypes with different *Ppd* alleles: 1-10 Set 1; 11-25 Set 2; 27-47 Set 3; 49-66 Set 4; 26, 48 and 67 cv. Paragon. All values are in cm.



The average stem height varied from 89.7 cm in the Set 1 to 100.8 cm in the Set 4. Significant differences regarding this trait were found between the Serbian cultivars (Set 1) and the NILs from the sets 2 (98.1 cm) and 4, and between the NILs from the Sets 3 (92.6 cm) and 4. The same relations among the sets of the genotypes were found for the average spike length. With respect to the average peduncle length, there were no significant differences between the Serbian cultivars (Set 1-12.4 cm) and the sets of NILs with different changes in *Ppd* alleles. The differences were only found between the NILs from the Sets 2 (14.0 cm) and 3 (11.3 cm), and between the Sets 3 and 4 (14.6 cm).

Tabela 1. Poređenja sredina po Takejevom testu za: dužinu stabljike (a), vršne internodije (b) i klasa (c) u setovima genotipova pšenice sa različitim *Ppd* alelima
Table 1. Tukey multiple comparisons of means for: stem height (a), peduncle length (b), and spike length (c) in the sets of wheat genotypes with different Ppd alleles

a)

Panel	diff	lwr	upr	p adj
S2-S1	8,389125	0,128104	16,65015	0,045218*
S3-S1	2,884636	-4,93111	10,70039	0,76468
S4-S1	11,12337	3,117117	19,12962	0,002787**
S3-S2	-5,50449	-12,2378	1,228804	0,146596
S4-S2	2,734243	-4,21927	9,687756	0,728074
S4-S3	8,238732	1,820568	14,6569	0,006534**

b)

Panel	diff	lwr	upr	p adj
S2-S1	1.63175	-1.58239	4.845887	0.541484
S3-S1	-1.07836	-4.11926	1.962531	0.785743
S4-S1	2.26879	-0.84622	5.383803	0.229328
S3-S2	-2.71011	-5.32985	-0.09037	0.039907*
S4-S2	0.63704	-2.06838	3.342461	0.924859
S4-S3	3.347153	0.850021	5.844285	0.004158**

c)

Panel	diff	lwr	upr	p adj
S2-S1	1.3535	0.115845	2.591155	0.026715*
S3-S1	0.464182	-0.70676	1.635127	1.635127
S4-S1	1.807842	0.608356	3.007328	0.001025**
S3-S2	-0.88932	-1.89809	0.119455	0.102865
S4-S2	0.454342	-0.58742	1.496108	0.659646
S4-S3	1.34366	0.3821	2.305221	0.002607**

S1- Set 1, S2 - Set 2, S3 - Set 3, S4 -Set 4, diff- razlika između utvrđenih sredina (cm), lwr - donja granica intervala, upr- gornja granica intervala, p adj - p vrednost nakon prilagođavanja za višestruka poređenja, *p<0,05, **p<0,01.

S1- Set 1, S2 - Set 2, S3 - Set 3, S4 -Set 4, diff- the difference in the observed means (cm), lwr - the lower end point of the interval, upr - the upper end point of the interval, p adj - the p-value after adjustment for the multiple comparisons, *p<0,05, **p<0,01.

Conclusion

The results revealed differences between Serbian well-adapted cultivars and NILs with specific combinations of *Ppd* alleles regarding whole stem height and spike length in agro-climate conditions of Southeast Europe. Peduncle length was similar in the Serbian cultivars and the NILs with different *Ppd* alleles. Changes in *Ppd* alleles in the sets 2 and 4 caused an increase of the analyzed traits in relation to the cultivars developed at the IFVCNS, while the lines from the set 3 were very similar to the Serbian cultivars. In the material some promising lines with good potential for breeding programs were identified.

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