UDC: 63 ISSN 1450-8109

JOURNAL OF AGRICULTURAL SCIENCES BELGRADE

Vol. 65, No. 3, 2020

**Published by University of Belgrade
Faculty of Agriculture
Republic of Serbia**

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Republic of Serbia

Journal of Agricultural Sciences (Belgrade)
J. Agric. Sci (Bg).
www.joas.agrif.bg.ac.rs

PUBLISHED BY

University of Belgrade-Faculty of Agriculture
11081 Belgrade-Zemun, Nemanjina 6, PO Box 14, Serbia
Tel: + 381 11 4413-555/467; Fax: + 381 11 2193-659; E-mail: redakcija@agrif.bg.ac.rs
URL: http://www.agrif.bg.ac.rs/

DTP Service: Snežana Spirić

Printed by the Faculty of Agriculture, Belgrade-Zemun
Circulation: 100

Publishing is supported by the Ministry of Education, Science and Technological Development
of the Republic of Serbia, Belgrade

According to the opinion of the Ministry of Science of the Republic of Serbia
No. 413-00-1928/2001-01 dated November 6, 2001 this
Journal is exempt from general tax liability

Frequency: Four times per year

Abstracting and Indexing
CAB Abstracts, AGRICOLA, SCIndeks, EBSCO, Scopus, DOAJ

Number of institutions the Journal is exchanged with: 80

JOURNAL OF AGRICULTURAL SCIENCES BELGRADE
Vol. 65, No. 3, 2020

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Journal of Agricultural Sciences (Belgrade) https://doi.org/10.2298/JAS2003199C
Vol. 65, No. 3, 2020 UDC: 635(497.11)
Pages 199-212 Review paper

ZNAČAJ ROTACIJE USEVA U INTENZIVNOJ PROIZVODNJI POVRĆA U ZAŠTIĆENOM PROSTORU

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Sažetak: Intenzivna proizvodnja povrća danas predstavlja velikog „potrošača” energije. Proizvođači najviše gledaju ekonomsku stranu ove proizvodnje, što najčešće biva i izgovor za njenu trenutnu realizaciju. Intenziva proizvodnja povrća se danas svodi na gajenje nekoliko povrtarskih vrsta a sve češće u monokulturi. Ovakvim sistemom razmišljanja i gajenja povrća u monokulturi, cela proizvodnja može biti dovedena u neodrživu situaciju. Zbog toga bi trebalo proizvodnju povrća u zaštićenom prostoru organizovati sistemom gajenja pretkulture, glavne kulture i naknadne kulture. Intenzivna proizvodnja povrća trebalo bi da podrazumeva maksimalno dobro organizovano korišćenje raspoloživog zemljišta i resursa. To znači pravilan plodored sa kompletnom agrotehnikom, te poznavanje tržišta kao mogućnosti plasmana viška proizvodnje. Dobrom organizacijom rotacije i vremenskim smenjivanjem useva, zaštićeni prostor možemo pretvoriti u koristan prostor za proizvodnju povrća.

Ključne reči: monokultura, plodored, povrtarske vrste, organska materija.

Uvod

Poljoprivredni proizvođači odavno koriste raznovrsne i složene rotacije useva radi kontrole balansa nutrijenata i vode, korova, štetočina, bolesti, kao i da ispuni potrebe ljudi i stoke za hranom. U modernim gazdinstvima uvedeni su pojednostavljeni obrasci korišćenja zemljišta. U poslednjih 50 godina rotacija useva dramatično se pojednostavila (npr. smanjenjem broja vrsta useva u plodoredu i povećanim učešćem zemljišta koje se koristi pod monokulturom) zbog pojave sintetičkih đubriva, pesticida i sve većeg razdvajanja gajenja useva i stočarstva (Barbieri et al., 2017).

Jedan od razloga nedovoljne iskorišćenosti raznovrsnosti useva je i taj što su agronomska i pitanja životne sredine usko povezana sa ekonomskim i socijalnim pitanjima, kao što su zaposlenje, organizacija rada, ili čak prodaja tržišta. Veći deo

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povrća danas se prodaje na tržištu u svežem obliku. Raznovrsnost i dostupnost povrća za tržišta direktno zavisi od stepena diverzifikacije i načina proizvodnje na gazdinstvu. Diverzifikacija useva može čak dovesti pod znak pitanja i organizaciju rada na gazdinstvu (Castilla et al., 2004; Navarretea et al., 2015).

Proizvodnja povrća u plastenicima postaje sve češća realnost širom sveta. Predstavlja najintenzivniju poljoprivrednu proizvodnju sa visokim nivoom inputa (Dimitrijević et al., 2014). Proizvodnja povrća u plasteniku često koristi neobnovljive resurse i troši velike količine energije. S druge strane, plastenička proizvodnja bi trebalo da je veoma produktivna sa visokim prinosima (Gruda, 2005). Poređenjem proizvodnji otvorenog i zaštićenog prostora u područjima sa umerenom klimom, prinosi mogu biti od 2 do 3 puta viši kod negrejanih plastenika pa do 10 puta viši u grejanim plastenicima.

Proizvodnja povrća iz zaštićenog prostora u jugoistočnoj Europi je u neprestanom porastu. Najviše zbog mogućnosti ranog prolećnog i produženo jesenjeg vremena proizvodnje, što može biti ekonomski značajno za proizvođače (Gruda, 2017).

U Europi pod plastenicima se nalazi oko 405 000 ha povrtarske proizvodnje, dok u zemljama jugoistočne Europe pod zaštićenim prostorom dominira proizvodnja povrća na oko 104 560 ha. Najčešće se gaje paradajz, paprika, plavi patlidžan, dinja, krastavac, tikvica, lubenica, i zelena boranija. Investiciona ulaganja u ovu proizvodnju su dosta visoka, a prinosi često ne pokrivaju troškove. Ovakva situacija u sistemu gajenja može dovesti do pojave monokulture, što je jedan od važnijih problema u plasteničkoj proizvodnji.

Rezultati istraživanja Dimitrijević et al. (2016) ukazuju da proizvodni uslovi u objektima zaštićenog prostora mogu da zavise od tipa konstrukcije objekta i od gajene biljne vrste.

Diverzifikacija (različitost) biljaka u intenzivnoj proizvodnji povrća u zaštićenom prostoru postaje sve važnija, imajući u vidu njenu vitalnu ulogu u ekonomskoj održivosti same proizvodnje (Lazić et al., 2003; Castilla et al., 2004; Tüzel i Öztekin, 2017).

Uvođenjem diverzifikacije u intenzivnu plasteničku proizvodnju stvaraju se uslovi za:

- Korišćenje povezanosti između poljoprivredne proizvodnje i ekonomije,
- Usvajanje novih sistema i proizvodnih tehnologija,
- Implementaciju novih tehnologija u preradi, čuvanju i marketingu,
- Reagovanje na trendove u zahtevima tržišta zbog promena u potrošačkim navikama.

Povrtarska proizvodnja u Republici Srbiji se odvija ukupno na 101953 hektara sa krompirom. Krompir se gaji na 38472 ha, paprika na 17386 ha, pasulj na 13181 ha, paradajz na 10917 ha, kupus i kelj na 10213 ha, dinje i lubenice na 8372 ha, grašak na 8097 ha, krastavci na 4271 ha, crni luk na 4145 ha, mrkva na 2465 ha, i beli luk na 1820 ha (www.stat.gov.rs., 2019).

Preko 95% proizvodnje povrća u Srbiji odvija se na otvorenom polju, a samo manji deo, do 5%, realizuje se u zaštićenom prostoru. Oko 20% proizvodnje na otvorenom polju zauzima proizvodnja u baštama i okućnicama čime postaje sve značajnija Červenski et al., (2015).

U Republici Srbiji dominantan način proizvodnje povrća u zaštićenom prostoru je na prirodnom zemljištu. Preostali načini proizvodnje su zastupljeni na zanemarljivo malim površinama, (Ilin, 2019).

Proizvodnja povrća u baštama i okućnicama često se vezuje za gajenje samo nekoliko značajnijih povrtarskih vrsta, kako na otvorenom polju tako i u zaštićenom prostoru Dimitrijević et al., (2011). U svetu je poznato preko 1500 vrsta povrća a u Srbiji se najčešće gaji od 20 do 30 vrsta Lazić et al., (2003). Deo površina bašti ili okućnica ne ispunjava uvek sve uslove potrebne za proizvodnju povrća, kao recimo nedostatak sunca ili kvalitet zemljišta. Stoga tokom godine može biti manje kultivisan ili delom zakorovljen (CoDyre et al., 2015).

Izborom određenog načina proizvodnje – otvoreno polje ili zaštićen prostor uz obavezno navodnjavanje, dobro odabranim i organizovanim vremenom izvođenja radova i potrebnim inputima, mnogo toga se može proizvesti na površini jedne bašte ili okućnice, ali i prodati na lokalnim zelenim pijacama. Ovakav sistem organizovanja povrtarske proizvodnje treba da ima za cilj da se na istoj površini u toku godine proizvedu 2–3 kulture, čime se može povećati i ekonomičnost proizvodnje Červenski et al., (2013).

Intenzivni povrtarski plodored može da se osloni na princip tropoljnog povrtarskog plodoreda. U toku jedne vegetacione sezone ili godine, na istom zemljištu uzastopno, ili istovremeno, gaji se više vrsta povrća. To znači da se odmah po skidanju jedne vrste seje ili sadi druga. Navedeni plodored je moguć zbog različite dužine vegetacije povrća, razlika u zahtevima za toplotom, otpornosti nekih vrsta na niske temperature i različitog zahteva za vegetacionim prostorom. Principi smene useva mogu se opredeliti i po glavnom usevu, povrću, koje ima najdužu vegetaciju ili najveći prinos. Zato bi trebalo u intenzivnom plodoredu razlikovati: pretkulturu (najčešće neka rana prolećna ili ozima vrsta kao što su: salate, spanać, keleraba, rotkvica, grašak, blitva, rani krompir, mladi luk); glavnu kulturu koja ima najdužu vegetaciju (paprika, paradajz, boranija, kupus, crni luk, tikvica) ili najveći prinosi i naknadnu kulturu koja se gaji posle glavne kulture (jesenji beli luk, srebrenjak, salata, spanać) (Lazić et al., 2013).

Rezultati istraživanja koje su sproveli Vlahović et al. (2013) navode da značajan deo potražnje prosečne četvoročlane porodice za voćem i povrćem može biti zadovoljen iz bašte površine 200–400 m^2 zavisno od načina kultivacije i organizacije poslova.

Organizacija plodoreda u intenzivnoj proizvodnji povrća

Važan uslov intenzivne proizvodnje povrća bi trebalo da je uvođenje plodoreda odnosno smene useva u vremenu i prostoru, pre svega zbog moguće pojave zajedničkih bolesti, korova i štetočina kod grupe useva, kao i zahteva za ishranom uz pravilnu kontrolu, održavanje i povećavanje plodnosti zemljišta (Lazić et al., 2003; Shafique et al., 2016; Popsimonova et al., 2017). Červenski et al. (2016) su istraživali mogućnost unapređenja proizvodnje povrća u plasteniku bez grejanja, tj. smenu povrtarskih kultura na istoj površini tokom 12 meseci. Rad je obuhvatio preko 10 gajenih povrtarskih vrsta u plasteniku. Njihovi rezultati govore da se organizacijom proizvodnje povrća kroz sistem gajenja preduseva, glavnog useva i naknadnog useva, prostor plastenika može pretvoriti u koristan prostor za proizvodnju povrća. Kao pretkulturu savetuju da se poseje spanać, grašak, rotkvica, prolećna salata ili keleraba. Posle pretkulture trebalo bi organizovati proizvodnju glavne kulture, kao recimo paradajza, paprike i krastavca. Nakon glavne kulture sejati ili rasađivati naslednu kulturu tj. ozimu salatu, jesenji beli luk, crni luk, cveklu, blitvu, spanać. Ovakvom organizacijom proizvodnje povrća u plasteniku omogućili su gajenje većeg broja povrtarskih vrsta, što treba da predstavlja određenu sigurnost proizvodnje i bolje planiranje intenzivnog povrtarskog plodoreda.

Mnogi poljoprivrednici danas nisu samo proizvođači robe, već i dobavljači kvalitetne hrane i menadžeri ekosistema. O ulozi stočarske proizvodnje u čitavom eko-bio sistemu pokazuju istraživanja koje su sproveli Šperanda et al. (2019). Njihovi rezultati pokazuju značaj upotrebe stajnjaka kao izvora hranjivih materija, bio-resursa i regulatora ekološkog ciklusa, koji povećava ne samo sadržaj organske materije u zemljištu već i održava njegovu plodnost. Prema istim autorima ukoliko je odnos C/N u organskom đubrivu 10:1 ili niži, ukazuje na stabilnost organskog đubriva i njegovu produženu aktivnost u zemljištu. Odnos C/N ispod 10:1 u organskom đubrivu indikator je visokokvalitetnog đubriva.

Složen povrtarski plodored trebalo bi da uključi smenu useva u toku godine, kao i gajenje mešanih useva (Ouma and Jeruto, 2010). Ovakav plodored je najintezivniji i može omogućiti raznovrsnu proizvodnju povrća tokom cele godine, maksimalno korišćenje raspoloživih resursa (zemljišta i radna snage) i visoku rentabilnost. Povrtarski plodored treba da se zasniva na različitim zahtevima biljaka, pre svega prema hranivima (stajnjaku) i biološkim osobinama gajenih vrsta. Najčešći tropoljni povrtarski plodored zasniva se na prethodnoj podeli i zahtevu povrtarskih vrsta prema hranivima.

U odnosu na zahteve za hranivima, povrće se može podeliti u tri grupe:

I grupa useva su vrste koje imaju velike zahteve za hranivom i dobro reaguju na obilno đubrenje stajnjakom (vrežaste vrste, kupusnjače, paradajz, paprika, plavi patlidžan, celer, praziluk) a pri tome povećavaju prinos uz održavanje kvaliteta.

II grupa useva su vrste sa manjim zahtevom za hranivima te i stajnjakom i često se gaje druge godine posle unošenja stajnjaka (peršun, mrkva, paštrnak, crni luk, salata, spanać, rotkva, rotkvica).

III grupa useva su vrste koje obogaćuju zemljište azotom – leguminoze (grašak, boranija, pasulj, bob) (tabela 1).

Tabela 1. Tropoljni povrtarski plodored (Lazić, 2002).
Table 1. Three-field vegetable crop rotation (Lazić, 2002).

	Polje/Field		
Godina/Year	I	II	III
Prva/First	Paradajz, paprika, plavi patlidžan, krastavac, tikvice, tikve, praziluk, kupusnjače	Mrkva, peršun, paštrnak, cvekla, crni luk, beli luk	Boranija, grašak, pasulj, bob
Druga/Second	II	III	I
	Mrkva, peršun, paštrnak, cvekla, crni luk, beli luk	Boranija, grašak, pasulj, bob	Paradajz, paprika, plavi patlidžan, krastavac, tikvice, tikve, praziluk, kupusnjače
Treća/Third	III	I	II
	Boranija, grašak, pasulj, bob	Paradajz, paprika, plavi patlidžan, krastavac, tikvice, tikve, praziluk, kupusnjače	Mrkva, peršun, paštrnak, cvekla, crni luk, beli luk

Vrste povrća sa dubokim korenovim sistemom trebalo bi uzgajati nakon onih sa plitkim, kako bi se održala dobra struktura, prozračnost i poroznost zemljišta (korenasto povrće i leguminoze; plodovito i korenasto povrće) (Nikolić et al., 2012). Zatim bi bilo dobro vršiti smenu vrsta koje tokom vegetacije produkuju različitu biomasu (crni i beli luk i vrežaste vrste). Pravilnu smenu jarih i ozimih vrsta povrća trebalo bi organizovati, da bi se smanjila zakorovjenost gajenog prostora, uz što manje korišćenje pesticida i racionalnije korišćenje površine (tabela 2).

Tabela 2. Primer organizovanja povrtarskog četvorogodišnjeg plodoreda u negrejanom plasteniku (autor).
Table 2. Example of organizing a vegetable four-year crop rotation in an unheated greenhouse (author).

Godina/Year	Predusev/Preceding crop	Glavni usev/Main crop	Naknadni usev/Stubble crop
1.	Salata	Paprika	Luk srebrenjak
2.	Rani grašak	Tikvice	Kelj
3.	Rotkvica	Paradajz	Jesenji beli luk
4.	Keleraba	Boranija	Spanać

Jedan od najvažnijih zahteva pravilne primene plodreda je da grupe useva često imaju zajedničke bolesti i štetočine. Trebalo bi izbegavati uvođenje u plodored jedne za drugom povrtarskih vrsta, koje pripadaju istoj porodici, zbog moguće pojave zajedničkih insekata i izazivača bolesti (Vuković et al., 2014; Shafique et al., 2016; Vlajić et al., 2018). To se naročito odnosi na paradajz, plavi patlidžan, papriku, krastavac, kupusnjače, zatim na korenasto povrće (mrkvu, peršun, celer i paštrnak) kao i za lukove (crni i beli luk, praziluk).

U poslednjih nekoliko decenija, monokultura je česta pojava kod gajenja povrća u zaštićenom prostoru tj. sa istom kulturom ili vrstom na istom zemljištu. Plodored ili rotacija useva treba da ima agronomske, ekonomske i ekološke prednosti u poređenju sa monokulturnim načinom gajenja. Uvođenjem jedno i višegodišnjih leguminoza u rotaciju useva predstavlja realnu praksu poštovanja diverzifikacije useva u održivoj poljoprivredi (Lazić et al., 2003). Pravilom CL12 (b) iz Regulative 834/2007 (European Commissin, 2007) za pravilnu ishranu biljaka preporučuje se rotacija mahunarki i zelenog stajnjaka. Direktiva EU naglašava da, bez obzira na gajene vrste u plodoredu, kratkoročna upotreba zelenog stajnjaka i mahunarki neophodna je za sprečavanje pojave štetočina i korova na proizvodnom zemljištu. Organizovanje plodoreda kombinacijom proizvodnje povrća i cveća predstavlja drugu mogućnost, međutim treba imati u vidu da povrće i cveće zahtevaju različita ulaganja i znanja, te su namenjeni i različitim tržištima.

Prednosti plodoreda ili rotacije useva u intenzivnoj proizvodnji povrća

Uvođenjem plodoreda u intenzivnu proizvodnju povrća stvaraju se uslovi za:

Veću kontrolu bolesti, štetočina i korova.

Gajenjem povrtarskih biljaka u monokulturi na istoj površini možemo dovesti do nagomilavanja uzročnika biljnih bolesti u zemljištu (Castilla et al., 2004), kao i do povećanja brojnosti štetočina i korova, uporedo sa jednostranim i nepravilnim trošenjem hraniva iz zemljišta (Medić-Pap et al., 2017). Intenzivnom proizvodnjom povrća treba omogućiti da naredna ili nova setva počinje odmah nakon prethodnog useva, te da zemljište ne ostaje prazno, a štetočine, bolesti i korovi ne pronalaze optimalne uslove za svoj rast. Naslední usevi obično nemaju iste bolesti ili štetočine čime se životni ciklus štetočina može efikasno prekinuti, te može dovesti do smanjenja i lakše kontrole populacije štetočina. Plodored sa većim brojem vrsta, trebalo bi da smanji dominaciju uskog broja korovskih vrsta usled različite tehnologije gajenja useva (Liebman i Dick 1993). Važno je primenjivati pravilan plodored u prevenciji borbe protiv korova (Dimsey et al., 2010). Korovi se efikasnije kontrolišu kada se zemljište koristi gajenjem povrća u kontinuitetu, jer se populacija korova najviše povećava u periodu između gajenja dva useva.

Manju upotrebu pesticida.

Proizvodnja povrća u plastenicima može se oceniti kao veoma intenzivna zbog rotacije useva koja bi trebalo da obezbedi profit tokom cele godine. Ovakva proizvodnja se povezuje sa opsežnijom primenom hemijskih đubriva i pesticida. Usled mogućeg potencijalnog zagađenja životne sredine, povećava se i zabrinutost o zdravstvenoj bezbednosti hrane. Zbog toga bi za održavanje plodnosti zemljišta i zaštitu povrtarskih vrsta trebalo maksimalno koristiti prirodne resurse, kako bi se smanjila upotreba hemikalija (Nikolić et al., 2012; Tringovska et al., 2015). U intenzivnoj povrtarskoj proizvodnji sa upotrebom ograničene palete herbicida, plodored može činiti važnu komponentu integralnog programa suzbijanja korova (Nordell, 1992). Pored mogućnosti štetnog nagomilavanja ostataka pesticida u finalnom proizvodu (plodovi, listovi, koren) te životnoj sredini, pesticidi mogu imati negativan uticaj i na biodiverzitet, problem nastanka rezistentnosti i sl. Stoga je važno primenjivati i druge mere integralne zaštite koje će doprineti smanjenju brojnosti populacije insekata, a samim tim i smanjenoj upotrebi pesticida (Medić-Pap et al., 2017). Manjom upotrebom pesticida mogu se smanjiti troškovi proizvodnje, ublažiti njihov negativni uticaj na životnu sredinu te pozitivno uticati na čovekovo zdravlje.

Proizvođači povrća se često suočavaju sa izazovom da obezbede „čiste i zelene" proizvode, budući da „trgovci" danas zahtevaju od svojih dobavljača potvrdu da je hrana koju kupuju zdravstveno bezbedna i da se proizvodila na ekološki prihvatljiv način (Lazić et al., 2003). U budućnosti proizvođači povrća i hrane biće sve više povezani sa sistemom kontrole zdravstvene bezbednosti svojih proizvoda i dobijanja odgovarajućih sertifikata (Ntinas et al., 2017).

Veću mogućnost korišćenja zaliha vlage i hranljivih materija u zemljištu.

Sastaviti dobar plodored sa svim elementima kao što su poljosmena, plodosmena i odmor zemljišta nije nimalo jednostavno, jer je potrebno pravilno odabrati vrstu, sortu, đubrenje, obradu zemljišta, rokove setve i sadnje, kao i vreme dozrevanja. Pri planiranju plodoreda trebalo bi obratiti pažnju i na smenu vrsta sa različitom dubinom korena, te smenjivati vrste sa različitim potrebama za vodom i hranivima. Na primer, vrste koje troše puno vode kao paprika, paradajz, krastavac i kupusnjače trebalo bi smenjivati sa vrstama koje imaju umerene potrebe za vodom (korenasto povrće, lukovi i mahunarke) (Červenski i Medić-Pap, 2018).

Povećavanje plodnosti zemljišta.

Oranični sloj koji je izložen uticajima klime, biljnog pokrivača i zemljišne faune, kao i uticajima intenzivnog navodnjavanja i gaženja, obradom zemljišta trebalo bi dovesti u takvo stanje u kojem će gajene biljke imati optimalne uslove za rast i razvoj. Uporedo sa tim, potrebno je voditi računa da se održava i povećava njegova plodnost. Zemljište bi trebalo koristiti, a ne iskorišćavati. To znači da korišćenjem zemljišta treba da održavamo ili povećavamo njegovu plodnost a ne da je smanjujemo (Bajkin et al., 2014). Plodored može biti značajna preventivna mera kojom se smanjuje pojava štetnih organizama, poboljšava plodnost zemljišta i povećava prinos (Brust i Stinner, 1991; Sumner, 1982; Shafique et al., 2016; Červenski i Medić-Pap, 2018). Odgovarajuća smena useva bi trebalo da omogući kontinuirano gajenje biljnih vrsta koje su ekonomski značajne za dati region pri čemu se ne narušava plodnost zemljišta i ne dolazi do ekstremnih gubitaka usled pojave bolesti (Curl, 1963).

Poboljšavanje strukture zemljišta.

Sistem intenzivne proizvodnje povrća trebalo bi da podrazumeva kontinuirano povećavanje organske materije u zemljištu, a smanjivanje degradacije zemljišta na drugoj strani, što bi rezultiralo većim prinosima i dugoročnom profitabilnošću gazdinstva. Izborom odgovarajućeg plodoreda stvaramo mogućnost pozitivnog ili negativnog uticaja na strukturu zemljišta. Isključivanjem dugogodišnjih rotacija može imati za posledicu degradaciju strukture zemljišta, što je delom vezano za sadržaj organske materije u zemljištu. Dugogodišnja smena useva u plodoredu trebalo bi da ima značajan uticaj na formiranje strukture zemljišta, pri čemu svaki od gajenih useva u plodoredu daće svoj doprinos formiranju povoljne strukture. Takođe, potrebno je ulagati značajne napore i kroz pojedine mere obrade, rotaciju useva, ali i primenu organskih đubriva (Pejić et al., 2005; Šperanda et al., 2019).

Organska đubriva popravljaju strukturu zemljišta, utiču na vodno-vazdušni i toplotni režim zemljišta, zatim na biološke i hemijske osobine zemljišta. Treba voditi računa koje su to vrste koje dobro reaguju na neposrednu upotrebu stajnjaka i komposta, a koje dolaze u plodoredu drugu ili treću godinu iza đubrenja (www.polj.savetodavstvo.vojvodina.gov.rs).

Povoljna struktura zemljišta dovešće do poboljšanja drenaže, smanjenja rizika od preplavljivanja tokom poplava te povećanja zalihe vode u zemljištu tokom suša.

Manju potrebu za veštačkim đubrivima.

Različiti sistemi proizvodnje povrća često koriste visoke doze azota, sa primenjenim količinama koje mogu da pređu i preko 220 kg/ha/sezoni (De Rosa et al., 2016). Sistemom intenzivne proizvodnje povrća trebalo bi povećati nivo organske materije, zadržavanje vode i hranljivih materija u zemljištu, a smanjiti upotrebu veštačkih đubriva. Iz navedenog razloga potrebno je uključiti leguminoze u plodored (Nikolić et al., 2012; Benko, 2017). Leguminoze vezuju atmosferski azot u zemljištu (sa biološkom fiksacijom azota od 100 kg N/ha^{-1}/godinu^{-1}), čime povećavaju njenu plodnost, a smanjuju potrebu za veštačkim azotnim đubrivima (Tüzel i Öztekin, 2017). Iz navedenog razloga, grašak, boraniju ili pasulj bilo bi dobro sejati kao usev u četvrtoj godini povrtarskog plodoreda. Posle žetve graška, boranije ili pasulja savetuje se uneti 50–60 t stajnjaka po hektaru dubokim jesenjim oranjem (Červenski i Medić-Pap, 2018).

Manju emisiju gasova koji izazivaju efekat staklene bašte.

Povrtarska proizvodnja je potrošač značajne količine energije za rad poljoprivrednih mašina, navodnjavanje, upotrebu hemikalija, mikroklimatsku kontrolu (grejanje i hlađenje), transport i skladištenje u hladnjačama. Ovakva potrošnja energije doprinosi globalnom zagrevanju, jer uzrokuje emisiju gasova koji izazivaju efekat staklene bašte i to uglavnom ugljen-dioksida (CO_2), metana (CH_4) i azotnog suboksida (N_2O) (Ntinas et al., 2017).

Povećavanje nivoa ugljen-dioksida (CO_2) i drugih gasova u nižim slojevima atmosfere doprinosi zagrevanju Zemljine površine i naziva se efekat staklene bašte. Vodena para, ugljen-dioksid, metan, azot-suboksid i hlorofluorokarbonati su gasovi koji izazivaju efekat staklene bašte. Oni imaju visoke potencijale globalnog zagrevanja (GWP-Global warming potential) i zadržavaju toplotu koja se reflektuje od Zemljine površine. Na taj način čine planetu toplijom i time doprinose klimatskim promenama.

Govoreći o klimatskim promenama izazvanim ljudskim aktivnostima, posebnu pažnju treba posvetiti ugljen-dioksidu (CO_2) i metanu (CH_4). Metan u odnosu na ugljen-dioksid je u stanju da zadržava čak 25 puta više toplote, te zbog toga može predstavljati značajan faktor klimatskih promena. Metan je i produkt mnogih ljudskih aktivnosti poput proizvodnje prirodnog gasa, tretmana otpadnih voda i deponija. Međutim 39% emisija ovog gasa potiče od poljoprivrede. Više od polovine ukupnih emisija gasova u poljoprivredi potiču iz stočarstva. Stoka tokom procesa varenja hrane oslobađa velike količine ovog gasa.

Organska đubriva koja se koriste u povrtarskoj proizvodnji povezana su sa povećanom stopom razgradnje organske materije, što povećava emisiju N_2O i CO_2, (De Rosa et al., 2016). Upotrebom stajnjaka blago povećavamo i mogućnost emisije CH_4 (metana). Na drugoj strani, smanjenim đubrenjem azotnim đubrivima smanjujemo i emisiju N_2O. Racionalnim upravljanjem hranivima kroz rotaciju useva možemo smanjiti upotrebu azotnih đubriva. Smanjenom upotrebom veštačkih đubriva takođe dovodimo do smanjenja emisije gasova staklene bašte povezane sa proizvodnim procesom i transportom (Savvas et al., 2017).

Manje zagađenje voda.

Ograničavanjem unosa velikih količina veštačkih đubriva smanjujemo mogućnost zagađenja voda azotom. Plodored sa niskom zavisnošću od pesticida takođe doprinosi umanjenju potencijalne mogućnosti oticanja u podzemne vode. Nitratna direktiva usvojena 1991. godine naložila je smanjivanje ili sprečavanje daljeg zagađenja podzemnih voda sa nitratima poljoprivrednog porekla. Direktiva zahteva noviji pristup poljoprivredi, kako od strane nadležnih institucija, tako i od poljoprivrednih proizvođača (Šperanda et al., 2019). Nova regulativa Europske unije (Regulation EU 2018/848) o organskoj proizvodnji takođe potvrđuje napore čitave zajednice da zaštiti zemljište i životnu sredinu.

Povećanu sposobnost čuvanja ugljenika.

Suva materija biljaka u proseku sadrži oko 45% C, 42% O_2, 6,5% H, 1,5% N i 0,5% mineralnih materija (Kastori i Tešić, 2006). Prema tome, biljke treba da imaju veoma važnu ulogu u kruženju ugljenika jer predstavljaju mesto vezivanja CO_2 iz atmosfere, koji se neposredno unosi u zemljište i čini primarni izvor ugljenika u agroekosistemu nakon transformacije u organsku materiju (Sekulić et al., 2010).

Dobrim plodoredom možemo dovesti do povećenja sadržaja zemljišnog ugljenika, kroz periode gajenja pokrovnih useva, smanjeni intenzitet i učestalost obrade zemljišta, a čime se ublažavaju posledice klimatskih promena (Tüzel i Öztekin, 2017).

Proizvodnja u plastenicima je sve češća realnost svetskog poljoprivrednog sistema u obezbeđivanju hrane zbog veće sigurnosti same proizvodnje u odnosu na klimatske prilike koje se javljaju u proizvodnji na otvorenom polju (Mariani et al., 2016). Zbog toga obrazovanje i obuka proizvođača povrća o značaju plodoreda kroz radionice treba da predstavljaju jednu od osnova u intenzivnoj proizvodnji povrća (Lazić et al., 2003; Castilla et al., 2004; Červenski et al., 2013).

Zaključak

Korišćenje većeg broja povrtarskih vrsta u sistemu proizvodnje treba da predstavlja određenu sigurnost proizvodnje. Pre donošenja odluke o intenzivnoj proizvodnji povrća, proizvođači bi trebalo da razmotre šta, kada i kako će proizvoditi, te gde će plasirati i prodavati svoje proizvode. Povrtarske vrste u plodoredu treba pažljivo odabrati, uzimajući u obzir njihov najpovoljniji datum setve. Intenzivna proizvodnja povrća u zaštićenom prostoru zahteva maksimalno dobro organizovano korišćenje raspoloživog zemljišta i resursa. Smenom 2–3 povrtarske kulture na istoj površini tokom 12 meseci ili gajenjem pretkulture, glavne kulture i naknadne kulture zaštićeni prostor se može pretvoriti u koristan prostor za proizvodnju povrća. Plodored ili rotacija useva u zaštićenom prostoru tokom jedne godine gajenja, ali i u višegodišnjem sistemu proizvodnje povrća predstavljao bi rešenje dobro organizovane intenzivne proizvodnje povrća. Zbog toga bi trebalo uvek gajiti više povrtarskih vrsta na jednom prostoru u višegodišnjem sistemu proizvodnje, a izbegavati sistem monokulture, koja može postati ograničavajući faktor povrtarske proizvodnje u zaštićenom prostoru.

Zahvalnica

Ovaj rad predstavlja rezultat Ugovora (Evidencioni broj: 451-03-68/2020-14/ 200032) o realizaciji i finansiranju naučnoistraživačkog rada između Ministarstva prosvete, nauke i tehnološkog razvoja Repulike Srbije i Instituta za ratarstvo i povrtarstvo.

Literatura

Bajkin, A., Ponjičan, O., Sedlar, A., Zoranović, M., & Turan, J. (2014). *Ekološki i energetski parametri primene poljoprivredne mehanizacije*, Novi Sad: Poljoprivredni fakultet.

Barbieri, P., Pellerin, S., & Nesme, T. (2017). Comparing crop rotations between organic and conventional farming. *Scientific Reports, 7* (13761), 1-10.

Benko, B., (2017). Improving greenhouse production of French bean, kohlrabi and kale by GAP implementation, *Book of Abstracts, VII South-Eastern Europe Syposium on Vegetables & Potatoes*, (pp. 50). Maribor, Slovenia.

Brust, E., & Stinner, R. (1991). Crop rotation for insect, plant pathogen, and weed control. In D. Pimentel (Eds.), *CRC Handbook of Pest Management in Agriculture I. Second edition*. (pp. 217-236). Boca Raton, FL:CRC.

Castilla, N., Hernández, J., & Abou-Hadid, A.F. (2004). Strategic crop and greenhouse management in mild winter climate areas. *Acta Horticulturae, 633,* 183-196.

CoDyre, M., Fraser, D.G.E., & Landmanb, K. (2015). How does your garden grow? An empirical evaluation of the costs and potential of urban gardening, *Urban Forestry & Urban Greening, 14,* 72-79.

Curl, E. (1963). Control of the Plant diseases by crop rotation. *Botanical Review, 29* (4), 413-479.

Červenski, J., Gvozdanović-Varga, J., Vasić, M., Zekić, V., Ferencz, Á., Taskovics-Tóthné, Z., Szabó, T., Kalmár, R. (2013). *New farming models in backyards as possible solutions for generating additional income and self-employment in the rural cross-border area.* Institute of Field and vegetable crops, Novi Sad: Maxima graf.

Červenski, J., Vasić, M., Gvozdanović-Varga, J., Takač, A., Bugarski, D., Popović, V., Stojanović, A., Medić-Pap, S., Danojević, & D., Savić, A. (2015). Sortiment povrća za setvu 2015 godine, *Zbornik referata 49 Savetovanje Agronoma Srbije* (pp. 65-71). Zlatibor.

Červenski, J., Gvozdanović-Varga, J., Vasić, M., Stojanović, A., Medić-Pap, S., Danojević, D. & Savić, A. (2016). Home gardens and backyards – suitable area for vegetable production. *Acta Horticulturae, 1142,* 179-186.

Červenski, J., & Medić-Pap, S. (2018). *Proizvodnja kupusa*. Novi Sad: SZR Bizi štampa.

De Rosa, D., Rowlings, D.W., Biala, J., Scheer, C., Basso, B., Mc Green, J., & Grace, P.R., (2016). Effect of organic and mineral N fertilizers on N_2O emissions from an intensive vegetable rotation. *Biology and Fertility of Soils, 52* (6), 895-908.

Dimsey, R., Carey, D., & Henderson, S. (2010). *A Guide to Integrated Pest Management for Brassica-Insect Pest, Disease, Virus, Nematode and Weed Control, Manual*. State of Victoria. Retrieved April 11, 2019, from http://era.daf.qld.gov.au/id/eprint/2587/

Dimitrijević, A., Blažin, S., Blažin, D., Miodragović, R., & Mileusnić, Z. (2011). Proizvodnja povrća u zaštićenom prostoru na malom posedu. *Poljoprivredna tehnika, 2,* 23-32.

Dimitrijević, A., Bajkin, A., Blažin, S., & Blažin, D. (2014). Uniformity of air temperature and relative humidity inside and outside the different types of greenhouses. *Journal on Processing and Energy in Agriculture, 18* (3), 107-110.

Dimitrijević, A., Šundek, B., Blažin, S., & Blažin, D. (2016). Production Conditions For Greenhouse Vegetable Production on Small Scale Family Farms. *Journal on Processing and Energy in Agriculture, 20* (1), 21-24.

European Commissin, (2007). European communities council regulation (EC) No. 834/2007 of 28 June 2007 on organic production and labelling of organic products and repealing Regulation (EEC) No. 2092/91. *Official Journal of he European Union* L, *189*, 1-23.

Gruda, N. (2005). Impact of Environmental Factors on Product Quality of Greenhouse Vegetables for Fresh Consumption. *Critical Reviews in Plant Sciences, 24,* 227-247.

Gruda, N. (2017). Protected Vegetables in South-East Europe, Book of Abstracts, *VII South-Eastern Europe Syposium on Vegetables & Potatoes,* (pp. 15). Maribor, Slovenia.

Ilin, Ž. (2019). Proizvodnja povrća u zaštićenom prostoru u svetu i kod nas. *Poljopivrednikov poljoprivredni kalendar 2019,* Novi Sad: Dnevnik-Poljoprivrednik: AD.

Kastori, R., & Tešić, M. (2006). Ekološki aspekti primene žetvenih ostataka njivskih biljaka kao alternativna goriva. *Zbornik radova Instituta za ratarstvo i povrtartvo, 42* (1), 3-13.

Lazić, B. (2002). *Dečija bio bašta*. Novi Sad: Poljoprivredni fakultet.

Lazić, B., Đurovka, M., & Mišković A. (2003). Osnove organske poljoprivrede u povrtarstvu. *Savremena poljoprivredna tehnika, 29* (1-2), 56-62.

Lazić, B., Ilić, Z., & Đurovka, M. (2013). *Organska proizvodnja povrća*. Novi Sad: Tampograf, Centar za organsku proizvodnju- Selenča i Unverzitet Edukons-S.Kamenica.

Liebman, M., & Dyck, E. (1993). Crop rotation and intercropping strategies for weed management. *Ecological Applications, 3* (1), 92-122.

Mariani, L., Cola, G., Bulgari, R., Ferrante, A., & Martinetti, L. (2016). Space and time variability of heating requirements for greenhouse tomato production in the Euro-Mediterranean area. *Science of the Total Environment, 562,* 834-844.

Medić-Pap, S., Červenski, J., Danojević, D. (2017). Plodored u proizvodnji kupusa kao prevencija pojave štetnih organizama. *Biljni lekar, 45* (3), 293-302.

Navarrete, M., Dupre, & L., Lamine, C., (2015). Crop management, labour organization, and marketing: three key issues for improving sustainability in organic vegetable farming. *International Journal of Agricultural Sustainability, 13* (3), 257-274.

Nikolić, Lj., Milošev, D., Šeremešić, S., Latković, D., & Červenski, J. (2012). Diverzitet korovske flore u konvencionalnoj i organskoj poljoprivredi. *Acta Herbologica, 21* (1), 13-20.

Nordell, E. (1992). Crop rotations today. *Small Farmer's Journal, 16* (1), 29-31.

Ntinas, G.K., Neumair, M., Tsadilas, Ch.D., & Meyer, J. (2017). Carbon footprint and cumulative energy demand of greenhouse and open-field tomato cultivation systems under Southern and Central European climatic conditions. *Journal of Cleaner Production, 142* (4), 3617-3626.

Ouma, G., & Jeruto, P. (2010). Sustainable horticultural crop production through intercropping: The case of fruits and vegetable crops. *Agriculture and Biology Journal of North America, 1* (5), 1098-1105.

Pejić, B., Šeremešić, S., Belić, M., Milošev, D., & Kurjački, I. (2005). Uticaj plodoreda i navodnjavanja na strukturno stanje černozema. *Letopis naučnih radova, 29* (1), 85-91.

Popsimonova, G., Benko, B., Karić, L., & Gruda, N. (2017). Protected Vegetables in South-East Europe, *Book of Abstracts, VII South-Eastern Europe Syposium on Vegetables & Potatoes,* (pp. 55). Maribor, Slovenia.

Regulation (EU) 2018/848 of the European Parliament and of the Council of 30 May 2018 on organic production and labelling of organic products and repealing Council Regulation (EC) No 834/2007, *Official Journal of he European Union L, 150* (1), 1-92.

Savvas, D., Ntatsia, G., & Barouchas, P.E. (2017). Soil conservation, soil fertility and plant nutrition management. In: Food and Agriculture organisation of the United Nations, *Good Agricultural Practices for greenhouse vegetable production in the South East European countries, Principles for sustainable intensification of smallholder farms,* (pp. 53-78). Rome.

Sekulić, P., Ninkov, J., Hristov, N., Vasin, J., Šeremešić, S., & Zeremski-Škorić, T. (2010). Sadržaj organske materije u zemljištima AP Vojvodine i mogućnost korišćenja žetvenih ostataka kao obnovljivog izvora energije. *Ratarstvo i povrtarstvo, 47* (2), 591-598.

Shafique, H.A., Sultana, V., Ehteshamul-Haque, S., & Athar, M. (2016). Management of soil-borne diseases of organic vegetables. *Journal of Plant Protection Research, 56* (3), 221-230.

Sumner, R. (1982). Crop rotation and plant productivity. In M. Rechcigl (eds.), *Handbook of Agricultural Productivity*. (pp. 273-313). Boca Raton, FL:CRC.

Šperanda M., Popović, B., Zmaić, K., Lončarić, Z., & Đidara, M. (2019). The role of livestock production in a sustainable circular bio-economy. *Proceedings of 54th Croatian & 14th International Symposium on Agriculture* (pp. 21-29). Vodice, Croatia.

Tringovska, I., Yankova, V., Markova, D., & Mihov, M. (2015). Effect of companion plants on tomato greenhouse production. *Scientia Horticulturae, 186,* 31-37.

Tüzel, Y., & Öztekin, G.B. (2017). Crop diversification, management and practical uses. In: Food and Agriculture organisation of the United Nations, *Good Agricultural Practices for greenhouse vegetable production in the South East European countries, Principles for sustainable intensification of smallholder farms,* (pp.105-122). Rome.

Vlahović, B., & Puškarić, A. (2013). *Organska poljoprivreda-šansa za agrobiznis*. Novi Sad: Gradska uprava za privredu.

Vlajić, S., Gvozdanović-Varga, J., Maširević, S., Iličić, R., Barać, R., Červenski, J., & Božić, V. (2018). Kila kupusa - da li predstavlja opasnost? *Zbornik radova XXIII Savetovanje o biotehnologiji sa međunarodnim učešćem,* (pp. 390-395). Čačak.

Vuković, S., Inđić, D., Gvozdenac, S., & Červenski J. (2014). Efficacy of insecticides in the control of cabbage pests. *Research Journal of Agricultural Science, 46* (2), 421-425.

www.polj.savetodavstvo.vojvodina.gov.rs.

www.stat.gov.rs.

Primljeno: 26. septembra 2019.
Odobreno: 5. avgusta 2020.

THE IMPORTANCE OF CROP ROTATION IN INTENSIVE VEGETABLE PRODUCTION IN A GREENHOUSE

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A b s t r a c t

Intensive vegetable production nowadays is a large “energy consumer“. Producers look only at the economic side of such production, which is most often the excuse for its current realization. Intensive vegetable production is now reduced to cultivating several vegetable species, more often in the single-crop system. By thinking this way we bring the entire production into an unsustainable situation. Therefore, vegetable production in a greenhouse should be organized by growing preceding crops, main crops and stubble crops. Intensive vegetable production implies the maximally well-organized use of available land and resources. This includes proper crop rotation and cultivation practices, as well as knowledge of the market, as a possibility of placing excess production. With the good organization of crop rotation and the timely replacement of crops, we can transform a greenhouse into a useful place for vegetable production.

Key words: single-crop system, crop rotation, vegetable species, organic matter.

Received: September 26, 2019
Accepted: August 5, 2020

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Journal of Agricultural Sciences (Belgrade) https://doi.org/10.2298/JAS2003213A
Vol. 65, No. 3, 2020 UDC: 635.654(669)
Pages 213-224 Original scientific paper

IMPROVING THE GROWTH AND YIELD OF OKRA BY INTERCROPPING WITH VARYING POPULATIONS OF LEGUMES

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Abstract: An experiment was conducted at the Vegetable Research Farm of the National Horticultural Research Institute, Ibadan, Oyo State, Nigeria, in the rain-forest agro-ecological zone in 2016 and 2017 to determine suitable cropping systems to increase the yield of okra. The seed of okra (*Abelmoschus esculentus* (L.) Moench), cv. LD-88, was planted at a spacing of 60 × 40 cm as an intercrop and monocrop to produce an average density of 4.2 plants·m^{-2}; the intercrops cowpea (*Vigna unguiculata* (L.) Walp.), var. Ife brown, and peanut (*Arachis hypogaea* L.), var. Kampala, were planted to provide average densities of 5.6 plants·m^{-2}, 4.2 plants·m^{-2}, 3.3 plants·m^{-2} and 2.7 plants·m^{-2}. Data were collected on plant height, number of leaves, leaf area, stem diameter and fruit yield of okra. Year affected plant height, number of leaves, leaf area, stem diameter and fruit yield of okra intercropped with legumes at different densities. Legume densities affected plant height, number of leaves, stem diameter, leaf area and fruit yield. The interaction of year × legume densities affected plant height, number of leaves, stem diameter, leaf area and fruit yield of okra. Intercropping okra with peanut at the density of 2.7 plants·m^{-2} enhanced its growth and yield and appeared to be the best configuration for these crops.

Key words: cowpea, intercropping, peanut, spacing and vegetable.

Introduction

Intercropping systems of okra (*Abelmoschus esculentus* (L.) Moench) or tomato (*Solanum lycopersicum* L.) with cowpea (*Vigna unguiculata* (L.) Walp.); amaranth (*Amaranthus* spp. L.) with cowpea; cucumber (*Cucumis sativus* L.) with cowpea; field corn (*Zea mays* L.) with cowpea, and cassava (*Manihot esculenta*

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Crantz.) with cowpea have been reported (Susan and Mini, 2005; Akande et al., 2006; Mohammed et al., 2006; Odedina et al., 2014). These studies indicated that intercropping was more productive than monocropping. Other benefits of intercropping include prevention of pests and diseases, weed suppression and improvement of soil fertility (Sanginga and Woomer, 2009; Seran and Brintha, 2010). Intercropping systems are flexible and may maximize profit and minimize risk (Matusso et al., 2012). Intercropping improves the environment (Gilley et al., 2002) as well as the use of water, nutrients and solar energy, and enhances crop productivity compared to monocrops (Odedina et al., 2014).

The appropriate crop and sowing densities are important in intercropping. The success of this way of farming depends on interactions between component crops and environmental conditions (Lithourgidis et al., 2011). Intensification in space and time, competition between and among system components for light, water and nutrients are concerns related to intercropping (Tajudeen, 2010).

Okra is a widely cultivated vegetable crop and very important in the diet of Africans (Omotoso and Shittu, 2008; Adewole and Ilesanmi, 2011). Fresh edible okra pods provide the supplementary vitamins A, B-Complex, C, iron, and calcium (Akanbi et al., 2010; Jaibir et al., 2004; Chutichudet et al., 2007). The pod mucilage has its medicinal properties as an emollient, laxative and expectorant (Khan et al., 2000). Many problems have been known to arise from the sole cropping system such as a build-up of pests and diseases and depletion of soil nutrients which have been reported to reduce the growth and yield of crops like okra (Iyagba et al., 2012). Very little has been reported on compatibility and suitable spacing of legumes intercropped with vegetables like okra. There is the need to investigate the appropriate density of legumes intercropped with okra to improve its yield.

Materials and Methods

The experiment was conducted in 2016 and 2017 at the Vegetable Research Farm of the National Horticultural Research Institute (NIHORT), Ibadan, Nigeria, in the rain-forest agro-ecological zone at 7°33’N and 3°56’E at 168 m above sea level. Soil samples were collected randomly at a depth of 0–15 cm with a soil auger before herbicide application and taken to El-Alpha Mega Services laboratory, Ibadan, Nigeria for analysis of physical and chemical properties.

Soil pH was determined in distilled water. About 10 g of air-dried soil (< 2 mm fraction) were put into separate 50-ml beakers, and 10 ml of distilled water were added into each beaker to attain the 1:1 ratio and allowed to equilibrate for 30 minutes with occasional stirring. The electrode was calibrated with pH buffers 4.0 and 7.0 before insertion into the suspension, and the reading was taken with a digital pH meter (Corning Mosel 220 digital – the United Kingdom). The average of two readings taken to one decimal place was recorded as the pH of the soil in water (Bates, 1954).

Particle size distribution was determined according to Bouyoucos (1951), where 100 g of air-dried 2-mm sieved soils were weighed into a dispersion cup, 50 ml of 5% sodium hexametaphosphate (Calgon) solution and 200 ml of distilled water were added and stirred with a glass rod. After 30 minutes, the suspension was stirred for 15 minutes with a mechanical stirrer, poured into a 1000-ml glass cylinder and distilled water was added to make 940 ml. The cylinder was vigorously shaken in a back-and-forth manner, placed on a table and the hydrometer inserted. The first hydrometer reading was taken after 40 seconds, and the temperature was also recorded. After two hours, the second hydrometer and temperature reading was taken, and the percentages of sand, silt and clay were determined thereof. The textural class of the soils was determined by using the USDA soil textural triangle.

The Walkley-Black method (1934) as modified by Heanes (1984) was employed, 0.5 g of 0.5 mm sieved soil was weighed into a 50-ml glass beaker, and 5 ml of 1M potassium dichromate were added and swirled to mix thoroughly. Thereafter, 10 ml of concentrated sulphuric acid were added into the suspension, and the mixture heated for exactly 30 minutes on a hot plate at 150 °C. After the mixture had cooled down, it was diluted to 50 ml with distilled water and allowed to stand overnight. This is to allow for a clear supernatant solution. Standard carbon solutions were prepared from oven-dried sucrose, mixed with the same volume of potassium dichromate and concentrated sulphuric acid and digested as the soils. The standards and samples were read on a spectrophotometer (Labomed 20D Spectrophotometer – the United States of America) at a wavelength of 600 nm using a 1-cm cell. The amount of C in the samples was determined from a standard curve.

Nitrogen was determined by the macro-Kjeldahl method. About 0.5 g of 0.5-mm sieved soil was weighed into a digestion flask together with 0.5 g of the salt/catalyst mixture of sodium sulphate and copper sulphate (ratio 10:1) in 5 ml of concentrated sulphuric acid and digested for about 3 hours (Amin and Flowers, 2004). The digested solution was made up to 50 ml with distilled water and shaken in a back-and-forth manner. Thereafter, an aliquot of the digest was taken and the N content determined by the colorimetric Technicon (Technicon, 1973) auto analyser method with a spectrophotometer (Labomed 20D Spectrophotometer – the USA) at 630 nm.

Available phosphorus was determined by extractants as enumerated earlier in Mehlich-3 (Mehlich, 1984). One g of soil was extracted with 10 ml of the extractants (ratio 1:10) on a reciprocating shaker for five minutes. Extracts were filtered through Whatman No. 42 filter paper. A 5-ml aliquot of the extracts was taken into a 25-ml volumetric flask, 5 ml of ascorbic acid (Watanabe and Olsen,

1965) were added, shaken and made to mark with distilled water. Phosphorus content was determined with the aid of a spectrophotometer (Labomed 20D Spectrophotometer – the USA) on a wavelength of 882 nm (Bray and Kurtz, 1945).

Exchangeable potassium was determined in Mehlich-3 as for available P. Ca, Mg, K and Na were determined by the Atomic Absorption Spectrophotometer (AAS) (Buck Scientific AAS Model 210 VGP – the United States of America). Micronutrients (Zn, Cu, Mn and Fe) were also determined in Mehlich-3 extractant by the Atomic Absorption Spectrophotometer (AAS) (Buck Scientific AAS Model 210 VGP – the United States of America). Exchangeable acidity ($Al^{3+} + H^{+}$) was determined using the 1 N KCl extraction method, and titrated with 0.01 N NaOH (Black, 1965). About 2 g of 2-mm sieved soil were weighed into a beaker while 20 ml of 1 N KCl were added and stirred with a reciprocating shaker for 5 minutes. It was filtered with Whatman No. 42 filter paper, to get the filtrate. Two drops of phenolphthalein were added, and the solution was titrated with 0.01 N NaOH until the pink colour was observed. Effective cation exchange capacity (ECEC) was calculated by summation of exchangeable bases and exchangeable acidity.

Exchange acidity = $H^{+} + Al^{+}$.

Base saturation (BS) was calculated from the formula:

$$BS\ (g/kg) = \frac{\text{ECEC} - \text{exchangeable acidity (Al + H)}}{\text{ECEC}} \times 1000 \tag{1}$$

Table 1. Physical and chemical properties of the soil.

Parameter	2016	2017
pH (in water, 1:2.5)	6.76	5.1
Organic carbon (%)	0.25	4.4
Total N (%)	0.094	0.03
Available phosphorus (mg/kg) (Bray-1)	4.94	0.4
Exchangeable bases:		
Potassium (K) ($Cmol \cdot kg^{-1}$)	0.15	2.77
Calcium (Ca) ($Cmol \cdot kg^{-1}$)	0.08	0.24
Sodium (Na) ($Cmol \cdot kg^{-1}$)	0.26	0.19
Magnesium (Mg) ($Cmol \cdot kg^{-1}$)	1.02	0.14
Particle size:		
Sand ($g \cdot kg^{-1}$)	872	85.2
Silt ($g \cdot kg^{-1}$)	68	10.4
Clay ($g \cdot kg^{-1}$)	60	4.4
Texture class	Sandy loam	Sandy loam

In both years, the experiment was conducted between July and September. Rainfall, temperature and relative humidity varied between years (Table 2). The field was disc plowed twice, harrowed and treated with the systemic herbicide

Force-up®, a.i. glyphosate, at 250 mL to 18 L of water, using a knapsack sprayer before planting. No fertilizer was applied. The experiment comprised 17 treatments arranged in a randomized complete block design replicated 3 times. The seeds of okra, var. LD-88, obtained from NIHORT were planted at a spacing of 60 × 40 cm in intercrops and monocrops corresponding to a plant population of 4 plants·m^{-2}. Cowpea, var. Ife brown, and peanut, var. Kampala, were planted at densities of 5.6 plants·m^{-2}, 4.2 plants·m^{-2}, 3.3 plants·m^{-2} and 2.7 plants·m^{-2}. The plot size was 2.4 × 2 m (4.8 m^2). Weeding was carried out manually at 6 and 8 weeks after sowing. The insecticide DD-force®, Dichlorvos 1000EC, was applied to cowpea at 1.9 mL to 0.75 L of water using a hand sprayer.

Five okra plants were randomly selected per plot and tagged for data collection. Data on plant height, number of leaves, leaf area, stem diameter and fruit yield of okra were collected. Data collected were subjected to analysis of variance using SAS (ver. 9, SAS Institute, Cary, NC) software at the 5% level of probability.

Table 2. Weather data of the experimental site.

Month	2016				2017			
	Max. temp. ºC	Min. temp. ºC	RH (%)	Rainfall (mm)	Max. temp. ºC	Min. temp ºC	RH (%)	Rainfall (mm)
January	35	20	82	10.6	35	22	87	148.8
February	36	23	87	0.0	34	23	87	0.0
March	34	24	88	242.8	35	24	88	173.3
April	34	25	88	344.6	33	24	88	239.7
May	30	22	82	383.5	32	23	87	703.7
June	30	23	89	423.8	30	23	88	457.9
July	29	24	90	106.2	29	23	92	620.7
August	28	23	89	89.2	28	22	92	241.9
September	30	23	91	645.7	30	22	88	353.8
October	32	23	88	556.3	32	23	91	176.9
November	33	25	89	75.4	33	24	90	0.0
December	34	22	87	9.2				
Total				2887.3				3116.7
Mean	32.13	23.1	87.5		32.0	23.0	89.0	

Source: National Horticultural Research Institute, Ibadan, Oyo State, Nigeria.

Results and Discussion

The chemical and physical properties of soil in the experimental location as presented in Table 1 showed that organic carbon, total nitrogen, the macro- and micronutrients of the site were below the minimum requirement for plant growth and yield.

Results of the analysis showed that the year had a significant (*P* < 0.01) effect on the growth and yield of okra intercrop with different densities of legume (Table 3). Okra was significantly taller with significantly higher leaf area and stem diameter in 2016. Also, the significantly higher fruit yield of 7.3 t. ha^{-1} was obtained in 2016, while 4.9 $t.ha^{-1}$ was obtained in 2017 (Table 4).

Table 3. The analysis of variance of the growth and yield of okra intercropped with different densities of legumes.

Sources of variation	df	Plant height	Number of leaves	Leaf area	Stem diameter	Fruit yield
Replicate	2	1.39	0.12	11049.35	0.01	0.52
Year (Y)	1	2012.05**	4.49	833093.16**	45.76**	79.28**
Density (D)	8	142.12**	61.37**	196719.04**	0.63**	5.59**
Y × D interaction	8	107.25**	8.84**	93096.31**	0.32**	2.51**
Error	34	11.95	1.34	7723.08	0.04	0.56
Total	53					

** indicates significant at the 0.01% probability level.

Table 4. The growth and yield of okra as affected by legume densities.

Source	Plant height (cm)	Number of leaves	Leaf area (cm^2)	Stem diameter (cm)	Fruit yield ($t·ha^{-1}$)
Year					
2016	28.4ab	10.9	618.1a	3.0a	7.3a
2017	40.8a	11.5	369.7b	1.4b	4.9b
SED ($P \leq 0.05$)	1.9	Ns	48.61	0.1	0.4
Legume density					
OP1	37.7bc	11.6c	535.7bc	2.1cd	5.0d
OP2	34.4cd	9.6de	612.2b	2.1bc	5.4cd
OP3	35.4cd	13.3b	618.0b	3.6a	6.0bc
OP4	29.8ef	16.1a	814.6a	2.3ab	7.4a
OC1	32.2de	6.8f	252.0d	1.9de	5.8bcd
OC2	39.8ab	7.8f	272.3d	1.7e	5.4cd
OC3	27.3f	9.4e	505.0c	1.9de	5.4cd
OC4	32.3de	10.8cd	347.8d	1.7e	6.3b
Okra/no legume	42.7a	15.3a	485.6c	2.4a	7.9a
SED ($P \leq 0.05$)	4.1	1.4	103.1	0.2	0.9

Means in columns followed by the same letter are not significantly different ($P \leq 0.05$) according to Duncan's multiple range test. ns = not significant. OP1, OP2, OP3 and OP4 = Okra/peanut at densities of 5.6 $plants·m^{-2}$, 4.2 $plants·m^{-2}$, 3.3 $plants·m^{-2}$ and 2.7 $plants·m^{-2}$. OC1, OC2, OC3 and OC4 = Okra/cowpea at densities of 5.6 $plants·m^{-2}$, 4.2 $plants·m^{-2}$, 3.3 $plants·m^{-2}$ and 2.7 $plants·m^{-2}$.

Intercropping okra with legumes at different densities significantly affected the growth and yield of okra. Okra/no legume was the tallest (42.7 cm) though not significantly different from okra intercropped with cowpea at the density of 4.2 plants·m^{-2} that was 39.8 cm (Table 4). Also, okra intercropped with peanut at the density of 2.8 plants·m^{-2} produced a significantly higher number of leaves (16.1), but not significantly different with okra/no legume (15.3). IIntercropping okra with cowpea at 5.6 plants·m^{-2} and 4.2 plants·m^{-2} significantly reduced the number of okra leaves (Table 4). However, leaf area of okra intercropped with peanut at 2.8 plants·m^{-2} 814.6 cm was significantly higher. The stem diameter of okra was also significantly (P < 0.01) affected by intercropping with legumes at different densities (Table 3) as okra/no legume (2.4 cm) and okra intercropped with peanut at 3.3 plants·m^{-2} had the highest stem diameter of 3.5 cm (Table 4). The fruit yield of okra was also significantly (P < 0.01) influenced by different densities of legumes (Table 3) as okra/no legume and okra intercropped with peanut at 2.8 plants·m^{-2} had the significantly higher fruit yields of 7.8 and 7.4 t/ha, respectively (Table 4).

Interaction of year × intercropping as shown in Table 5 revealed that in 2017, okra/no legume was significantly taller (54.3 cm) while the shortest plant was observed with okra intercropped with peanut at the densities of 4.2 plants·m^{-2} and 2.8 plants·m^{-2} in 2016 (23.6 and 22.2 cm). Also, okra intercropped with peanut at 2.8 plants·m^{-2} had a higher number of leaves (16.1) in 2016 while in 2017 okra intercropped with cowpea at 5.6 plants·m^{-2} had the lowest number of leaves (5.9). However, the highest and lowest numbers of leaves were observed in okra/no legume in 2017 (17.9) and in okra intercropped with cowpea at 5.6 plants·m^{-2} (5.9). Okra intercropped with peanut at the density of 2.8 plants·m^{-2} in 2016 had significantly larger leaf area (1148.2 cm^{2}) while okra intercropped with cowpea at 5.6 plants·m^{-2} in 2017 had the lowest leaf area (231.0 cm). The highest stem diameter (3.7 cm) was observed in okra intercropped with peanut at 3.3 plants·m^{-2} which was significantly higher compared to okra intercropped with cowpea at all the densities and sole okra in 2016. No significant difference was observed in fruit yield of okra/no legume and okra intercrop with peanut and cowpea at 2.8 plants·m^{-2}, and cowpea at 5.6 plants·m^{-2} in 2016. Okra intercropped with cowpea at 5.6 plants·m^{-2} and 4.2 plants·m^{-2} in 2017 had lower fruit yield though not significantly different from okra intercropped with peanut at 5.6 plants·m^{-2} and 4.2 plants·m^{-2} and also okra intercropped with cowpea at 2.8 plants·m^{-2} (Table 5).

Obasi (1989) and Orkwor et al. (1991) have observed that the most important feature of plants that determines their competitive ability for light is height. They have concluded that a successful competitor for light is the component that has its foliage at a higher canopy layer. Palaniappan (1985) and Olasantan and Lucas (1992) have also noted that canopy height is one of the important features which determines the competition ability of plants for light. Palaniappan (1985) has observed that when one component is taller than the other in an intercropping situation, the taller component intercepts the major share of the light such that growth rates of the two components will be proportional to the quantity of the photosynthetically active radiation they intercept. From this study, okra sown as a sole crop was observed to be significantly taller than okra intercropped with either groundnut or cowpea. This could probably be due to the fact that there was an early onset of inter-specific competition between okra and component crops and these component crops had a smothering effect on okra that made the growth and development of okra be hindered compared to okra sown as a sole crop that did not experience any inter-specific competition.

Table 5. Interaction effects of year × legume density on the growth and yield of okra.

Interaction	Plant height (cm)	Number of leaves	Leaf area (cm^2)	Stem diameter (cm)	Fruit yield (t/ha)
2016 cropping season					
OP1	31.8cdef	11.3def	708.4b	2.7cd	5.8ef
OP2	23.7h	9.0ghi	799.4b	3.0b	6.8cde
OP3	25.6gh	14.2bc	800.7b	3.8a	6.2de
OP4	22.3h	16.1ab	1148.3a	2.8bcd	8.1ab
OC1	32.2cdef	7.7ijk	273.0ef	2.8bcd	8.1ab
OC2	33.5cde	8.8ghi	294.7def	2.7cd	7.3bcd
OC3	27.1fgh	8.1ijk	731.0b	3.0bc	6.6cde
OC4	27.9efgh	9.9fgh	311.3def	2.6d	7.7abc
Okra/no legume	31.0defg	12.7cd	496.3c	3.6a	8.9a
2017 cropping season					
OP1	43.5b	11.6def	363.0cdef	1.4f	4.3gh
OP2	45.0b	10.2fg	424.9cd	1.3f	4.0gh
OP3	45.1b	12.3de	435.3cd	1.3f	5.8ef
OP4	37.4c	16.1ab	481.0c	1.9e	6.7cde
OC1	32.2cdef	5.9k	231.0f	0.9g	3.5h
OC2	46.0b	6.8jk	253.9ef	0.7g	3.4h
OC3	27.4fgh	10.7efg	279.0ef	0.8g	4.2gh
OC4	36.6cd	11.6def	384.4cde	0.9g	4.9fg
Okra/no legume	54.4a	17.9a	474.9c	1.3f	6.8cde
SED ($P \leq 0.05$)	5.7	1.9	145.8	0.3	1.2

Means with the same alphabets in the same column are not significantly different from one another ($P \leq 0.05$) according to Duncan's multiple range test. OP1, OP2, OP3 and OP4 = Okra/peanut at densities of 5.6 plants·m^{-2}, 4.2 plants·m^{-2}, 3.3 plants·m^{-2} and 2.7 plants·m^{-2}. OC1, OC2, OC3 and OC4 = Okra/cowpea at densities of 5.6 plants·m^{-2}, 4.2 plants·m^{-2}, 3.3 plants·m^{-2} and 2.7 plants·m^{-2}.

This result was contrary to the report of Njoku et al. (2007), who reported that intercropped okra was taller than the sole crop. Muoneke et al. (1997) also reported that the taller okra plants obtained when intercropped with maize was in a bid to display their leaves for solar radiation. This result implies that okra intercropped with either groundnut or cowpea had less ability to compete for light, unlike okra sown alone. Okra intercropped with groundnut at the high density (4.2 plants·m^{-2}) was observed to be significantly taller, whereas okra intercropped with either groundnut or cowpea at the low density (3.3 plants·m^{-2}) was observed to be the shortest. This implies that intercropping okra at close spacing initiated a competition to the extent they grow taller than those intercropped at wide spacing. This result corroborates the report of Ibeawuchi et al. (2005), who also reported that okra plant height decreased as row spacing increased.

Okra sown as a sole crop and okra intercropped with groundnut at the low density (2.8 plants·m^{-2}) had the wider stem diameter. This could be due to the fact that the level of competition in sole okra and okra intercropped at wider spacing was low that made these plants take more nutrients from the soil and had more space for growth. Okra intercropped at wider spacing was the shortest and probably this could have enhanced the wide diameter. This result is also in accordance with the report of Ibeawuchi et al. (2005), who also observed that wide row spacing with lesser plant population led to an increase in the girth of okra stems. Okra intercropped at the high density (4.2 plants·m^{-2}) had the least stem diameter. Okra plant was able to compete favorably with groundnut at close spacing but not with cowpea. This showed that cowpea initiated more competition than groundnut.

Sole okra had higher leaf area than okra intercropped with either groundnut or cowpea. In the intercrop, leaf area increased with decreasing plant density. This could be a result of less competition for nutrient, light and space and could also be a result of the aggressive growth habit of cowpea and groundnut. This result was corroborated by the report of Odedina et al. (2014) who stated that the aggressive growth habit of the cowpea variety used in their study could be responsible for the reduction of leaf area and LAI in okra + IT84S 2246-6 intercrop. In 2016, about 807.3 mm of rainfall fell during the crop cycle from June to September, however, in 2017 of the same cropping cycle there was more rainfall (1,674.3 mm). The better yield and performance of okra in 2017 may be attributed to the better rainfall during the entire crop cycle.

Conclusion

This study shows that okra fruit yield increased at wider spacing. Therefore, intercropping okra with peanut at the density of 2.8 plants·m^{-2} has proven to be suitable and appropriate and could therefore be recommended.

References

Adewole, M.B., & Ilesanmi, A.O. (2011). Effects of soil amendments on the nutritional quality of okra *(Abelmoschus esculentus* [L.] Moench). *Journal of Soil Science and Plant Nutrition, 11* (3), 45-55.

Akanbi, W.B., Togun, A.O., Adediran, J.A., & Ilupeju, E.A.O. (2010). Growth, Dry matter and Fruit Yield components of okra under organic and inorganic sources of nutrients. *American-Eurasian Journal of Sustainable Agriculture, 4* (1), 113.

Akande, M.O., Oluwatoyinbo, F.I., Kayode, C.O., & Olowokere, F.A. (2006). Response of maize (*Zea mays*) and okra (*Abelmoschus esculentus*) intercrop relayed with cowpea (*Vigna unguiculata*) to different levels of cow dung amended phosphate rock. *World Journal of Agriculture Sciences, 2* (1), 119-122.

Amin, M., & Flowers, T.H. (2004). Evaluation of Kjeldahl Digestion Method. *Journal of Research Science, 15* (2), 159-179.

Bates, R.G. (1954). *Electrometric pH Determinations.* John Willey and Sons. Inc., New York.

Black, C.A. (1965). *Methods of Soil Analysis: Agronomy No.9. Part 2* Amer. Soc. Agronomy, Madison, Wisconsin.

Bouyoucos, G.H. (1951). A recalibration of the hydrometer method of making mechanical analysis of soils. *Agronomy Journal, 43*, 435-438.

Bray, R.H., & Kurtz (1945). Determination of total, organic and available forms of P in soils. *Soil Science, 59*, 39-45.

Chutichudet, B., Chutichudet, P., & Chanaboon, T. (2007). Effect of Chemical Paclobutrazol on Growth, Yield and Quality of Okra (*Abelmoschus esculentus* L.) Har Lium Cultivar in Northeast Thailand. *Pakistan Journal of Biological Sciences, 10,* 433-438.

Gilley, J.E., Kramer, L.V., & Eghball, B. (2002). Managing runoff following manure application. *Journal of Soil and Water Conservation, 57* (6), 530-533.

Heanes, D.L. (1984). Determination of total organic-C in soils by an improved chromic acid digestion and spectrophotometric procedure. *Communications in Soil Science and Plant Analysis, 15* (10), 1191-1213.

Ibeawuchi, I.I., Obiefuna, J.C., & Ofoh, M.C. (2005). Effect of row spacing on yield and yield components of okra (*Abelmoschus esculentus*) and mixture groundnut (*Arachis hypogaea*). *Journal of Agronomy, 4* (4), 304-307.

IITA (1982). *Automated and semi – automated methods of soil and plant analysis.* Manual series No 7. IITA, Ibadan, Nigeria. pp. 4-15.

Iyagba, A.G., Onuegbu, B.A., & Ibe, A.E. (2012). Growth and yield response of okra [*Abelmoschus esculentus* (L.) Moench] varieties to weed interference in South-Eastern Nigeria. *Global Journal of Science Frontier Research, 12:7* (1), 23-31.

Jaibir, T., Singh, H.B., Vivek, and Tripathi, S.S. (2004). Integrated weed management in intercropping of mungbean (Vigna radiata) and cowpea fodder (*Vigna unguiculata*) with pigeon pea (*Cajanus cajan*) under western U.P. condition. *Indian Journal of Weed Science, 36,* 133-134.

Khan, B.M., Asif, M., Hussain, N. & Iqbal (2000). Agro-economic impact of different weed control strategies in wheat. *Journal of Research (Science), 11*, 46-49.

Lithourgidis, A.S., Dordas, C.A., Damalas, C.A., & Vlachostergios, D.N. (2011). Annual Intercrops: An alternative pathway for sustainable agriculture. *Australian Journal of Crop Science, 5* (4), 396-410.

Matusso, J.M.M., Mugwe, J.N., & Mucheru-Muna, M. (2012). Potential role of cereal-legume intercropping systems in integrated soil fertility management in smallholder farming systems of sub-Saharan Africa Research Application Summary. *Third RUFORUM Biennial Meeting*, Entebbe, Uganda.

Mehlich, A. (1984). Mehlich 3 soil test extractant: A modification of Mehlich 2 extractant. *Communications in Soil Science & Plant Analysis, 15* (12), 1409-1416.
Mohammed, M.A., Variyapuri, K. Alagesan, A. Somasundaram, E. Sathyamoorths, K., & Pazhanivelan, S. (2006). Effect of intercropping and organic manures on yield and biological efficiency of cassava intercropping system (*Manihot esculenta* Crantz). *Research Journal of Agriculture and Biological Sciences, 2* (5), 201-208.
Muoneke, C.O., Asiegbu, J.E., & Udeogalanya, A.C.C. (1997). Effect of relative sowing time on the growth and yield of the component crops in okra/maize and okra/cowpea intercropping systems. *Journal of Agronomy and Crop Science, 179* (3), 179-185.
Obasi, M.O. (1989). Some studies on the growth, development and yield of ground bean (*Kerstingiella geocarpa* Harms). PhD Dissertation. Department of Crop Science, University of Nigeria, Nsukka, Nigeria.
Odedina, J.N., Fabunmi, T.O., Adigbo, S.O., Odedina, S.A., & Kolawole, R.O. (2014). Evaluation of cowpea varieties [*Vigna unguiculata* (L.) Walp] for intercropping with okra [*Abelmoschus esculenta* (L.) Moench]. *American Journal of Research Communication*, *2* (2), 92-97.
Olasantan, F.O., & Lucas, E.S. (1992). Intercropping maize with crops of differing canopy heights and similar or different maturities using different spatial arrangement. *Journal of Agricultural Science and Technology, 1 & 2* (1), 13-15.
Omotoso, S.O., & Shittu, O.S. (2008). Soil properties, leaf nutrient composition and yield of okra (*Abelmoschus esculentus* (L.) Moench) as affected by broiler litter and NPK 15:15:15 fertilizers in Ekiti State, Nigeria. *International Journal of Agricultural Research 3*, 140-147.
Orkwor, G.C., Okereke, O.U., Ezedinma, F.O.C., & Ezumah, H.C. (1991). Critical period of weed interference in maize (*Zea mays* L.) intercropped with yam (*Dioscorea rotundata* Poir), okra [*Abelmoschus esculentus* (L.) Moench] and sweet potato [*Ipomoea batatas* (L.) Lam]. *Nigeria Agricultural Journal, 26*, 61-70.
Palaniappan, S.P. (1985). *Cropping systems in the tropics: Principles and management.* Willey Eastern Ltd., New Delhi, India.
Sanginga, N., & Woomer, P.L. (2009). *Integrated soil fertility management in Africa: Principles, practices and development process.* Tropical Soil Biology and Fertility Institute of the International Centre for Tropical Agriculture, Nairobi, Kenya.
SAS (1999). SAS Institute Inc., SAS/STAT® User's Guide, Version 8, Cary, NC: SAS Institute Inc., 1999.
Seran, T.H., & Brintha, I. (2010). Review on maize based intercropping. *Journal of Agronomy*, *9* (3), 135-145.
Susan, A.J., & Mini. C. (2005). Biological efficiency of intercropping in okra [*Abelmoschus esculentus* (L.) Moench]. *Journal of Tropical Agriculture, 43* (1-2), 33-36.
Tajudeen, O.O. (2010). *Evaluation of Sorghum-Cowpea intercrop productivity in Savanna agro-ecology using competition indices.* Horticulture Department, Abubakar Tafawa Balewa University, Bauchi, Nigeria.
Technicon Instrument Corporation. (1973). Preliminary Total Nitrogen (Kjeldhal). Industrial method No. 154-71W. Tarrytown N.Y.
Walkley, A., & Black, I.A. (1934). An Examination of Degtjareff Method for Determining Soil Organic Matter and Proposed Modification of the Chromic Acid Titration Method. *Soil Science, 37*, 29-38.
Watanabe, F.S., & Olsen, S.R. (1965). Test of an Ascorbic Acid Method for Determining P in Water and NaHCO3 Extracts From Soils. *Soil Science Society of America Journal, 29*, 677-678.

Received: March 30, 2020
Accepted: June 29, 2020

POBOLJŠANJE RASTA I PRINOSA BAMIJE ZDRUŽIVANJEM SA RAZLIČITIM POPULACIJAMA LEGUMINOZA

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R e z i m e

Eksperiment je sproveden na Povrtarskom istraživačkom dobru Nacionalnog instituta za hortikulturna istraživanja, Ibadan, Država Ojo, Nigerija, u agroekološkoj zoni kišnih šuma 2016. i 2017. godine kako bi se odredio pogodan sistem gajenja da bi se povećao prinos bamije. Seme bamije (*Abelmoschus esculentus* (L.) Moench), sorte LD-88, posejano je na rastojanju 60 × 40 cm kao međuusev i monokultura kako bi se postigla prosečna gustina od 4,2 biljke po m^{-2}; posejani su i združeni usevi vigne (*Vigna unguiculata* (L.) Walp.), sorte Ife brown, kikirikija (*Arachis hypogaea* L.), sorte Kampala, kako bi se postigle prosečne gustine od 5,6 biljaka m^{-2}, 4,2 biljke m^{-2}, 3,3 biljke m^{-2} i 2,7 biljaka m^{-2}. Prikupljeni su podaci o visini biljke, broju listova, površini lista, prečniku stabla i prinosu ploda bamije. Godina je uticala na visinu biljke, broj listova, površinu lista, prečnik stabljike i prinos ploda bamije združene sa leguminozama pri različitim gustinama. Gustine leguminoza su uticale na visinu biljke, broj listova, prečnik stabljike, površinu lista i prinos ploda. Interakcija godina × gustine leguminoza uticala je na visinu biljke, broj listova, prečnik stabljike, površinu lista i prinos ploda bamije. Združivanje bamije sa kikirikijem pri gustini od 2,7 biljaka po m^{-2} povećalo je njen rast i prinos i pokazalo se da predstavlja najbolju kombinaciju za ove useve.

Ključne reči: vigna, združivanje, kikiriki, rastojanje i povrće.

Primljeno: 30. marta 2020.
Odobreno: 29. juna 2020.

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Journal of Agricultural Sciences (Belgrade)
Vol. 65, No. 3, 2020
Pages 225-237
https://doi.org/10.2298/JAS2003225D
UDC: 635.655:632.51(669)
Original scientific paper

THE EFFECT OF THE PERIOD OF WEED INTERFERENCE ON THE GROWTH AND YIELD OF SOYBEAN (*GLYCINE MAX* L. MERRILL)

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Abstract: Field trials were conducted to evaluate the effect of different periods of weed interference on weed infestation, growth and yield of soybean in 2016–2017 cropping seasons. In both years, soybean grain yields ranged from 888–1148 kg ha $^{-1}$ in plots where weeds were allowed to grow until harvest to 2103–2389 kg ha $^{-1}$ in plots where weeds were controlled until harvest, indicating a 52–58% yield loss with uncontrolled weed growth. Weed interference until 3 weeks after sowing (WAS) had no detrimental effect on soybean growth and yield provided the weeds were subsequently removed. However, further delay in weed removal until 6 WAS or longer depressed soybean growth and resulted in irrevocable yield reduction, with the number of pods per plant being the most affected yield component. For optimum growth and yield, it was only necessary to keep the crop weed-free between 3 and 6 WAS.

Key words: weed removal, weed competition, hoeweeding, critical period, soybean yield.

Introduction

Soybean (*Glycine max* L.) is an important economic legume crop, largely cultivated by smallholder farmers in Sub-Saharan Africa (SSA) (Joubert and Jooste, 2013). It plays an important role in the provision of food and nutrition security for millions of people in developing countries and improves the livelihood of farmers through income generation (Abate et al., 2012). Compared with other crops, soybean is a feasible alternative to addressing malnutrition in SSA because of its high protein (>40%) and oil (20%) content as well as its excellent profile of highly digestible amino acids (Joubert and Jooste, 2013). In addition, soybean has the ability to fix nitrogen (44–103 kg ha^{-1} per years) in poor agricultural soils for its

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own use and the benefit of intercropped cereals and subsequent crops in rotation, which makes it the choice crop for soil fertility improvement (Ronner et al., 2016).

Nigeria is the largest consumer and the second largest producer of soybean in SSA. However, Nigeria currently produces only 25% (680,000 tons) of its annual soybean requirement (2.2 million tons) with an average yield of 960 kg ha $^{-1}$ leaving a supply gap of 1.5 million tones (Khojely et al., 2018). Among different factors attributed to the poor yield and productivity of soybean in Nigeria and other parts of SSA, weed infestation appears to be the most deleterious (Imoloame, 2014; Daramola et al., 2020). According to estimates, weeds alone cause an average yield reduction of 37% while other pests and diseases account for 22% of yield losses (Oerke and Dehne, 2004). Depending on the level of weed infestation and infesting weed species, between 77% and 90% of potential soybean yield is lost due to weed infestation in different zones in Nigeria (Imoloame, 2014).

Hoe weeding is the predominant weed management method of smallholder farmers in SSA. However, labour shortage and its high cost are a constraint (Daramola et al., 2019). Consequently, the crops are subjected to heavy weed infestation, or the weeds removed well after the crops have suffered irrevocable yield losses (Chikoye et al., 2007). Herbicide use, on the other hand, is expensive and does not provide season-long weed control (Adigun et al., 2020). In addition, smallholder farmers lack the technical know-how for correct herbicide application. Although the use of herbicides for weed control is effective and efficient, phytotoxicity and environmental problems that might be induced when herbicides are wrongly applied have made the use of post-emergence herbicides less desirable for smallholder farmers in SSA (Labrada, 2003).

All crops have a stage during their life cycle when they are particularly sensitive to weed competition (Knezevic et al., 2003). This period has been regarded as the critical period of weed competition (CPWC). Weed interference before and after the critical period of weed competition does not result in unacceptable yield loss (Knezevic et al., 2002). Appropriate timing of weed control during the critical period of weed competition, therefore, will help farmers to make efficient use of available resources. Although the effects of weed competition on crop growth and yield are well documented, appropriate timing and the number of weeding treatments required to achieve minimum weed competition and maximum yield of soybean are still poorly understood. Hence, the objective of this study was to evaluate the effects of different periods of weed interference on the growth and yield of soybean to determine the appropriate timing of weed management.

Materials and Methods

The experiment was conducted at the Research Farm of the Institute of Food Security, Environmental Resources and Agricultural Research located at latitude 7°

15′ N and longitude 3° 25 ′E in the forest-savanna transition zone of Nigeria during the 2016–2017 cropping seasons. The site received a total rainfall of 669.6 and 544.6 mm in 2016 and 2017, respectively. The soil at the experimental sites was sandy with 89.8% and 87.9% sand, 5.4% and 5.3% silt and 4.8% and 4.6% clay in 2016 and 2017, respectively. The soils had a pH of 7.7 and 7.5; organic matter of 2.5% and 2.1% and nitrogen of 0.17% and 0.15% in 2016 and 2017, respectively. Prior to planting, the experimental site was ploughed and harrowed at a two-week interval while levelling was done manually using a hand hoe. Soybean seeds were sown manually at inter-row and intra-row spacings of 50 cm and 5 cm, respectively. The soybean variety (var. TGX 1448-2E) used in this study is a semi-determinate, late maturing (115–120 days) and high yielding (1.7–2.3 ton ha^{-1}) with good nodulation (Tefera, 2011). The gross and net plot sizes in both years were 4.5 m × 3.0 m and 3.0 m × 3.0 m, respectively. The experimental site was previously fallow land for 1 year after cropping with groundnut (*Arachis hypogea* L.) for the previous years.

The experiments in both years consisted of two sets of treatments in a randomised complete block design. One set consisted of plots initially kept weed-free for 3, 6 and 9 WAS and subsequently kept weed-infested until harvest. The other set of treatments consisted of plots initially kept weed-infested until 3, 6 and 9 weeks after sowing (WAS) and subsequently kept weed-free until harvest. Two treatments of weed-infested and weed-free plots throughout the crop life cycle were also included as the checks (Table 1). Weed density (m^{-2}), weed dry weight (g m^{-2}), crop vigour score, canopy height (cm), number of leaves and branches per plant, leaf area index, number of pods and seeds per plant, pod and seed weight per plant (g), 100-seed weight (g) and seed yield (kg) were the parameters used to evaluate the performance of the treatments in both years. Crop vigour score was taken by visual observation based on the scale 0–10, where 0 represented plots with crops completely killed and 10 represented plots with the most vigorous growing and healthy crop (Adigun et al., 2018). Soybean dry weight was determined from five plants by destructive sampling within the net plot. The plants were uprooted and then oven-dried at 70°C until a constant weight was obtained. The crop growth rate was calculated as proposed by Hunt (1978), as indicated below:

$$crop\ growth\ rate = \frac{W2 - W1}{T2 - T1} \qquad (1)$$

Where W1 and W2 are values of dry weight at times T1 (6 weeks after sowing) and T2 (12 weeks after sowing), respectively. Leaf area index (LAI) was calculated following the formula of Watson (1947), as follows:

$$LAI = \frac{Leaf\ area\ per\ plant\ (cm^2)}{Ground\ area\ per\ plant\ (cm^2)} \qquad (2)$$

Table 1. The details of the duration of weed interference treatments.

Treatments	Details
WR3	Weed removal until 3 weeks after sowing
WR6	Weed removal until 6 weeks after sowing
WR9	Weed removal until 9 weeks after sowing
WRH	Weed removal until harvest
WI3	Weed interference until 3 weeks after sowing
WI6	Weed interference until 6 weeks after sowing
WI9	Weed interference until 9 weeks after sowing
WIH	Weed interference until harvest

Weeds were removed by a hand hoe at the required time and weekly intervals thereafter. Weed cover score for each treatment was evaluated by visual observation before weed removal based on a rating scale of 1 to 10, where 1 represents a complete weed-free situation while 10 represents a complete weed cover (Adigun et al., 2017). In the weed-free treatment, weeds were removed at weekly interval throughout the growing season. Weeds were sampled from two quadrats of 0.5m × 0.5m size before any weeding was done and cumulative weed dry weight produced was recorded at harvest. Weeds were sampled by cutting them at the ground level. Weed density was taken by physically counting the number of weeds in the quadrats, and these were dried in an oven at 70°C for 72h. Soybean seeds were harvested manually per plot when 95% of plants had 80% mature pods. Seed yield from the net plot was converted to kg ha^{-1} at 12% moisture content.

Data were subjected to analysis of variance using the GenStat (VSN International Ltd, Hempstead UK) discovery package to determine the level of significance of the treatments. The treatment means were separated using the least significant difference (LSD) at $p \leq 0.05$ probability level.

Results and Discussion

The effect of the duration of weed interference on weed growth in soybean

The experimental sites in 2016 and 2017 were infested with weeds such as *Tridax procumbens*, *Euphorbia heterophylla*, *Commelina benghalensis*, *Gomphrena celosioides*, *Digitaria horizontalis*, *Panicum maximum*, *Cynodon dactylon*, *Eleusine indica*, *Rottboellia cochinchinensis*, *Cyperus rotundus*, etc. However, some of the weed species such as *Euphorbia heterophylla*, *Commelina benghalensis*, *Gomphrena celosioides*, *Digitaria horizontalis* and *Panicum maximum* with a moderate infestation (30–59%) in 2016 were found with a high infestation (60–90%) in 2017 (Table 2). This was possible because of more evenly distributed rainfall experienced in 2017 than in 2016 (Figure 1). In 2016, more than

57% of the season rainfall occurred between September and October when the crops were already well established and able to smother emerging weed species.

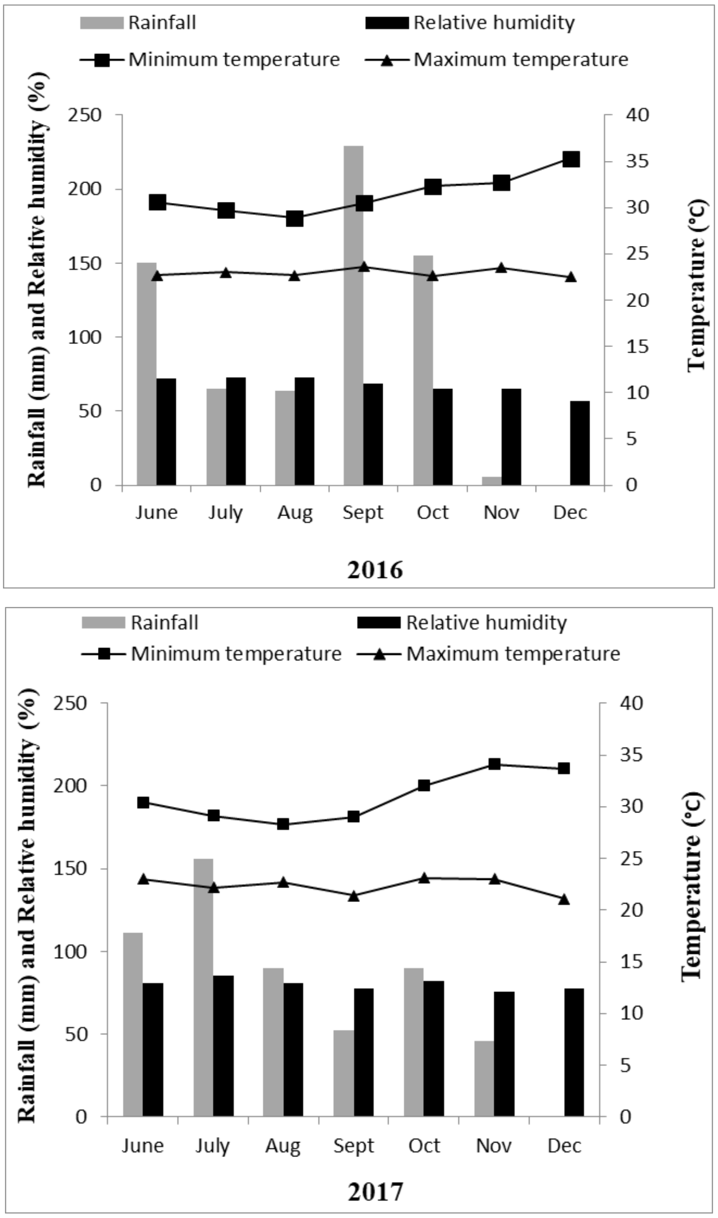

Figure 1. Weather data during the period of crop growth in 2016 and 2017.

Table 2. Weed species and the level of infestation during the experiment in 2016 and 2017.

Weed species	Plant family	Level of infestation	
		2016	2017
Broad leaves			
Amaranthus spinosus (Linn.)	Amaranthaceae	MI[a]	MI
Boerhavia diffusa (Linn.)	Nyctaginaceae	MI	HI
Commelina benghalensis (Burn.)	Commelinaceae	MI	HI
Euphorbia heterophylla (Linn.)	Euphorbiaceae	HI	HI
Gomphrena celosioides (Mart.)	Amaranthaceae	MI	HI
Spigelia anthelmia (Linn.)	Loganiaceae	HI	HI
Tridax procumbens (Linn.)	Asteraceae	MI	HI
*Chromolaena odorata (*L.) R.M. King and Robinson	Asteraceae	MI	HI
Talinum triangulare (Jacq.) Willd.	Portulacaceae	MI	MI
Grasses			
Digitaria horizontalis (Willd.)	Poaceae	MI	MI
Panicum maximum (Jacq.)	Poaceae	MI	MI
Axonopus compressus (Sw.) P. Beauv	Poaceae	MI	MI
Eleusine indica (Gaertn.)	Poaceae	MI	MI
Rottboellia cochinchinensis (Lour.) Clayton	Poaceae	LI	LI
Cynodon dactylon (L) Gaertn	Poaceae	MI	MI
Paspalum scrobiculatum (Linn.)	Poaceae	MI	MI
Sedges			
Cyperus rotundus (Linn.)	Cyperaceae	MI	MI
Cyperus esculentus (Linn.)	Cyperaceae	MI	MI

[a] LI = Low infestation 1–29%; MI = Moderate infestation 30–59%; HI = High infestation 60–90%.

However, in 2017, higher rainfall was recorded in July during the early period of crop growth, which encouraged high weed infestation from the start of the season, when the crops were less competitive against weeds. It has been reported that rainfall affects weed species distribution and their competitiveness within a weed community (Vitorino et al., 2017).

In both years, the duration of weed interference significantly affected weed cover score, weed density and weed dry matter (Table 3). Weed cover score increased significantly with increasing duration of weed interference and decreased significantly with increasing duration of weed removal from 3 WAS until harvest in both years (Table 3). Weed density and dry matter were similar between plots where weeds were allowed to infest the crops until 3 WAS only (WI3) and where weeds were removed until 6 (WR6) and 9 (WR9) WAS in both years. However, allowing weeds to infest the crops until 6 WAS (WI6) or longer significantly increased weed density by 66–86% and weed dry matter by 74–144% compared with plots where weeds were controlled until 6 WAS (WR6) in both years. Weed density and dry matter were also similar between plots where weeds were allowed to infest the crops until 6 (WR6) and 9 (WR9) WAS. Similarly, weed density and dry matter were similar between plots where weeds were removed until 3 WAS (WR3) only and those where weeds were allowed to grow until 6 WAS (WI6), 9 (WI9) and until the harvest (WIH). This trend suggests that rapid weed growth and critical weed-crop interference in soybean were between 3 and 6 WAS. This result is similar to the observation of Osipitan et al. (2013) in cowpea.

Table 3.The effect of the duration of weed interference on weed cover score, weed density and weed dry weight in 2016 and 2017.

	Weed cover score		Weed density (no m^{-2})		Weed dry weight (kg ha^{-2})	
	2016	2017	2016	2017	2016	2017
WR3	8.2	8.7	45.6	64.3	3024	3697
WR6	5.2	6.5	30.3	32.3	1400	2213
WR9	4.2	5.5	25.8	30.7	1413	2127
WI3	3.1	4.4	26.7	29.0	1863	2677
WI6	3.3	4.5	50.5	56.9	3033	3847
WI9	8.1	6.4	55.7	57.1	3117	3897
WIH	8.9	8.5	56.5	58.6	3410	3813
Lsd ($p<0.05$)	0.33	0.82	7.9	8.2	468.5	480.4

WR3 – Weed removal until 3 weeks, WR6 – Weed removal until 6 weeks, WR6 – Weed removal until 9 weeks, WI3 – Weed interference until 3 weeks, WI6 – Weed interference until 6 weeks, WI9 – Weed interference until 9 weeks, WIH – Weed interference until harvest, Lsd – Least significant difference.

The effect of the duration of weed interference on the growth and yield of soybean

Duration of weed interference had a significant effect on all the growth and yield parameters of soybean in 2016 and 2017 (Tables 4 and 5). Canopy height, number of leaves and branches, crop vigour, leaf area index, dry weight, crop growth rate, number of pods and seeds per plant, 100-seed weight, pod and seed weight per plant and grain yield of soybean were similar between plots where weeds were allowed to grow until 3 WAS only (WI3) and where weeds were controlled until harvest (WRI) in both years (Tables 4 and 5). This showed that weed infestation for only 3 WAS had no detrimental effect on soybean growth and yield probably because weeds were not yet well established and hence reduced competitiveness at this time. Only grass weed seedlings and few annual broad-leaved weeds were present at this initial stage of crop growth. Such weeds, with an only rudimentary root system and few leaves, could not compete vigorously with the crop. This result is contrary to the report of Periera et al. (2015) that weed infestation from 7 days after emergence was detrimental to soybean grain yield in a study conducted in Brazil, where the main infesting weed species were *Digitaria* *horizontalis* and *Ipomea grandifolia*. Such difference in the effect of weed interference on soybean grain yield in the present study may be due to differences in soybean cultivars, locations, soil types, infesting weed species, soil moisture regimes and prevailing agro-climatic conditions. Our results, however, corroborate the previous findings of Osipitan et al. (2013) and Adigun et al. (2017) who reported that weed infestation for the first 3 WAS did not have any adverse effects on crop yield in a study conducted in the forest-savanna transition agro-ecological zone of Nigeria.

Table 4.The effect of the duration of weed interference on soybean growth in 2016 and 2017.

	Crop vigour score		Canopy height (cm)		Number of branches		Number of leaves		Leaf area index		Dry weight (g/plant)		Crop growth rate	
	2016	2017	2016	2017	2016	2017	2016	2017	2016	2017	2016	2017	2016	2016
Duration of weed interference														
WR3	4.6	3.6	86.6	84.0	6.4	6.3	16.0	14.6	2.01	2.03	27.4	27.0	0.34	0.33
WR6	7.7	7.8	97.2	94.5	8.3	7.6	33.0	31.6	3.18	3.08	40.1	39.4	0.54	0.52
WR9	7.8	7.5	99.6	96.0	8.4	7.9	33.0	31.6	3.15	3.05	41.5	41.8	0.53	0.52
WRH	8.1	7.6	100.2	98.5	8.3	7.6	33.3	32.0	3.15	3.03	40.2	39.7	0.55	0.54
WI3	6.3	5.6	98.3	96.6	8.3	7.7	29.0	27.6	2.91	2.43	40.5	40.1	0.56	0.54
WI6	5.5	5.0	86.4	84.7	7.0	6.6	20.3	19.0	2.12	2.13	28.7	23.1	0.34	0.33
WI9	4.7	4.2	81.8	79.2	6.6	6.3	14.0	12.6	2.10	2.04	26.8	25.2	0.33	0.33
WIH	4.4	3.8	83.3	80.6	6.7	6.1	13.0	11.7	2.04	2.06	27.2	25.0	0.32	0.34
Lsd ($p<0.05$)	0.32	0.43	5.82	5.74	0.43	0.37	4.3	4.6	0.17	0.18	2.2	2.6	0.06	0.06

WR3 – Weed removal until 3 weeks, WR6 – Weed removal until 6 weeks, WR6 – Weed removal until 9 weeks, WRH – Weed removal until harvest, WI3 – Weed interference until 3 weeks, WI6 – Weed interference until 6 weeks, WI9 – Weed interference until 9 weeks, WIH – Weed interference until harvest, Lsd – Least significant difference.

In this study, allowing weeds to grow until 6 WAS (WI6) or longer resulted in a significant reduction in all the growth and yield parameters of soybean compared to plots where weeds were controlled until the harvest (WRH) (Tables 4 and 5). The number of leaves of soybean was reduced by 38–40% with increasing duration of weed interference until 6 WAS (WI6) and by 57–63% with increasing duration of weed interference until 9 WAS (WI9) compared to the weed-free treatment. Similarly, crop vigour was reduced by 31–34% with increasing duration of weed interference until 6 WAS (WI6) and by 42–45% with increasing duration of weed interference until 9 WAS (WI9) compared to the weed-free treatment in both years. Weed interference until 6 WAS (WI6) reduced the number of branches by 13–20%, leaf area index by 32–35%, dry weight of soybean by 29–40% and the crop growth rate by 37–42% compared to the weed-free treatment in both years. Allowing the weeds to remain in the plots until 6 WAS (WI6) or longer reduced the number of pods by 52–60%, number of seeds by 25–29%, 100-seed weight by 13–16%, pod weight by 43–50%, seed weight by 28–39% and grain yield of soybean by 49–56%. Rapid weed growth occurred between 3 and 6 weeks after sowing. Hence, the reduction in growth and yield observed may be attributed to increased weed competition for growth resources. The previous findings of Khaliq et al. (2012) have shown that there is limited use of resources (moisture, light and nutrients) for crop growth and yield as a result of increased weed competition. Our result also corroborates the report of Mohammadi and Amiri (2011) that increasing the period of weed interference resulted in a drastic yield reduction. In this study, the number of pods per plant was the yield component most affected by weed interference, while the number of seeds per pod was not affected by season-long weed interference. This result is similar to that of Van Acker et al. (1993). It is possible that the reduction in the number of branches due to weed interference resulted in the reduced number of soybean pods per plant, whereas the number of seeds per pod was maintained.

Table 5.The effect of the duration of weed interference on yield and yield components of soybean in 2016 and 2017.

	Number of pods/plant		Number of seeds/plant		Numberof seeds/pod		Pod weight		100-seed weight		Seed weight		Seed yield	
							Kg ha^{-1}							
Treatments	2016	2017	2016	2017	2016	2017	2016	2017	2016	2017	2016	2017	2016	2017
Weed interference														
WR3	63.8	61.0	216.0	170.5	2.7	2.7	19.4	17.2	8.8	8.6	16.3	14.8	1103	1079
WR6	123.5	104.4	277.1	201.6	2.8	2.4	29.2	29.0	10.4	10.0	25.2	21.2	2322	2038
WR9	120.6	101.7	267.2	196.9	2.8	2.3	27.7	24.0	10.4	9.8	24.5	20.5	2358	2056
WRH	122.5	102.2	260.4	191.1	2.8	2.3	28.9	26.6	10.3	9.8	24.3	20.4	2389	2103
WI3	119.9	102.0	255.0	190.9	2.6	2.3	29.5	27.7	10.1	9.9	23.8	19.8	2312	1901
WI6	53.8	51.1	182.3	149.2	2.7	2.4	16.9	16.0	8.8	8.7	16.2	15.3	1299	1019
WI9	53.5	50.1	144.2	142.1	2.6	2.3	16.5	16.5	8.7	8.5	15.6	14.2	1187	979
WIH	49.3	48.6	142.4	143.2	2.8	2.4	14.8	16.4	8.5	8.6	15.3	14.3	1148	888
Lsd ($p<0.05$)	4.7	3.0	15.1	12.1	3.6ns	1.9ns	2.2	1.6	0.4	0.2	1.8	1.8	153.2	134.8

WR3 – Weed removal until 3 weeks, WR6 – Weed removal until 6 weeks, WR6 – Weed removal until 9 weeks, WRH – Weed removal until harvest, WI3 – Weed interference until 3 weeks, WI6 – Weed interference until 6 weeks, WI9 – Weed interference until 9 weeks, WIH – Weed interference until harvest, Lsd – Least significant difference.

In this study, weed removal for only 3 WAS did not increase all the growth and yield parameters of soybean significantly compared with crops weed-infested until the harvest (WIH) in both years (Tables 4 and 5). However, weed removal until 6 WAS (WR6) or longer resulted in a significant increase in soybean growth and yield compared to weed interference until 6 WAS (WI6) or beyond (Tables 4 and 5). Allowing weeds to remain in the crops until 6 WAS (WI6) and subsequently removing the weeds did not obviate growth and yield depression of the crop compared to crops weed-infested until the harvest. Weed density and dry matter in plots where weeds were allowed to remain in the crop until 6 WAS did not differ significantly from those where weeds were allowed to remain in the plots until 9 WAS or throughout the crop life cycle. Hence, their subsequent removal was therefore not expected to alleviate crop growth. On the other hand, weed removal until the harvest (WRH) did not improve all the growth and yield parameters of soybean significantly compared to weed removal for only 6 or 9 WAS in both years. This was probably a result of soybean canopy closure which could have limited light penetration to weeds emerging below the leaves thereby reducing late-season weed competition and giving the crop a competitive advantage over weeds coming later in the seasons (Steckel and Sprague, 2004). These results are similar to the previous findings of Imoloame (2014), who reported that if weeds were controlled within the first 5 weeks after sowing, the canopy of soybean can suppress late-emerging weeds.

Our study has shown that soybean can tolerate weed infestation until 3 WAS and beyond 6 WAS without causing any significant reduction in soybean growth and yield compared to crops kept weed-free until the harvest. Hence, weed removal between 3 and 6 weeks after sowing was sufficient to maintain maximum grain yield. This period coincided with the period of maximum weed growth and the most significant difference in leaf area index and dry matter production between weed-infested and weed-free soybean. This suggests that the leaf area index and dry matter production are indicators of the detrimental effect of weed interference on soybean grain yield.

Conclusion

The results of this study have shown that soybean can tolerate weed infestation until 3 WAS and beyond 6 WAS without causing any significant reduction in growth and yield compared to crops kept weed-free until harvest. Hence, weed removal between 3 and 6 weeks after sowing was sufficient to maintain maximum grain yield. This period coincided with the period of maximum weed growth and the most significant difference in leaf area index and dry matter production between weed-infested and weed-free soybean. This suggests that the leaf area index and dry matter production are indicators of the detrimental effect of weed interference on soybean grain yield. The establishment of maximum leaf area index and good branching ability could enhance soybean competitiveness against weeds. However, weed removal between 3 and 6 weeks after sowing is crucial for optimum grain yield.

References

Abate, T., Alene, A., & Bergvinson, B. (2012). *Tropical Grain Legumes in Africa and South Asia: Knowledge and Opportunities*. Nairobi, Kenya: ICRISAT.

Adigun, J.A., Daramola, O.S., Adeyemi, O.R., Olorunmaiye, P.M., Osipitan, O.A., & Idiodemise, O. (2017). Effects of Row-Spacing and Period of Weed Interference on Growth and Yield of Cowpea (*Vigna unguiculata* (L.) Walp). *Nigerian Journal of Ecology*, *16* (2), 88-100.

Adigun, J.A., Daramola, O.S., Adeyemi, O.R., Olorunmaiye, P.M., & Osipitan, O.A. (2018). Nitrogen and weed management in transplanted tomato in the Nigerian forest-savanna transition zone. *Annals of Agrarian Science*, *16,* 281-285.

Adigun, J.A., Adeyemi, O.R., Daramola, O.S., & Olorunmaiye, P.M. (2020). Response of cowpea to inter-row spacing and weed competition. *Agricultura Tropica et Subtropica*, *53* (2), 73-79.

Chikoye, D., Ellis-Jones, J., Riches, C., & Kanyomeka, L. (2007). Weed management in Africa: experiences, challenges and opportunities. XVI International Plant Protection Congress. (pp. 652-653). Glassgow, Scotland, UK

Daramola, O.S., Adeyemi, O.R., Adigun, J.A., & Adejuyigbe, C.O. (2019). Economics of row spacing and integrated weed management in soybean. *Journal of Agricultural Sciences (Belgrade)*, *64* (3), 265-278.

Daramola, O.S., Adeyemi, O.R., Adigun, J.A., & Adejuyigbe, C.O. (2020). Weed interference and control as affected by row spacing in the transition zone of south west Nigeria. *Journal of Crop Improvement*, *34* (1), 103-121.

Hunt, R. (1978). *Plant Growth Analysis*. Edward Arnold, London.

Imoloame, E.O. (2014). The effects of different weed control methods on weed infestation, growth and yield of soybeans (*Glycine max* (L) Merrill) in the southern guinea savanna of Nigeria. *Agro search*, *14* (2), 129-143.

Joubert, J.C.N., & Jooste, A.A. (2013). Comparative analysis of different regions of South Africa Soybean industry.*Proceedings of the World Soybean Research Conference IX,* (pp. 1-11). Urban, South Africa.

Khaliq, A.A., Matloob, S., Mahmood, R.N., Abbas, M.B., & Khan, K. (2012). Seeding density and herbicide tank mixture furnishes better weed control and improve the growth, yield and quality of direct seeded fine rice. *International Journal of Agricultural Biology*, *14*, 499-508.

Khojely, D.M., Ibrahim, S.E., Sepey, E., & Han, T. (2018). History, current status, and prospect of soybean production and research in sub-Saharan Africa. *The crop Journal*, *6*, 226-235

Knezevic, S.Z., Evans, S.P., Blankenship, E.E., Van Acker, R.C., & Lindquist, J.L. (2002). Critical period for weed control: the concept and data analysis. *Weed Science*, *50*, 773-786.

Knezevic, S.Z., Evans, S.P., & Mainz, M. (2003). Row spacing influences the critical timing for weed removal in soybean (*Glycine max*) *Weed Technology*, *17* (4), 666-673.

Labrada, R. (2003). The need for improved weed management in rice. In: Van Tran, Dat, Duffy, R. (Eds.), Sustainable Rice Production for Food Security 2003. *Proceedings of the 20th Session of the International Rice Commission Bangkok, Thailand*. (pp. 1-11). FAO, Rome, Italy.

Mohammadi, G.R., & Amiri, F. (2011). Critical period of weed control in soybean (*Glycine max*) as influenced by starter fertilizer. *Australian Journal of Crop Science*, *5* (11), 1350-1355

Nikoa, R.M., Owen, D.K., & Swanton, C.J. (2015). Weed Abundance, Distribution, Diversity, and Community Analyses. *Weed Science*, *63*, 64-90.

Oerke, E.C., & Dehne, H.W. (2004). Safeguarding production-losses in major crops and the role of crop protection. *Crop Production*, *23*, 275-285.

Osipitan, O.A., Adigun, J.A., Lagoke, S.T.O., & Afolami, S.O. (2013). Effect of inter-row spacing and weed control methods on growth and yield of cowpea (*Vigna unguiculata* L. Walp) in South Western Nigeria. *Nigeria Journal of Plant Protection*, *27*, 97-111.

Periera, F.A.R., Bono, J.A.M., Neto, J.F.R., Silveira, D.S., Berselli, C., & Carvalho, T. (2015). Period of competition between weeds and soybean crop in Cerrado. *African Journal of Agricultural Research, 10* (37), 3644-3649.

Ronner, E., Franke, A.C., Vanlauwe, B., Diande, M., Edeh, E., Ukem, B., Bala, A., Van Heerwaarden, J., & Giller, K.E. (2016). Understanding variability in soybean yield and response to P-fertilizer and rhizobium inoculants on farmers' field in northern Nigeria, *Field Crop Research*, *186*, 33-145.

Steckel, L.E., & Sprague, C.L. (2004). Late season common water hemp (*Amaranthus rudis*) interference in narrow- and wide-row soybean. *Weed Technology*, *18,* 947-952.

Suryanto, P., Sulistyaningsih, E., Putra, E.T.S., Kastono, D., & Taufan, A. (2017). Estimation of critical period for weed control in soybean on agro-forestry system with kayu Putih. *Asian Journal of Crop Science, 9* (3), 91-105.

Tefera, H. (2011). Breeding for promiscuous soybean at IITA, In: A. Sudaric (Ed.), *Soybean-Molecular Aspect of Breeding*, In Tech, Rijeka, Croatia.

Van Acker, R.C., Weise, S.F., & Swanton, C.J. (1993). Influence of interference from mixed weed species on soybean (*Glycine max* (L.) Merr.) growth. *Canadian Journal of plant Science, 73*, 1293-1304.

Vitorino, H.S, Silva, A.C., Gonçalves, C.G., & Martins, G. (2017). Interference of a weed community in the soybean crop in functions of sowing spacing. *Revista Ciência Agronômica*, *48* (4), 605-613.

Watson, D.J. (1947). Comparative physiological studies in the growth of field crops. I. Variation in net assimilation rate and leaf area between species and varieties, and within and between years. *Annals of Botany*, *11*, 41-76.

Received: August 29, 2019
Accepted: July 2, 2020

UTICAJ DUŽINE PRISUSTVA KOROVA NA RAST I PRINOS SOJE (*GLYCINE MAX* L. MERRILL)

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R e z i m e

Poljski ogledi su sprovedeni kako bi se ocenio uticaj različite dužine prisustva korova na zakorovljenost, rast i prinos soje u 2016. i 2017. sezoni gajenja. Tokom obe godine, prinosi zrna soje kretali su se od 888–1148 kg ha^{-1} u parcelama gde su korovi bili prisutni do žetve soje, do 2103–2389 kg ha^{-1} u parcelama gde su korovi kontrolisani do žetve, ukazujući na gubitak prinosa od 52% do 58% pri nekontrolisanom rastu korova. Prisustvo korova do 3 nedelje posle setve nije štetno uticalo na rast i prinos soje pod uslovom da su korovi naknadno suzbijeni. Međutim, dalje odlaganje uklanjanja korova do 6 nedelja posle setve ili duže smanjilo je rast soje i vodilo do nepovratnog smanjenja prinosa, sa brojem mahuna po biljci kao najviše pogođenoj komponenti prinosa. Za optimalni rast i prinos, neophodno je da se korovi uklone između 3 i 6 nedelja posle setve.

Ključne reči: uklanjanje korova, kompeticija korova, okopavanje, kritični period, prinos soje.

Primljeno: 29. avgusta 2019.
Odobreno: 2. jula 2020.

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Journal of Agricultural Sciences (Belgrade) https://doi.org/10.2298/JAS2003239M
Vol. 65, No. 3, 2020 UDC: 634.21:631.547.4(497.11)
Pages 239-249 Original scientific paper

FENOLOGIJA CVETANJA SORTI KAJSIJE NA PODRUČJU BEOGRADA

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Sažetak: Fenologija cvetanja proučavana je kod 50 sorti kajsije na području Beograda u periodu od osam godina (2009–2016). U okviru fenofaze cvetanja registrovane su tri potfaze: početak cvetanja, puno cvetanje i kraj cvetanja. Pored toga, ispitivani su trajanje i obilnost cvetanja. Prosečan datum početka cvetanja za sve sorte bio je 22. mart, punog cvetanja 25. mart, a kraja cvetanja 1. april. Prosečno trajanje cvetanja je bilo 9,7 dana, sa variranjem po sortama od 7,5 dana (Gergana) do 12 dana (Ninfa i Radka). Najmanju prosečnu ocenu (3,0) za obilnost cvetanja dobila je sorta Mađarska najbolja, a najvišu ocenu (4,6) sorte Harkot i Leskora. U godinama sa višim temperaturama u toku fenofaze cvetanja registrovan je manji raspon u vremenu cvetanja sorti, kao i kraće trajanje cvetanja. Na osnovu početka cvetanja, ispitivane sorte su podeljene u tri grupe: ranocvetne (14 sorti), srednjecvetne (21 sorta) i poznocvetne (15 sorti). Na tok i trajanje fenofaze cvetanja veći uticaj su imali meteorološki faktori (temperatura vazduha), nego genetičke osobine sorti.

Ključne reči: *Prunus armeniaca*, početak cvetanja, puno cvetanje, trajanje cvetanja, obilnost cvetanja, temperatura.

Uvod

Cvetanje je kritična fenofaza u godišnjem ciklusu razvoja kajsije od koje u najvećoj meri zavisi njena rodnost. Kajsija se odlikuje ranim cvetanjem. Među kontinentalnim voćkama, ona cveta posle leske i badema, a pre breskve i trešnje. Pored naslednih karakteristika sorte, na vreme cvetanja utiču i vremenske prilike pred cvetanje i u toku cvetanja. Ukoliko su temperature više, cvetanje počinje ranije i traje kraće (Milatović, 2013).

Kajsija ima kratko i nestabilno duboko (biološko) zimsko mirovanje, čije je trajanje uslovljeno naslednim karakteristikama sorti. Ruml et al. (2018) su utvrdili da se duboko zimsko mirovanje kajsije u beogradskom području, u zavisnosti od

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sorte, završava u periodu od početka januara do sredine februara. Nakon ovog perioda nastupa prinudno (ekološko) mirovanje koje je uslovljeno niskim temperaturama. Period od desetak dana sa temperaturama iznad 10°C može dovesti do ulaska u period vegetacije, odnosno do početka cvetanja. Rano cvetanje izlaže kajsiju riziku od pojave prolećnih mrazeva i osnovni je razlog njene neredovne rodnosti. S obzirom na to, poznavanje fenofaze cvetanja je veoma značajno za izbor lokaliteta za gajenje kajsije, kao i za izbor sorti za gajenje u određenom području.

Kod kajsije je registrovan veliki broj samobesplodnih (autoinkompatibilnih) sorti, posebno kod novostvorenih sorti iz oplemenjivačkih programa u Evropi i Severnoj Americi (Burgos et al., 1997; Milatović i Nikolić, 2007; Milatović et al., 2013). Pored toga, postoji veliki broj interinkompatibilnih grupa sorti (Halász et al., 2010). S obzirom na to, poznavanje fenofaze cvetanja je značajno i za određivanje sortne kompozicije u zasadu, odnosno izbora adekvatnih oprašivača.

Ispitivanjem fenofaze cvetanja kod 42 sorte kajsije u periodu od 10 godina u beogradskom području, Milatović (2005) je utvrdio da se ona prosečno dešava u trećoj dekadi marta i da traje u proseku 10,2 dana. Razlika između sorti sa najranijim i najkasnijim vremenom cvetanja bila je relativno mala i prosečno je iznosila 10 dana. U zemljama sa toplijom klimom, kao što su Italija i Španija, ova razlika je znatno veća i može biti više od mesec dana (Ruiz i Egea, 2008). Nasuprot tome, u zemljama sa hladnijom klimom razlika u vremenu cvetanja sorti je manja. Na primer, u Mađarskoj, ona prosečno iznosi 4–5 dana (Szabó et al., 2003), a u Češkoj 3–9 dana (Vachůn, 2003).

Cilj ovog rada je bio da se kod većeg broja sorti kajsije u beogradskom području ispita fenologija cvetanja. Dobijeni rezultati značajni su za izbor sorti za gajenje, kao i za izbor odgovarajuće sortne kompozicije u zasadima kajsije.

Materijal i metode

Fenologija cvetanja je ispitivana u kolekcionom zasadu kajsije na Oglednom dobru „Radmilovac" Poljoprivrednog fakulteta u Beogradu u periodu od osam godina (2009–2016). Ogledni zasad je podignut 2007. godine, podloga je sejanac džanarike (*Prunus cerasifera* Ehrh.), a razmak sadnje je 4,5 × 3 m. U zasadu su primenjivane standardne agrotehničke mere, bez navodnjavanja. Ispitivanjem je obuhvaćeno 50 sorti kajsije. Svaka sorta je zastupljena u zasadu sa po pet stabala.

Cvetanje je registrovano prema preporukama Međunarodne radne grupe za polinaciju (Wertheim, 1996): početak cvetanja – kada se otvori 10% cvetova, puno cvetanje – kada se otvori 80% cvetova, a kraj cvetanja – kada otpadne 90% kruničnih listića. U radu su prikazani prosečni datumi početka cvetanja, punog cvetanja i kraja cvetanja, kao i prosečno trajanje cvetanja u danima za period od osam godina. Obilnost cvetanja ocenjivana je na skali od 0 (bez cvetova) do 5 (obilno cvetanje) i prikazani su prosečni rezultati za osmogodišnji period.

Podaci o temperaturama vazduha dobijeni su sa automatske meteorološke stanice „MeteosCompact" (Pessl Instruments GmbH, Austria) koja se nalazi na OD „Radmilovac". Između raspona cvetanja sorti za pojedine potfaze (početak cvetanja i puno cvetanje), kao i dužine trajanja cvetanja, s jedne strane i temperature vazduha u odgovarajućim vremenskim periodima, s druge strane, izračunati su odgovarajući koeficijenti korelacije. Statistička značajnost koeficijenata korelacije je testirana pomoću t-testa za verovatnoće 0,05 i 0,01.

Rezultati i diskusija

Cvetanje kajsije na području Beograda prosečno se odvijalo u drugoj polovini marta i početkom aprila (tabela 1). Prosečan datum početka cvetanja za sve sorte bio je 22. mart. Najraniji početak cvetanja utvrđen je kod sorti Ninfa i Vitillo (17. marta), a najkasniji kod sorte Čudovij (27. marta).

Između godina ispitivanja utvrđeno je veliko variranje u pogledu početka cvetanja. Najranije cvetanje kod svih sorti bilo je 2014. godine, kada je prosečan datum početka cvetanja bio 8. mart. Sorte Ninfa i Vitillo su u ovoj godini cvetale najranije, 24. februara. Najkasniji početak cvetanja je bio 2009. godine, kada je prosečan datum početka cvetanja za sve sorte bio 2. april. U ovoj godini, sorte Čudovij i NS-6 su imale najkasniji početak cvetanja (4. aprila).

Tabela 1. Datumi pojedinih faza cvetanja sorti kajsije na području Beograda (2009–2016. godine).
Table 1. Dates of certain flowering phases of apricot cultivars in the Belgrade region (2009–2016).

Sorte *Cultivars*	Početak cvetanja *The beginning of flowering*			Puno cvetanje *Full flowering*	Kraj cvetanja *End of flowering*
	Prosečno *Average*	Najranije *The earliest*	Najkasnije *The latest*		
Aurora	19. mart	28. februar	1. april	23. mart	30. mart
Bella d'Imola	20. mart	2. mart	1. april	23. mart	30. mart
Bergarouge	22. mart	8. mart	1. april	25. mart	31. mart
Bergeron	21. mart	2. mart	1. april	25. mart	1. april
Betinka	22. mart	7. mart	1. april	25. mart	31. mart
Candela	21. mart	8. mart	1. april	24. mart	30. mart
Cegledi Arany	26. mart	16. mart	3. april	29. mart	4. april
Čudovij	27. mart	16. mart	4. april	30. mart	4. april
Dacia	24. mart	13. mart	2. april	27. mart	1. april
Dunstan	20. mart	1. mart	1. april	24. mart	30. mart
Forum	26. mart	16. mart	2. april	28. mart	4. april
Gergana	23. mart	12. mart	3. april	26. mart	31. mart
Goldrich	19. mart	1. mart	31. mart	23. mart	30. mart

Tabela 1. Nastavak.
Table 1. Continued.

Sorte *Cultivars*	Početak cvetanja *The beginning of flowering*			Puno cvetanje *Full flowering*	Kraj cvetanja *End of flowering*
	Prosečno *Average*	Najranije *The earliest*	Najkasnije *The latest*		
Harcot	22. mart	8. mart	1. april	25. mart	31. mart
Hargrand	21. mart	4. mart	1. april	25. mart	30. mart
Harlayne	23. mart	9. mart	3. april	26. mart	1. april
Harogem	20. mart	4. mart	1. april	24. mart	30. mart
Harojoy	22. mart	8. mart	2. april	26. mart	1. april
Harostar	21. mart	8. mart	1. april	25. mart	31. mart
Laycot	19. mart	2. mart	1. april	23. mart	30. mart
Lebela	23. mart	13. mart	1. april	27. mart	2. april
Legolda	22. mart	7. mart	2. april	26. mart	1. april
Leskora	23. mart	10. mart	1. april	27. mart	2. april
Mađarska najbolja C235	24. mart	13. mart	3. april	27. mart	2. april
Mari de Cenad	24. mart	12. mart	3. april	26. mart	1. april
Marlen	24. mart	14. mart	3. april	27. mart	2. april
Neptun	24. mart	14. mart	2. april	28. mart	3. april
Ninfa	17. mart	24. februar	30. mart	22. mart	29. mart
Novosadska rodna	25. mart	15. mart	2. april	28. mart	3. april
NS-4	25. mart	12. mart	3. april	27. mart	2. april
NS-6	24. mart	13. mart	4. april	27. mart	2. april
Orangered	22. mart	6. mart	2. april	25. mart	1. april
Pinkcot	20. mart	1. mart	1. april	24. mart	1. april
Pisana	24. mart	13. mart	3. april	27. mart	2. april
Portici	19. mart	1. mart	1. april	23. mart	30. mart
Radka	20. mart	3. mart	1. april	24. mart	1. april
Robada	20. mart	2. mart	1. april	24. mart	30. mart
Roxana	25. mart	14. mart	3. april	28. mart	3. april
Silvercot	22. mart	6. mart	2. april	25. mart	31. mart
Sophia	22. mart	9. mart	1. april	24. mart	30. mart
Stark Early Orange	21. mart	9. mart	31. mart	24. mart	31. mart
Strepet	21. mart	6. mart	1. april	24. mart	1. april
Sylred	20. mart	3. mart	1. april	24. mart	1. april
Tomcot	21. mart	27. februar	2. april	25. mart	1. april
Veecot	19. mart	1. mart	31. mart	23. mart	29. mart
Velvaglo	21. mart	7. mart	2. april	24. mart	31. mart
Veselka	24. mart	13. mart	2. april	27. mart	3. april
Vesprima	26. mart	15. mart	3. april	29. mart	3. april
Vestar	22. mart	6. mart	2. april	25. mart	1. april
Vitillo	17. mart	24. februar	30. mart	20. mart	28. mart
Prosečno/*Average*	22. mart	8. mart	2. april	25. mart	1. april

Raspon između sorti sa najranijim i najkasnijim početkom cvetanja je bio mali i prosečno je iznosio 10 dana, dok je po godinama varirao od 5 do 20 dana, što je u skladu sa rezultatima ranijih istraživanja (Đurić, 1990; Szabó et al., 2003; Vachůn, 2003; Milatović, 2005; Ezzat et al., 2012; Gorina et al., 2016).

Posmatrano po godinama, variranje datuma početka cvetanja je bilo znatno više izraženo u poređenju sa sortama. Razlika između godine sa najranijim cvetanjem (2014) i godine sa najkasnijim cvetanjem (2009) je bila u proseku 25 dana, a po sortama je varirala od 17 do 34 dana. Iz dobijenih rezultata se može zaključiti da na početak cvetanja više utiču meteorološki faktori (prvenstveno temperatura vazduha), nego genetičke osobine sorti. Ovo je u skladu sa rezultatima koje su dobili Legave i Clauzel (2006) na osnovu višegodišnjeg proučavanja fenofaze cvetanja sorti kajsije u Francuskoj.

Naši rezultati o rasponu variranja cvetanja po godinama i sortama su u skladu sa literaturnim. Szabó i Nyéki (1999) navode da je u Mađarskoj variranje amplitude cvetanja između sorti 4–12 dana, dok između godina ona može biti i do 40 dana. Vachůn (2003) je proučavao fenologiju cvetanja kod 20 sorti kajsije u Češkoj u periodu od šest godina i utvrdio raspone variranja početka cvetanja između sorti 3–9 dana, a između godina 21–29 dana. Milatović (2005) je u uslovima Beograda u periodu od 10 godina ustanovio prosečnu amplitudu variranja početka cvetanja između sorti 5–19 dana, dok je amplituda između godina sa najranijim i najkasnijim cvetanjem bila znatno veća (47–51 dan).

Prosečan datum punog cvetanja za sve ispitivane sorte bio je 25. mart, sa variranjem između sorti u intervalu od 20. do 30. marta. Prosečan datum kraja cvetanja bio je 1. april, sa variranjem među sortama od 28. marta do 4. aprila.

Pozno vreme cvetanja je značajan cilj u oplemenjivanju kajsije (Krška, 2018). To je poželjna osobina, jer smanjuje rizik od prolećnih mrazeva. Najpoznijim vremenom cvetanja su se odlikovale introdukovane sorte Čudovij, Cegledi Arany, Vesprima, Forum, Roxana, kao i domaće sorte NS-4, NS-6 i Novosadska rodna.

U vreme cvetanja kajsije često se javljaju nepovoljni vremenski uslovi za let pčela, kao što su niže temperature (ispod 10°C), kiša i vetar koji sprečavaju let pčela i otežavaju oprašivanje. Zbog toga je duže trajanje cvetanja poželjna osobina, koja povećava mogućnost za uspešno oprašivanje. Cvetanje ispitivanih sorti prosečno je trajalo 9,7 dana (tabela 2). Najkraće cvetanje (prosečno 7,5 dana) je imala sorta Gergana. S druge strane, najduže cvetanje (12 dana) su imale sorte Ninfa i Radka. Pored njih, dužim cvetanjem (više od 11 dana) odlikovale su se i sorte Pinkcot, Goldrich, Sylred, Portici, Strepet i Aurora.

Posmatrano po godinama, najkraće cvetanje za većinu sorti bilo je 2009. godine – prosečno 5,3 dana, sa variranjem po sortama 4–7 dana. Najduže cvetanje kod većine sorti registrovano je 2013. godine – prosečno 14,0 dana, sa variranjem po sortama 11–20 dana.

Naši rezultati o trajanju cvetanja sorti kajsije su slični podacima koje navode drugi autori (Szalay et al., 2000; Rahović, 2002). U poređenju sa rezultatima koje je dobio Milatović (2005) na istom lokalitetu za 42 sorte kajsije u periodu od 10 godina (1995–2004) cvetanje je bilo nešto kraće (9,7 dana u poređenju sa 10,2 dana). To se može objasniti porastom srednjih dnevnih temperatura tokom fenofaze cvetanja u kasnijem periodu.

Tabela 2. Trajanje i obilnost cvetanja sorti kajsije na području Beograda (2009–2016. godine).
Table 2. Flowering duration and abundance of apricot cultivars in the Belgrade region (2009–2016).

Sorte *Cultivars*	Trajanje cvetanja (dani) *Flowering duration (days)*			Obilnost cvetanja Ocena (skala 0–5) *Flowering abundance Score (0–5 scale)*
	Prosečno *Average*	Najkraće *The shortest*	Najduže *The longest*	
Aurora	11,1	6	17	3,2
Bella d'Imola	10,0	5	17	3,6
Bergarouge	9,4	5	15	4,0
Bergeron	10,3	6	15	3,7
Betinka	9,6	6	14	3,3
Candela	9,4	5	15	3,7
Cegledi Arany	8,5	4	13	3,2
Čudovij	8,5	4	14	4,3
Dacia	8,5	5	15	3,9
Dunstan	10,4	5	17	4,4
Forum	9,6	5	16	4,3
Gergana	7,5	4	11	3,4
Goldrich	11,5	5	20	4,2
Harcot	9,5	6	14	4,6
Hargrand	9,1	5	14	3,6
Harlayne	8,9	4	13	4,4
Harogem	10,0	5	18	4,1
Harojoy	10,1	5	15	4,5
Harostar	9,8	5	14	3,5
Laycot	11,0	5	18	4,2
Lebela	9,9	5	14	4,5
Legolda	9,8	5	14	3,9
Leskora	9,8	6	15	4,6
Mađarska najbolja C235	8,4	4	13	3,0
Mari de Cenad	8,0	4	12	3,1
Marlen	8,1	5	13	3,4
Neptun	10,1	6	16	4,3
Ninfa	12,0	7	19	3,6

Tabela 2. Nastavak.
Table 2. Continued.

Sorte *Cultivars*	Trajanje cvetanja (dani) *Flowering duration (days)* Prosečno *Average*	Najkraće *The shortest*	Najduže *The longest*	Obilnost cvetanja Ocena (skala 0–5) *Flowering abundance Score (0–5 scale)*
Novosadska rodna	8,6	6	12	3,8
NS-4	8,4	6	11	3,8
NS-6	8,5	4	13	3,8
Orangered	9,6	5	14	3,9
Pinkcot	11,8	6	17	4,3
Pisana	8,6	4	12	3,5
Portici	11,3	6	17	4,5
Radka	12,0	6	18	3,4
Robada	10,3	5	17	3,2
Roxana	8,9	4	13	4,1
Silvercot	9,4	5	14	3,8
Sophia	8,8	5	13	3,6
Stark Early Orange	9,6	5	14	4,4
Strepet	11,3	5	17	4,1
Sylred	11,4	6	16	4,1
Tomcot	10,5	5	17	3,4
Veecot	10,9	5	17	3,9
Velvaglo	9,9	5	15	3,8
Veselka	10,0	6	16	3,4
Vesprima	8,8	5	14	3,3
Vestar	9,6	5	14	3,8
Vitillo	11,0	6	18	3,6
Prosečno/*Average*	9,7	5,1	15,4	3,8

Najmanju prosečnu ocenu (3,0) za obilnost cvetanja dobila je sorta Mađarska najbolja, a najvišu ocenu (4,6) sorte Harcot i Leskora. Najmanja obilnost cvetanja bila je u 2009. godini (prosečna ocena za sve sorte 3,2), što se može objasniti time što su tada stabla imala starost od tri godine, odnosno to je bila praktično prva godina rodnosti. Najveća obilnost cvetanja bila je u 2010. i 2016. godini (sa prosečnim ocenama za sve sorte 4,6 odnosno 4,5). To se može objasniti povoljnim uslovima za diferenciranje cvetnih pupoljaka u prethodnim godinama.

Odnos između trajanja pojedinih potfaza cvetanja i njihovog raspona među sortama kajsije, s jedne strane, i odgovarajućih temperatura, s druge strane, prikazan je u tabeli 3.

U godinama sa višim srednjim dnevnim temperaturama (iznad 12°C) u toku fenofaze cvetanja (što je bio slučaj u periodu 2009–2012. godine) raspon između sorti sa najranijim i najkasnijim cvetanjem bio je relativno mali: 3–7 dana za početak cvetanja, odnosno 3–6 dana za puno cvetanje. Nasuprot tome, u godinama sa nižim temperaturama (ispod 10°C) u toku cvetanja (kao što je bio slučaj u periodu 2013–2016. godine) ovaj raspon je bio značajno veći: 12–20 dana za početak cvetanja i 13–17 dana za puno cvetanje. To potvrđuju i visoke vrednosti koeficijenata korelacije dobijene za ove periode i odgovarajuće temperature (r=-0,91 za početak cvetanja, odnosno r=-0,92 za puno cvetanje). Takođe, vrlo visok i statistički značajan koeficijent korelacije (r=-0,97) utvrđen je između ukupnog trajanja cvetanja i prosečne temperature u toku cele fenofaze cvetanja.

Tabela 3. Raspon cvetanja sorti kajsije u određenim fenofazama, prosečne dnevne temperature vazduha u ovim periodima i koeficijenti korelacije između trajanja pojedinih faza cvetanja i odgovarajućih temperatura (2009–2016).
Table 3. The range of flowering among apricot cultivars in certain phenological phases, average daily air temperatures in these periods, and correlation coefficients between duration of certain flowering phases and corresponding temperatures (2009–2016).

Godina *Year*	Raspon faze cvetanja između sorti (dani) *Flowering range among cultivars (days)*		Prosečno trajanje cvetanja (dani) *Average flowering duration (days)*	Temperature vazduha (°C) u periodu raspona za: *Air temperatures (°C) in the range period of:*		
	Početak cvetanja *Beginning of flowering*	Puno cvetanje *Full flowering*		Početak cvetanja *Begining of flowering*	Puno cvetanje *Full flowering*	Ukupno trajanje cvetanja (dani) *Total flowering duration (days)*
2009.	5	5	5,3	13,7	14,3	14,5
2010.	7	6	7,8	14,3	14,8	13,8
2011.	5	5	5,9	13,0	14,1	13,6
2012.	3	3	7,3	13,8	12,8	12,0
2013.	16	17	14,0	4,9	5,6	7,2
2014.	20	17	11,9	7,3	8,8	8,9
2015.	12	13	12,1	8,7	9,4	9,1
2016.	14	14	13,4	7,6	8,0	7,3
Koeficijent korelacije/*Coefficient of correlation*				-0,91**	-0,92**	-0,97**

**Koeficijenti korelacije su statistički značajni za $P \leq 0.01$ na osnovu t-testa.
***Coefficients of correlation are statistically significant for $P \leq 0.01$ according to t-test.*

Na osnovu osmogodišnjeg proučavanja fenologije cvetanja u beogradskom području izvršena je klasifikacija sorti kajsije u tri grupe prema vremenu početka cvetanja:

1) *Ranocvetne sorte*: Vitillo, Ninfa, Veecot, Aurora, Goldrich, Portici, Laycot, Bella d'Imola, Dunstan, Robada, Pinkcot, Harogem, Radka i Sylred (ukupno 14 sorti ili 28%).

2) *Srednjecvetne sorte*: Strepet, Velvaglo, Candela, Tomcot, Hargrand, Bergeron, Harostar, Stark Early Orange, Bergarouge, Harcot, Sophia, Betinka, Silvercot, Harojoy, Orangered, Vestar, Legolda, Harlayne, Leskora, Gergana i Lebela (21 sorta ili 42%).

3) *Poznocvetne sorte*: Mari de Cenad, Dacia, Mađarska najbolja klon 235, Pisana, Neptun, Veselka, Marlen, NS-4, NS-6, Roxana, Novosadska rodna, Forum, Vesprima, Cegledi Arany i Čudovij (15 sorti ili 30%).

Ukoliko se za gajenje odabere neka samobesplodna sorta kajsije, treba voditi računa da se za nju izabere i odgovarajuća sorta oprašivač. Pored kompatibilnosti sa glavnom sortom i dobre klijavosti polena, sorte oprašivači treba da imaju i približno vreme cvetanja sa glavnom sortom. One treba da budu u istoj ili susednoj grupi po vremenu cvetanja.

Zaključak

Na osnovu proučavanja fenofaze cvetanja 50 sorti kajsije na području Beograda u periodu od osam godina (2009–2016) utvrđeno je da se ona prosečno odvija u drugoj polovini marta i početkom aprila. Prosečan datum početka cvetanja za sve sorte bio je 22. mart, a prosečno trajanje cvetanja bilo je 9,7 dana.

Na osnovu dobijenih rezultata može se zaključiti da je na fenofazu cvetanja kajsije veći uticaj imala temperatura vazduha, nego nasledne karakteristike sorti. Zbog toga, uspeh proizvodnje kajsije više zavisi od pravilnog izbora lokaliteta, nego od izbora sorte. U područjima gde se često javljaju prolećni mrazevi treba gajiti sorte kasnijeg vremena cvetanja, jer one u pojedinim godinama mogu da izbegnu oštećenja od mrazeva.

Zahvalnica

Ovaj rad je realizovan u okviru ugovora o realizaciji i finansiranju naučnoistraživačkog rada u 2020. godini između Poljoprivrednog fakulteta u Beogradu i Ministarstva prosvete, nauke i tehnološkog razvoja Republike Srbije, evidencioni broj ugovora: 451-03-68/2020-14/200116.

Literatura

Burgos, L., Egea, J., Guerriero, R., Viti, R., Monteleone, P., & Audergon, J.M. (1997). The self - compatibility trait of the main apricot cultivars and new selections from breeding programmes. *Journal of Horticultural Science*, *72* (1), 147-154.

Đurić, B. (1990). Vreme cvetanja u nekih sorti kajsije u uslovima Fruške gore. *Jugoslovensko voćarstvo*, *24*, 3-7.

Ezzat, A., Amriskó, L., Mikita, T., Nyéki, J., Soltész, M., & Szabó, Z. (2012). Variation between some apricot varieties in regard to flowering phenology in Boldogkőváralja, Hungary. *International Journal of Horticultural Science*, *18* (1), 7-9.

Gorina, V.M., Korzin, V.V., & Mesyats, N.V. (2016). Evaluation of new apricot cultivars introduced in Nikita Botanical Garden. VII International Scientific Agriculture Symposium "AgroSym 2016". Jahorina, Bosnia and Herzegovina, pp. 1439-1445.

Halász, J., Pedryc, A., Ercisli, S., Yilmaz, K.U., & Hegedüs, A. (2010). *S*-genotyping supports the genetic relationships between Turkish and Hungarian apricot germplasm. *Journal of the American Society for Horticultural Science*, *135*, 410-417.

Krška, B. (2018). Genetic apricot resources and their utilisation in breeding. In J. Soneji, & M. Nageswara-Rao (Eds.), *Breeding and health benefits of fruit and nut crops.* (pp. 63-82). London: IntechOpen.

Legave, J.M., & Clauzel, G. (2006). Long-term evolution of flowering time in apricot cultivars grown in southern France: which future impacts of global warming?. *Acta Horticulturae*, *717*, 47-50.

Milatović, D. (2005). Cvetanje sorti kajsije u beogradskom području. *Voćarstvo*, *39*, 285-293.

Milatović, D. (2013). *Kajsija*. Naučno voćarsko društvo Srbije, Čačak.

Milatović, D., & Nikolić, D. (2007). Analysis of self-(in) compatibility in apricot cultivars using fluorescence microscopy. *Journal of Horticultural Science and Biotechnology*, *82* (2), 170-174.

Milatović, D., Nikolić, D., & Krška, B. (2013). Testing of self-(in)compatibility in apricot cultivars from European breeding programmes. *Horticultural Science (Prague)*, *40*, 65-71.

Rahović, D. (2002). Biološke osobine introdukovanih sorti kajsije u beogradskom području. *Jugoslovensko voćarstvo*, *36*, 113-119.

Ruiz, D., & Egea, J. (2008). Analysis of the variability and correlations of floral biology factors affecting fruit set in apricot in a Mediterranean climate. *Scientia Horticulturae*, *115,* 154-163.

Ruml, M., Milatović, D., Đurović, D., Zec, G., Jokić, M., & Radović, M. (2018). Chilling and heat requirements for flowering in apricot cultivars. *Acta Horticulturae*, *1214*, 15-18.

Szabó, Z., & Nyéki, J. (1999). Floral biology and fertility of apricot. *International Journal of Horticultural Science*, *5* (3-4), 9-15.

Szabó, Z., Nyéki, J., & Soltész, M. (2003). Apricot (*Prunus armeniaca* L.). In: P. Kozma, J. Nyéki, M. Soltész, & Z. Szabó (Eds.). *Floral biology, pollination and fertilisation in temperate zone fruit species and grape*. (pp. 411-423). Budapest: Akadémiai Kiadó.

Szalay, L., Papp, J., & Szabó, Z. (2000). Variability in the blooming time of apricot varieties in Hungary. *Acta Horticulturae*, *538*, 139-141.

Vachůn, Z. (2003). Phenophases of blossoming and picking maturity and their relationships in twenty apricot genotypes for a period of six years. *Horticultural Science (Prague)*, *30* (2), 43-50.

Wertheim, S.J. (1996). Methods for cross pollination and flowering assessment and their interpretation. *Acta Horticulturae, 423*, 237-241.

Primljeno: 31. marta 2020.
Odobreno: 22. jula 2020.

FLOWERING PHENOLOGY OF APRICOT CULTIVARS IN THE BELGRADE REGION

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A b s t r a c t

The phenology of flowering was studied in 50 apricot cultivars in the Belgrade region over a period of eight years (2009–2016). Within the flowering phenophase, three sub-phases were registered: the beginning of flowering, full flowering and the end of flowering. In addition, the duration and abundance of flowering were examined. The average date of the beginning of flowering for all cultivars was March 22, of full flowering – March 25, and of the end of flowering – April 1. The average duration of flowering was 9.7 days, with a range among cultivars between 7.5 days (‘Gergana’) and 12 days (‘Ninfa’ and ‘Radka’). The lowest average score (3.0) for flowering intensity was obtained in ‘Hungarian Best’ cultivar, and the highest score (4.6) in ‘Harcot’ and ‘Leskora’ cultivars. In years with higher temperatures during the flowering, a smaller range in flowering time among cultivars was recorded, as well as shorter duration of flowering. Based on the beginning of flowering, the tested cultivars were classified into three groups: early-flowering (14 cultivars), medium-flowering (21 cultivars) and late-flowering (15 cultivars). Meteorological factors (air temperature) had a greater influence on the course and duration of the flowering phenophase than the genetic traits of the cultivars.

Key words: *Prunus armeniaca*, beginning of flowering, full flowering, flowering duration, flowering intensity, temperature.

Received: March 31, 2020
Accepted: July 22, 2020

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Journal of Agricultural Sciences (Belgrade) https://doi.org/10.2298/JAS2003251R
Vol. 65, No. 3, 2020 UDC: 631.445.8(497.11)
Pages 251-261 Original scientific paper

CHARACTERISTICS OF RENDZINA SOILS IN SERBIA AND THEIR WRB CLASSIFICATION

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Abstract: According to the Serbian official soil classification system, Rendzina is a soil *type* with an A-AC-C-R profile, developed on parent rock containing more than 20% of calcareous material (except soils with an A-R profile on hard pure limestone or dolomite). Previous investigations have shown that 29 Rendzina soil profiles from Serbia belong to the reference soil groups (RSGs) of *Leptosols*, *Regosols* and *Phaeozem*s according to the World Reference Base for Soil Resources (WRB 2015). The present study addresses the correlations among three WRB RSGs in terms of soil texture, mean weight diameter (MWD), total N content, and humus fractional composition using Principal Component Analysis (PCA). The objective is to better understand the mutual relationship between the classification soil units used in Serbia and the international WRB system. The results show that PCA cannot unequivocally distinguish between these three RSGs. *Leptosols* and *Regosols* are highly incoherent groups while the group of *Phaeozems* is highly coherent, leading to the conclusion that the physical and chemical properties of the soil profiles of *Phaoeozems* are specific. It is obvious that soil depth and color, which are the overriding factors in the differentiation of Rendzina soils into three WRB RSGs, had no significant effect on these properties. The results further show that soil properties such as texture, MWD, humus fractional composition, etc. cannot be used to correlate Rendzina soils from Serbia with WRB. Instead, careful correlation of individual soil profiles is needed based on quantitative soil data analysis as required by WRB.

Key words: Rendzina, WRB, texture, MWD, humus fractional composition, PCA.

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Introduction

There are a large number of national or regional soil classifications based on different principles. To facilitate international communication, the International Union of Soil Sciences (IUSS) has developed an international soil classification system – World Reference Base for Soil Resources (WRB) (IUSS Working Group WRB, 2015). Since its inception in 1988, many correlations between national soil classifications and WRB have been reported. It is usually very difficult to simply assign a classification unit of the national classification system to only one WRB reference soil group (RSG) (Balla et al., 2016; Zádorová and Penížek, 2011). This is the case with the soil type called Rendzina. From the very beginning (Kubiena, 1953), the term Rendzina referred to soils with an A-C profile, developed on limestones and dolomites, and Pararendzina meant soils developed on silicate-carbonate substrates like loess, marl, fluvio-glacial material, and alluvium. Even today, in many national soil classifications, Rendzina and/or Pararendzina denote soils formed on different calcareous parent material (Florea and Munteanu, 2000; Němeček and Kozak, 2002; Шишов et al., 2000; etc.). Internationally, the term Rendzina (along with many others) has not been used since the establishment of the revised legend of the FAO soil map of the world (FAO, 1988) and WRB (IUSS Working Group, 2015). According to the revised legend of the FAO soil map of the world (FAO, 1988) and all WRB editions from 1998 to 2015 (IUSS Working Group, 2015), Rendzinas from many national soil classifications belong to the RSG of *Leptosols* developed on calcareous rocks. Based on other literature sources (Balla et al., 2016; Krasilnikov and Arnold, 2009; Krasilnikov et al., 2013; Kyrylchuk, 2017; Shishkov and Kolev, 2014; Zádorová and Penížek, 2011), the correlation between Rendzinas/Pararendzinas and WRB is much more complex. Besides *Leptosols*, Rendzinas correspond to many other RSGs, such as *Phaeozems*, *Regosols*, *Arenosols*, *Umbrisols* and *Cambisols*.

According to the Serbian official soil classification system (Škorić et al., 1985), Rendzina is a soil *type* within the *order* of automorphic soils and the *class* of humus-accumulative soils with an A-AC-C-R profile. Rendzina includes soils developed on parent rock containing more than 20% of calcareous material (except soils with an A-R profile on hard pure limestone or dolomite, which are classified as a distinct soil type: Limestone-Dolomite Black Soil). The classification of 29 Rendzina soil profiles from Serbia according to WRB 2015 (IUSS Working Group WRB, 2015) in Radmanović et al. (2017) shows that they belong to *Leptosols* (41% profiles), *Regosol*s (35%) and *Phaeozems* (24%). The question is what caused the separation of a single soil type, Rendzina, into three RSGs. The classification of soils according to WRB is based on soil properties defined in terms of diagnostic horizons, diagnostic properties, and diagnostic materials (IUSS Working Group WRB, 2015). In this respect, soil depth, color (dry and moist), coarse fragments, soil organic carbon (SOC), $CaCO_3$, pH, and base saturation were needed for the classification of Rendzinas according to WRB (Radmanović et al., 2017). Soil depth and color were the dominant soil properties in separating Rendzinas into three RSGs. Soil depth caused the first differentiation between *Leptosols* and *Phaeozems*, while soil (moist) color led to the second differentiation between *Phaeozems* and *Regosols*. The paper examines whether these three RSGs also differ in terms of other soil characteristics (not used as WRB criteria), such as texture, structure, and humus fractional composition. The correlations among the three WRB RSGs in this regard were tested using PCA in order to better understand the relationship between the soil classification system used in Serbia and the international WRB soil classification system.

Materials and Methods

A total of 29 Rendzina soil profiles from different parts of Serbia were studied. The location, topography, parent material, carbonate status, and land use of the investigated soils are shown in Table 1.

Table 1. General site information and main soil formation factors.

Pr.	Location	Altitude (m a.s.) landform	Parent material	Variety	Land use
			Leptosols		
1	east	199, hill top	soft limestone	calcareous	forest
2	east	199, hill top	soft limestone	calcareous	forest
5	east	199, hill top	soft limestone	calcareous	grassland
9	east	250, gentle slope	soft limestone	calcareous	arable land
11	southwest	1210, slope 40°	marly limestone	calcareous	grassland
12	northwest	190. hill top	sandy marl	calcareous	grassland
16	west	443, slope 55°	soft limestone	calcareous	forest
17	west	560, hill top	soft limestone	decarbonated	grassland
18	central	261, hill top	soft limestone	calcareous	forest
19	central	240, slope 20°	soft limestone	calcareous	arable land
20	central	290, slope 60°	soft limestone	decarbonated	forest
29	southeast	370, slope 80°	calcareous marl	calcareous	forest
Pr.	Location	Altitude (m a.s.) landform	Parent material	Variety	Land use
			Phaeozems		
3	east	199, hill top	soft limestone	calcareous	grassland
4	east	199, hill top	soft limestone	calcareous	grassland
6	east	199, hill top	soft limestone	calcareous	grassland
7	east	199, gentle slope	soft limestone	decarbonated	forest
8	east	199, gentle slope	soft limestone	calcareous	grassland
10	east	250, gentle slope	marly limestone	decarbonated	arable land
22	southeast	438, slope 45°	marly limestone	calcareous	forest

Table 1. Continued.

			Regosols		
13	northwest	187, slope 60°	sandy marl	calcareous	grassland
14	west	172, hill top	marl	calcareous	arable land
15	west	151, slope 60°	marl	calcareous	forest
21	central	280, footslope	soft limestone	decarbonated	grassland
23	southeast	375, slope 60°	sandy marl	calcareous	forest
24	southeast	370, slope 30°	sandy marl	calcareous	arable land
27	southeast	337, footslope	soft limestone	calcareous	arable land
28	southeast	335, slope 45°	marly limestone	calcareous	grassland
30	southeast	720, slope 40°	soft limestone	calcareous	forest
31	southeast	715, slope 30°	soft limestone	calcareous	arable land

The study examined the following physical and chemical properties of the soils from the A horizon: texture, pH and total N using common methods (Van Reeuwijk, 2002), mean weight diameter (MWD) according to Le Bissonais (1996), and humus fractions using the Ponomarieva and Plotnikova method (Пономарева and Плотникова, 1968), where humic acids (HA), fulvic acids (FA) and humin are expressed as a percentage of SOC.

The objective of the Principal Component Analysis (PCA) of normally distributed soil properties was to verify the WRB classification of the soil samples. PCA was selected because of its numerous advantages. Primarily, it is an unsupervised method that is extremely informative when the structure of a set of input data is examined in maximum variance space. The analysis was performed using the IBM SPSS Statistics 19 software package.

Results and Discussion

As previously stated, Rendzina is a soil *type* according to the Serbian official soil classification system (Škorić et al., 1985). A soil type is the central unit of that soil classification, defined by the characteristic sequence of genetic horizons, soil-forming processes and qualitatively similar physical and chemical properties of the horizons. Heterogeneity within a soil type is represented by lower classification units: subtype, variety and form. Thus, all Rendzina profiles examined in this study belong to the same *subtype* – marl, marly limestone and soft limestone (the most widespread subtype in Serbia); three *varieties* – calcareous, decarbonated and colluvial; and several *forms* – mostly loamy, low to medium skeletal. These Rendzina soils have been divided into three WRB RSGs (Radmanović et al., 2017). According to the IUSS Working Group WRB (2015), the dominant identifiers, i.e. the soil-forming factors or processes that most clearly influence these RSGs, are: *Leptosols* – soils with root growth limitations, thin or with many coarse fragments; *Phaeozems* – pronounced accumulation of organic matter in the mineral topsoil, dark topsoil, no secondary carbonates (unless very deep), high base status; and *Regosols* – no significant profile development. Based on the two soil classifications, the investigated Rendzina soil profiles differ considerably from each other. It is well-known that the Rendzina soil characteristics examined in this study (texture, structure, total N content and humus fractional composition) are very important because they are closely related to soil-forming factors and processes (i.e. to other physical and chemical properties), so these properties would be expected to differ in the three RSGs.

Statistical descriptions of the studied soil characteristics are provided in Table 2.

Table 2. Rendzina soil properties (A horizon).

Soil properties	*Min.*	*Max.*	*Mean*	*SD*
		Leptosols (*n=12*)		
Sand (%)	20.4	70.2	39.7	13.6
Silt (%)	20.2	42.6	29.0	7.7
Clay (%)	8.0	44.8	31.1	11.0
MWD	0.0	2.5	1.4	0.9
pH	7.2	8.1	7.6	0.2
N (%)	0.1	0.5	0.4	0.1
HA (%)	18.3	35.7	27.9	4.9
FA (%)	26.9	41.1	37.0	4.2
Humin (%)	25.2	45.8	35.1	6.3
		Phaeozems (*n=7*)		
Sand (%)	39.1	53.5	45.1	5.9
Silt (%)	16.2	28.6	21.2	4.2
Clay (%)	27.7	39.2	33.4	3.9
MWD	0.9	1.9	1.4	0.4
pH	7.0	7.7	7.5	0.3
N (%)	0.2	0.5	0.3	0.1
HA (%)	24.8	30.1	26.8	2.0
FA (%)	29.5	37.0	32.9	3.1
Humin (%)	35.4	44.6	40.3	2.8
		Regosols (*n=10*)		
Sand (%)	28.0	68.7	45.1	13.9
Silt (%)	20.0	41.1	28.2	6.7
Clay (%)	9.8	42.4	28.1	11.5
MWD	0.7	2.3	1.4	0.4
pH	7.6	8.0	7.7	0.1
N (%)	0.1	0.5	0.3	0.1
HA (%)	24.8	33.9	29.2	3.4
FA (%)	32.2	45.1	37.2	4.7
Humin (%)	25.0	68.6	38.1	12.0

After verifying the normality (the Shapiro–Wilk test), the studied physical and chemical parameters were treated with multivariate analysis tools to gain the fullest possible insight into the structure of the RSG datasets and any discrimination among them. Sand, silt, clay, MWD, pH, HA, FA and humin were the parameters used to assess the discrimination informativity of the RSGs. Transformation into the maximum variance space retained slightly more than 74% of the dataset structure information.

As a result, Figure 1 (PC1-PC2-PC3) provides sound information about the structure of the RSG datasets. It is obvious that there is a plane in the maximum variance space where the RSGs could be unequivocally differentiated. At the same time, *Leptosols* and *Regosols* are extremely incoherent.

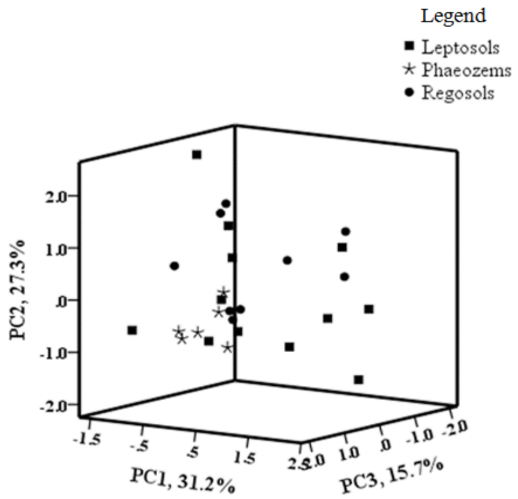

Figure 1. The scores plot of Rendzina soil properties.

This is a consequence of equal contributions of all the parameters assessed under PC2 to the total variance of the dataset. In absolute terms, the values of *Loadings* under PC2 (bold in Table 3) are very close and have a considerable effect on the incoherence of the groups of samples identified as *Leptosols* and *Regosols*.

The PCA results showed that the three WRB RSGs had not been separated. In other words, there was no substantial difference between them in terms of the studied physical and chemical parameters. As such, *Leptosols* and *Regosols* were very incoherent, possibly due to WRB classification requirements. In the case of *Leptosols*, soil depth did not affect the studied physical and chemical properties even though it is an important agroecological factor. The *Regosols* RSG was distinguished by soil color. Lighter shades of Regosols are probably due to lower SOC or higher $CaCO_3$ concentrations, but neither soil parameter had a significant effect on the studied physical and chemical properties.

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Table 3. PCA loadings of Rendzina soil properties.

Soil properties	PC		
	1	2	3
Sand	-0.787	0.483	-0.291
Silt	0.835	0.102	-0.184
Clay	0.362	**-0.646**	0.593
MWD	0.401	**-0.554**	-0.299
pH	-0.081	**0.540**	0.319
HA	0.317	**0.666**	0.510
FA	0.586	0.288	-0.578
Humin	-0.659	**-0.629**	-0.049

The variance of the humin parameter was characteristic of the extremely coherent *Phaeozems* RSG. A separate analysis of the physical and chemical parameters (Figure 2) was undertaken to examine the source of this RSG's coherence.

The conserved variance in the maximum variance space of the physical properties was 99.4%, so Figure 2a is an extremely good representation of the RSG dataset structures. It is apparent that the coherence of the *Phaeozems* RSG was conserved and that the small variance of the silt parameter contributed to the result. The coherence of the *Phaeozems* RSG in the maximum variance space of the chemical properties was slightly disturbed (Figure 2b), but it is obvious that the variance of the humin parameter was characteristic of the *Phaeozems* RSG. The coherence of the *Phaeozems* RSG might be pronounced because of the smallest number of soil profiles, but likely also due to the fact that all the soil profiles originated from eastern and southeastern Serbia and were developed on similar parent materials and in comparable climate conditions.

As previously indicated, a lot of attention in the field of soil science has recently been devoted to potential correlations between national soil classifications and WRB (Kabala et al., 2016). There have especially been attempts to directly associate a classification unit of the national classification system with the equivalent WRB

RSG (Krasilnikov and Arnold, 2009), or use available data from national soil archives to classify soils according to WRB (Balla et al., 2016).

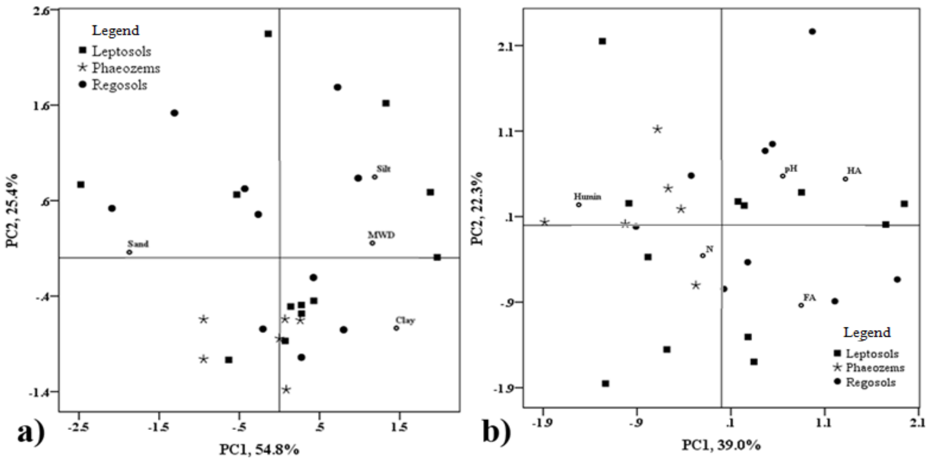

Figure 2. The scores plots of Rendzina soils: a) physical and b) chemical parameters.

The results of the present study showed that PCA of the investigated physical and chemical parameters of Rendzina soils did not recognize the WRB *Leptosols*, *Phaeozems* and *Regosols* RSGs. Consequently, in the case of these types of soil (and potentially other types as well), it is not possible to establish correlations based on the examined physical and chemical data. In addition, the results of the present study corroborate the conclusions of other authors (Kabala et al., 2016; Reintam and Köster, 2006; Zádorová and Penížek, 2011) that a careful correlation of individual soil profiles is needed based on analyses of quantitative soil data as required by WRB.

Conclusion

Previous investigations have shown that 29 Rendzina soil profiles from Serbia belong to the RSGs of *Leptosols*, *Regosols* and *Phaeozems* according to WRB 2015. The present study tested the correlations among these WRB RSGs in terms of soil texture, MWD, total N content, and humus fractional composition using PCA. The results showed that PCA cannot make an unequivocal distinction between the three RSGs. In addition, *Leptosols* and *Regosols* are extremely incoherent and *Phaeozems* extremely coherent, which leads to inferences about the specific nature of their physical and chemical properties. It is clear that soil depth and color, which drove the differentiation of the Rendzina soil type into three WRB

RSGs, had no significant effect on the properties tested in this research. The results further indicated that data on soil properties such as texture, MWD, and humus fractional composition cannot be used to correlate Serbia's classification of Rendzina soils with WRB. Therefore, a careful classification of individual soil profiles is needed, based on analyses of quantitative soil data as required by WRB.

Acknowledgements

This study was financially supported by the Ministry of Education, Science and Technological Development of the Republic of Serbia (Projects Nos. 37006 and 37021).

References

Balla, D., Novak, T.J., & Zichar, M. (2016). Approximation of theWRB reference group with the reapplication of archive soil data bases. *Agriculture and Environment, 8*, 27-38.

FAO (1988). *Soil map of the world. Revised legend, by FAO–UNESCO–ISRIC*. World Soil Resources Report No.60. Rome.

Florea, N., & Munteanu, I. (2000). *Sistemul Român de Taxonomie a Solurilor*. Iasi: University Al. I. Cuza. or correlation of Rendzina soils from Serbia with WRB system.

IUSS Working Group WRB (2015). *World Reference Base for Soil Resources 2014, update 2015*. International soil classification system for naming soils and creating legends for soil maps. World Soil Resources Reports No. 106. Rome: FAO.

Kabala, C., Oewitoniak, M., & Charzynski, P. (2016). Correlation between the Polish Soil Classification (2011) and international soil classification system World Reference Base for Soil Resources (2015). *Soil Science Annual, 67*, 88-100.

Krasilnikov, P. Gutiérrez-Castorena, C., Ahrens, R., Cruz-Gaistardo, C.O., Sedov, S., & Solleiro-Rebolledo, E. (2013). *The Soils of Mexico*. World Soils book Series. Dordrecht: Springer.

Krasilnikov, P., & Arnold, R. (2009). Soil Classifications and their Correlations. In P. Krasilnikov, J.-J. Ibáňez, R. Arnold & S. Shoba (Eds.), *Handbook of Soil Terminology, Correlation and Classification*. (pp. 45-335). London: Earthscan.

Kubiena, W. (1953). *The soils of Europe*. London: Thomas Murby.

Kyrylchuk, A. (2017): Geographic and bio-lithogenic features of genesis and dissemination of Rendzinas in the Western Ukrainian region. *Economic Engineering in Agriculture and Rural Development, 17*, 265-272.

Le Bissonnais, Y. (1996). Aggregate stability and assessment of soil crustability and erodibility: I. Theory and methodology. *European Journal of Soil Science, 47*, 425-437.

Němeček, J., & Koza, J. (2002). The Czech taxonomic soil classification system and the harmonization of soil maps. In E. Micheli, F.O. Nachtergaele, R.J.A. Jones & L. Montanarella (Eds.), *Soil Classification 2001*. (pp. 47-53). Luxembourg: Office for Official Publications of the European Communities.

Пономарева, В.В., & Плотникова, Т.А. (1968). Методика и некоторые результаты фракционирования гумуса черноземов. *Почвоведение, 11*, 104-117.

Radmanović, S., Životić, Lj., Nikolić, N., & Đorđević, A. (2017). Classification of Rendzina soils in Serbia according to the WRB system. In M. Belić, Lj. Nešić, V. Ćirić & K. Mačkić (Eds.), *Proceedings of the 2nd International and 14th National Congress of Soil Science Society of Serbia* (pp. 1-9). Novi Sad, Serbia.

Reintam, E., & Köster, T. (2006). The role of chemical indicators to correlate some Estonian soils with WRB and Soil Taxonomy criteria. *Geoderma*, 136, 199-209.

Shishkov, T., & Kolev, N. (2014). *The Soils of Bulgaria*. World Soils book Series. Dordrecht: Springer.

Шишов Л.Л., Тонконгов В.Д., & Лебедева И.И. (2000). *Классификация почв России*. Москва: Почвенный институт им. В.В. Докучаева РАСХН.

Škorić, A., Filipovski, G., & Ćirić, M. (1985). *Klasifikacija zemljišta Jugoslavije*. Sarajevo: ANUBH.

Van Reewijk, L.P. (2002). *Procedures for soil analysis*. Wageningen: ISRIC, FAO.

Zádorová, T., & Penížek, V. (2011). Problems in correlation of Czech national soil classification and World Reference Base 2006. *Geoderma*, *167-168*, 54-60.

Received: July 1, 2019
Accepted: July 2, 2020

KARAKTERISTIKE RENDZINA U SRBIJI I NJIHOVA KLASIFIKACIJA PREMA WRB SISTEMU

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R e z i m e

Prema zvaničnoj klasifikaciji zemljišta Srbije prema Škoriću i saradnicima, rendzina je *tip* zemljišta građe profila A-AC-C-R, čiji matični supstrati sadrže više od 20% karbonata (izuzev zemljišta građe profila A-R, obrazovanih na čistim tvrdim krečnjacima i dolomitima). Prethodna istraživanja su pokazala da 29 profila rendzine sa područja Srbije, prema međunarodnoj WRB klasifikaciji zemljišta iz 2015. godine, pripadaju referentnim grupama zemljišta (RSG): *leptosola, faozema* i *regosola*. U ovom radu je testiran međusobni odnos izdvojenih WRB RSG prema teksturi, prosečnom masenom prečniku (MWD), sadržaju ukupnog N i frakcionom sastavu humusa, metodom analize glavnih komponenti (PCA), a sve s ciljem boljeg razumevanja međusobnog odnosa klasifikacionih jedinica domaćeg i međunarodnog WRB sistema za klasifikaciju zemljišta. Rezultati su pokazali da PCA ne može na nedvosmislen način da razlikuje ove tri referentne grupe zemljišta. Pri tome su RSG *leptosola* i *regosola* veoma nekoherentne, dok je RSG *faozema* izrazito koherentna što ostavlja prostora za zaključak o specifičnosti fizičkih i hemijskih osobina rendzina koje pripadaju *faozemima*. Očito je da dubina i boja zemljišta, koje su bile presudne za diferenciranje zemljišta *tipa* rendzina na tri WRB RSG, nisu imale značajan uticaj na osobine ispitivane u ovom radu. Rezultati su nadalje pokazali da podatke o osobinama zemljišta kao što su tekstura, MWD, frakcioni sastav humusa, itd., nije moguće koristiti za korelaciju zemljišta tipa rendzina u Srbiji sa WRB sistemom klasifikacije, već je neophodna pažljiva klasifikacija svakog pojedinačnog profila zemljišta bazirana isključivo na kvantitativnim podacima koje je WRB sistem predvideo svojim zahtevima.

Ključne reči: Rendzina, WRB, tekstura, MWD, frakcioni sastav humusa, PCA.

Primljeno: 1. jula 2019.
Odobreno: 2. jula 2020.

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Journal of Agricultural Sciences (Belgrade)
Vol. 65, No. 3, 2020
Pages 263-281

https://doi.org/10.2298/JAS2003263S
UDC: 631:504.61
Original scientific paper

VULNERABILITY OF AGRICULTURE TO CLIMATE CHANGE IN SERBIA – FARMERS' ASSESSMENT OF IMPACTS AND DAMAGES

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Abstract: Considering the already observed trends of increasing air temperatures, changes in precipitation regimes, and extension of the growing season, as well as predictions that climate conditions in Serbia will deteriorate and the risks to farming will increase, the objective of this research is to assess the vulnerability of agriculture in Serbia to climate change, based on farmers' perceptions. A team of experts in all areas of agriculture and soil and water management compiled a questionnaire for a semi-open online survey. The snowball sampling approach was followed, relying on personal contacts and social media. In total, 141 farmers responded to the questionnaire. The data were evaluated using descriptive statistics. The differences by region, activity and topography were tested by ANOVA and Student's t-test. The feedback was used to assess the damages sustained by farmers due to climate change and reduced revenues in their respective areas of agricultural activity. Certain positive effects of climate change were also identified. A need for training in climate change impact mitigation is noted. The collected data were analyzed by descriptive statistics. The surveyed farmers believe that the most important effects of climate change were periods of extreme high temperature, droughts, late spring frost, and hail. Climate change seems to be reducing yields, facilitating the appearance of new diseases and pests, and causing a lower tolerance to existing diseases and pests. Farmers expressed considerable interest in climate change impact adaptation and mitigation training.

Key words: climate change, agriculture vulnerability, impacts, questionnaire.

Introduction

Agricultural production is closely coupled with natural rhythms (fluctuations). Natural changes and anomalies in weather, water and soil conditions affect all

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production systems in agriculture. Namely, in many countries in Europe, there have been frequent shifts in spring floods, summer droughts and heat waves (Author et al., 2018), which interfere with agricultural production.

"Warming of the climate system is unequivocal, and since the 1950s, many of the observed changes are unprecedented over decades to millennia. The atmosphere and ocean have warmed, the amounts of snow and ice have diminished, and sea level has risen" (IPCC, 2014). It brings about numerous risks and negative effects, which will likely increase in the forthcoming period. Agriculture is very vulnerable, given that it is an 'outdoor factory'. Plant production (of field crops, vegetables, fruits and grapevines) is particularly exposed to hazards, as are livestock breeding and fish farming, so ultimately the food industry as well. A lack of constancy in the food industry's supply chain leads to economic and social insecurity. The IPCC report (2019) stated: "Climate change has already affected food security due to warming, changing precipitation patterns, and greater frequency of some extreme events".

Forzieri et al. (2016) analyzed the probability of risk (heat and cold waves, river and coastal floods, droughts, wildfires and windstorms) in Europe through to the end of the 21st century. They state that the Balkans, including Serbia, will be exposed to the largest number of the studied risks. According to all scenarios, Serbia belongs to the group of countries most susceptible to the impact of climate change (European Environment Agency (EEA), 2017; IPCC, 2013; Jacob et al., 2014).

Studies on the expected climate change impact in Serbia suggest that the climate will be drier and warmer, but still suitable for agriculture (Ruml et al., 2012; Mihailović et al., 2015). Lalić et al. (2013) point out that a precipitation deficit will be the primary limiting factor for field crops. Author et al. (2014) as well as Jancic et al. (2015) claim that the irrigation water demand will increase, which is consistent with the conclusion of the Intergovernmental Panel on Climate Change (IPCC, 2014): "Assessment of many studies covering a wide range of regions and crops shows that negative impacts of climate change on crop yields have been more common than positive impacts".

According to the information presented in the Second National Communication (SNC) on climate change in Serbia (SNC, 2015), during the period from 1960 to 2012 upward trends have been observed in air temperature, heavy rainfall, altered precipitation distributions, extended growing seasons, and shortened winters. More than 70 floods have been registered, as well as heat waves, a higher frequency of hail events, etc. Some 30 risks have been identified in Serbian primary agricultural production, and the damages sustained due to unfavorable climate conditions have been estimated at 5 billion € in the past decade (NAP, 2015). Risks have been more pronounced over the last 20 years.

Farmers live and work in constant association with natural rhythms and changes. They are the first to feel the impact on health, plant growing, and the economy. In that regard, their perception of the vulnerability of agriculture to climate change is highly relevant to the status assessment.

Several surveys of farmers' perceptions suggest divided opinions about the variation in meteorological conditions moving in the direction of climate change. Always operating at some level of risk, farmers worldwide (Azhoni and Goyal, 2018; Jankó et al., 2017; Takahashi et al., 2016; Woods et al., 2017) and in Serbia (Ćosić et al., 2011) do not always have a clear picture of the onset of climate change. This is understandable to some extent because studies (Grothmann and Patt, 2005) point out that individuals systemically tend to underestimate risks that might lead to considerable damages. Farmers in Sweden believe that the commonly used indicators of the vulnerability of agriculture to climate change are too generalized and do not encompass the entire vulnerability context. According to them, polices and measures, primarily bureaucracy are exposure factors that must be handled more than climate change impacts (Neset et al., 2018).

However, the majority of research suggests that agricultural producers and consultants agree that climate change is happening and that it has a mostly negative impact. However, in some cases, albeit rare, the impact is positive. Climate change is assessed as a risk in Germany (Niels et al., 2015; Barkman et al., 2017), whereas in the US Midwest concerns focus on crop pricing vulnerability (Church et al., 2017). In addition, climate change is disquieting in the Northern Great Plains (the USA), but there is a degree of optimism because of the belief that farmers are able to adapt to the altered conditions they observe themselves (Grimberg et al., 2018). In Asian countries, reports point out the need to implement adaptation and mitigation measures in agriculture (Chunlan et al., 2018) and identify inherent obstacles (Azhoni and Goyal, 2018; Masud et al., 2017). Research conducted in the tropical countries of Central America shows that farmers are prepared to apply climate change adaptation measures and consultants are examining which measures from a set of specific challenges should be prioritized (Holland et al., 2017). In Denmark, farmers are more likely to adapt to positive than negative impacts, although respondents were neither very likely nor very unlikely to implement most of the implied adaptation measures (Woods et al., 2017).

The objective of the present research is to: i) identify and assess farmers' perceptions of climate change in Serbia; ii) provide a realistic picture of the extent and consequences of climate change, and iii) obtain farmers' feedback about their vision of the ability to adapt to climate change.

These objectives are consistent with predictions that climate conditions in Serbia will deteriorate and risks will increase, such that there is a need to identify all the negative effects of climate change on agriculture, to smartly recognize the positive effects, and to take action in a timely manner on all levels (from the government to stakeholders). Up to date, such research has not been undertaken in Serbia or surrounding countries. It provides insight into the state of affairs in a region threatened by climate change, compared to other regions worldwide. It could contribute to the implementation of measures and potential strategies that lead to climate-smart agriculture.

Materials and Methods

Study area

Serbia is situated in the southeastern continental part of Europe. The spatial distribution of climate parameters is governed by the geographic location, topography and local conditions, as a result of the combination of topography, large-scale air pressure distribution, and the presence or absence of rivers, lakes, vegetation, etc. The average annual air temperature over the period from 1961 to 1990 is 10.9^{o}C at elevations up to 300 m above sea level, 10.0^{o}C from 300 to 500 m, and 6.0^{o}C above 1000 m. Annual precipitation, on average, increases with altitude: 540 to 820 mm in lowlands and 700 to 1000 mm at elevations above 1000 m. The precipitation regime in most of Serbia is continental, with larger amounts of precipitation in the warm part of the year, except for the southwestern part of the country where this occurs in autumn (Republic Hydrometeorological Service, 2019). The country is divided into four regions: Vojvodina (VOJ), Belgrade region (BG), Šumadija and western Serbia (SWS); and southern and eastern Serbia (SES). These regions were used for a difference test comparison.

Farming takes place in all parts of the country, regardless of topography. Field crop farming and vegetable growing are dominant in the lowlands. In hilly areas, there is additionally orcharding, whereas in the mountainous areas, animal husbandry is the leading agricultural activity. The size of an average holding is only 5.4 hectares, comprised of six separate parcels of land on average. The average parcel is only about one hectare (Census of Agriculture, 2012). In terms of revenue, 61.7% comes from plant production and 38.3% from animal husbandry. The share of agriculture, forestry and fisheries in the national gross domestic product is 6–6.8%, and of full-time employees – about 15% (Statistical Yearbook, 2018), indicating a considerable climate change impact on the country’s agriculture and the overall economy.

Questionnaire structure and data collection

A team of experts in field crop farming, vegetable growing, orcharding, plant protection, water and soil management, and animal husbandry identified the negative and positive effects of climate change on agriculture and compiled a questionnaire for farmers. The effects listed in the SNC (2015) were used as a starting point. The questions were adapted so that farmers could assess the damages/benefits of climate change and give answers in order to provide insight into how they expected the problems to be addressed at local, regional and national levels. The questionnaire (Table 1) was posted online (https://goo.gl/forms/VfM5FMt1ENojWOB73 in the Serbian language, and https://goo.gl/forms/kcWHGejJEtV9pKvI3 in the English language). Some of the questions were multiple-choice questions, and others were open-ended to allow the farmers to write their opinions. The first section of the survey dealt with basic information about the farmers and their farming system in order to assess their specific vulnerability to climate change depending on topography, crop(s) and farming methods. The key questions in the survey focused on the identification of a climate change impact on agriculture in Serbia and the estimation of damages sustained by farmers depending on the type of activity.

Table 1. Survey questions.

Questions
Farmer and agricultural system passport data
– Age
– Education
– Municipality/region
– Average farm size (ha)
– Farmland topography: lowland (0–300 m a.s.l.), hilly (300–500 m), other (mountainous >500 m)
– Agricultural system (more than one choice possible):
– field crops; vegetables – open field; greenhousing; orcharding; vineyards; animal husbandry; other (nursery, flowers, herbs, etc.)
– How long have you been farming?
Climate change questions
– How do you rate the impact of climate change on environmental hazards in agriculture?
– (0 = no impact, 3 = moderate impact, 6 = extreme impact)
– Which consequences of climate change have you noted and to what extent?
– What is your personal estimate of the damages you have suffered, relative to usual profits from:
– field crops (FC); vegetables – open field V-OF; greenhousing (GH); orcharding (ORCH); vineyards (V); animal husbandry (AH); other (nursery, flowers, herbs, etc.) (Answers: 1 – no damages (up to 10%), 2 – moderate damages (10–30%), 3 – considerable damages (30–50%), 4 – enormous damages (>50%)
– Have you experienced any positive effects of climate change and, if so, which?
– Do you believe that additional awareness-raising activities and training related to climate change would be very useful?

The snowball approach was used to collect the data. Namely, the survey was forwarded to farmers, agricultural consultants, formal associations of young farmers, cooperatives, big agricultural companies, and agricultural magazines. It was also posted on social media (Facebook, Twitter, LinkedIn and Instagram) and portals frequented by farmers (Agronews, Agroclub, Soil and Water Management, Orcharding, Good Land). The disadvantages of the snowball approach were that the survey might not have included respondents from all farming municipalities. Furthermore, the oldest population (with the longest memory of climate change) might not have responded to an online survey, and that certain agricultural systems might have been given precedence over others. In order to maximize the survey's success, the team used personal contacts of the farmers and agronomists and asked them to respond to and forward the survey. Targeted web administrators in the regions with the fewest respondents were also contacted. Some of them asked for a summary of climate change observations and projections, to motivate readers to respond (e.g. web http://www.istocnevesti.com/ "Istočne vesti" – Eastern News). The aim was to include representatives of all agricultural systems, from lowland, hilly, and mountainous parts of the country. From September to the end of November 2018, the feedback was received from 141 farmers across Serbia (Figure 1). It is noteworthy that many readers of online magazines that posted the survey recognized the importance of examining the impact of climate change on agriculture.

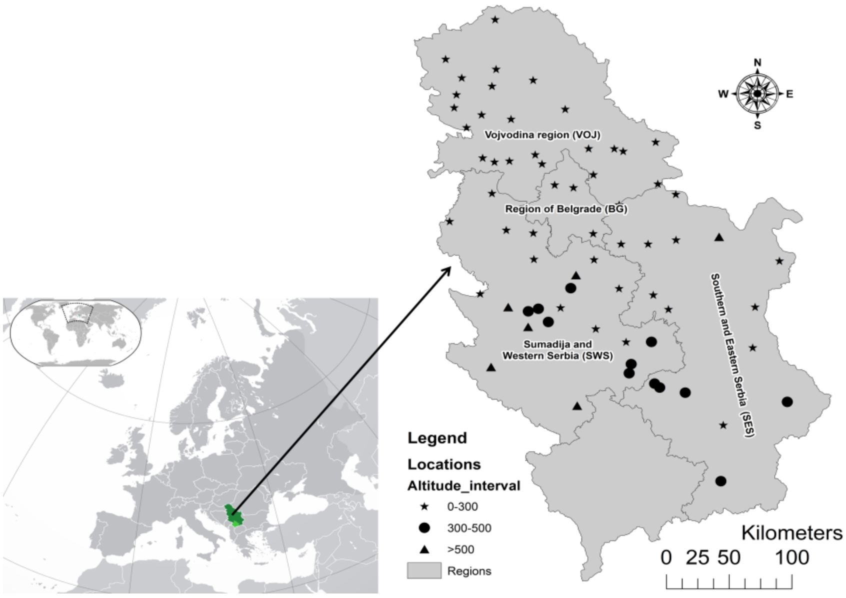

Figure 1. The map of Serbia showing locations of respondents.

They supported the survey in their comments, even though they did not take part because they were not actually farmers. For example, on the Agroklub portal (www.agroklub.rs – Agroclub), there were 165 likes, despite the fact that only three farmers responded.

Data analysis

The climate change impact level data were evaluated through descriptive statistics. The Principal Component Analysis (PCA) and the Varimax rotation were used. The suitability of the data for PCA factors was tested by the Kaiser-Meyer-Olkin Measure (KMO) and Bartlett's test. The KMO measure of sampling adequacy was higher than 0.6, with values of 0.749 and 0.769. Bartlett's test of sphericity was significant ($p=0.000$), so the factors analysis was justified. Two factors were distinguished: (i) a climate change impact on natural hazards in agriculture and (ii) the damage caused by climate change. All items had high factor loadings, which indicated factor homogeneity. Cronbach's α coefficient was used to test the reliability of the questionnaire. The reliability of the factors was satisfactory since the values of the factors were greater (>0.8) than the threshold value of 0.7. Analysis of variance (ANOVA) and Student's t-test were used to compare the means of independent samples. The correlation between two variables was tested by Pearson's coefficient. Univariate and multivariate linear regression was applied to check the predictive properties of the independent variables. The confidence level was set at $p>0.05$. XL_STAT and SPSS Ver. 24 (Statistical Package for Social Sciences) for Windows were used for statistical processing and analysis.

Results and Discussion

Most of the surveyed farmers were 25–35 years old (37.5%) and 35–55 years old (34.6%). There were 18.4% respondents younger than 25 and 9.6% older than 55. The majority of the respondents had a university education (65.4 %), followed by those who completed high school (29.3%), elementary school (3.8%), and junior college (1.6%). In terms of topography, most of the responses came from lowlands, up to 300 m above sea level (70.2%), followed by hilly areas (300–500 m, 16.3%) and mountainous regions (13.5%). Viewed by region, 31.2% of the respondents were from VOJ, 7.1% from BG, 39.7% from SWS, and 22.0% from SES. These proportions were consistent with the farming population by region (Census of Agriculture, 2012).

Figure 2 shows the types of agricultural activity of the respondents, where most of them were engaged in combined farming (62%). Only 38% were single agricultural system farmers, most of whom (16.8%) were orcharders. Of all the respondents, 58.2% were engaged in field crop farming, 49.6% in orcharding and 39.0% in animal husbandry in various combinations. The largest ranking combination was field crop farming and animal husbandry (16.6%, data not shown). Of all the respondents, 8.5% operated nurseries and grew medicinal herbs and flowers (‘other’). Fluctuating market prices and buyout uncertainty caused the farmers to follow a low-risk profit making strategy. The implication of such a business strategy is a change in actual agricultural practices and technologies.

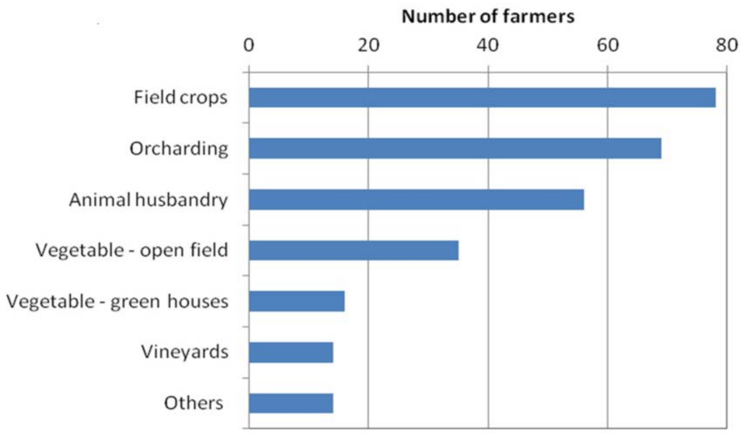

Figure. 2 Types of the agricultural activity of respondents.

The years of experience of the respondents were sorted in increments of five or ten, for a clearer representation. Most of the respondents had an 11–19-year experience in agriculture (45%), indicating that the responses came from skilled farmers, able to realistically assess the impact of climate change on their agricultural activities (Figure 3). The average experience was 18 years. Fifteen respondents did not provide specifics, stating “all my life”, “since an early age”, “for five generations”, etc.

The structure of the respondents reflected national demographics. The average age of the Serbian population is 41.4, according to the Statistical Office of the Republic of Serbia (http://publikacije.stat.gov.rs/G2017/Pdf/G201714014.pdf). Plant production is dominant in Serbia (Census of Agriculture, 2012), which was also the case in the survey. It is believed that the survey reflects a representative sample of Serbian farmers.

When asked to rate the impacts of climate change they have noted, the farmers responded: extreme high temperatures (EHT) average impact level of 4.1±1.43, drought (DR) (3.8±1.5), hail (3.1± 1.97), and late spring frost (LSFS) (2.94±1.71). Other impacts (soil water logging (SWL), extreme low temperature (ELT), snow over greenhouses (SN), flooding (FL), and soil erosion (SE) had also been observed, but to a lesser extent (Figure 4). The highest rating of 6 (extreme impact) was assigned to hail (frequency 24), DR (24), and EHT (23). This was not surprising, because hail, in addition to reducing yields by as much as 100% at times, has a protracted impact and affects next year's harvest (damaged buds, fruit-bearing branches, etc.). It is the farmers' perception that climate change is not causing floods and erosion, showing that Serbian farmers do not attribute these adverse events to climate change and do not perceive them as a threat.

Figure. 3 Respondents' years of experience in agriculture.

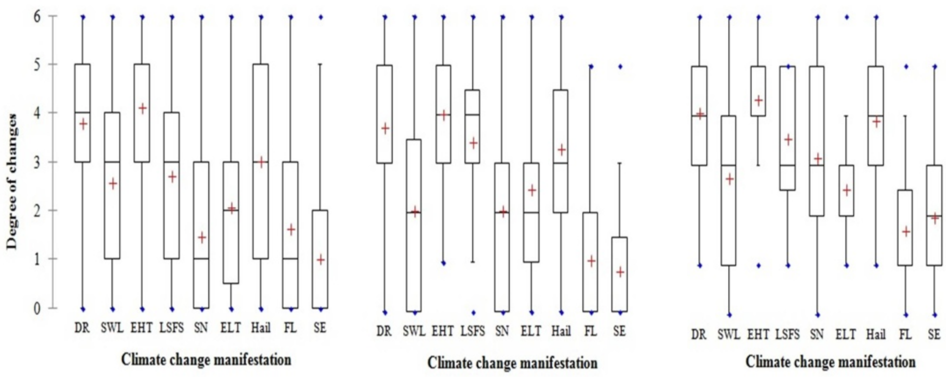

Figure. 4. Farmers' perception of climate change impact on natural hazards in agriculture at elevations: a) less than 300 m, b) 300–500 m, and c) greater than 500 m above sea level.

Legend: DR – drought; SWL – soil water logging; EHT – extreme high air temperature; LSFS – late spring frost or snow; SN – heavy snow in winter over greenhouse or fruit branches; ELT – extreme low air temperature; Hail; FL – flooding; SE – soil erosion. Symbols: + mean; – median; □ – bottom 1st quartile, top 3rd quartile.

Some of the responses varied depending on altitude. Namely, there is a higher frequency of ELT, heavy snowfall affecting greenhouses and fruit trees, and LSFS at high altitudes, above 500 m, so that the average ratings were 2.5, 3.1 and 3.5, respectively, compared to lower elevations (averaging 2.07, 1.46, 2.72, respectively). Floods and erosion were both rated as a minor impact of climate change and no respondent saw them as a threat. The proportion of zero ratings (no impact) was given by 60 and 80 respondents for floods and erosion, respectively.The answers to the question regarding the noted consequences of climate change on production and crops were evaluated based on the elevations of the holdings, given that the farmers were expected to have observed different consequences due to different climate conditions. The respondents believed that climate change had the largest impact on crop yields (YR) (Figure 5). The average rating was 3.9±1.68, with elevations from 300 to 500 m alone scoring an average of 4.3±1.58. This parameter was mostly deemed an extreme consequence (frequency 28), although some respondents stated there was no YR (frequency 3). Such responses were logical, especially in the case of greenhousing and grapevine growing, which will be discussed further below.

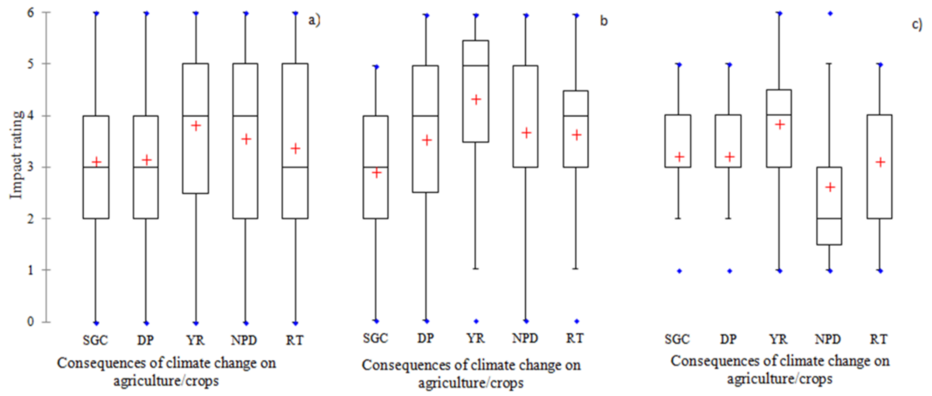

Figure 5. The level of the climate change consequences on agriculture/crops depending on elevation: a) <300 m, b) 300–500 m, and c) >500 m above sea level.

Legend: SCG – shorter growing cycle; DP – harvest; YR – yield reduction; NPD – new pests and diseases; RT – reduced tolerance to existing pests and diseases.

The high impact rating of yield leads to variations in economic gains, farm management and rural development. A moderate shortening of the growing season (SGS) was observed at all elevations, albeit more pronounced at higher altitudes (above 500 m), where the average was 3.2±1.15. Another moderate consequence was delayed harvesting of fruit and/or field crops due to rainfall (DP), somewhat more pronounced at elevations from 300 to 500 m. It is interesting to note that the farmers had observed the appearance of new pests and diseases (NPD) (moderate consequence 3.6±1.63) at elevations up to 500 m, as well as a reduced tolerance of crops to pre-existing pests and diseases. However, the respondents from higher elevations had detected fewer new invasive species (2.6±1.46) and a smaller impact on the tolerance of pre-existing invasive species (3.1±1.41). The highest frequency of responses was that all the effects were moderate (rating 3), except for YR, where the frequency of rating 5 was the highest.

The respondents provided qualitative answers to the question regarding noted positive impacts of climate change. Only 51.8% answered this question. Some of the responses were: earlier ripening, with a positive effect on product quality and revenue because of earlier market placement; good grape quality; drier corn and wheat grains, so less drying energy and time required; fewer pests in some cases; higher sugar concentrations in fruit; potential for growing citrus fruits in the foreseeable future; milder winters in the usually very cold area of Pešter, referred to as Serbian; modified spring harvest scheduling; and the like.

Nearly all the respondents answered the question regarding their estimated loss due to a negative impact of climate change, compared to standard profits within their agricultural activity. The responses of the entire sample were evaluated, but also responses by type of agricultural activity. The results did not differ much. In fact, they were identical in certain cases, for example, greenhousing (average impact rating of 1.7±0.86). Figure 6 shows only the data on that type of agricultural activity. According to the responses, the ratings were more severe. For example, the average loss in spring crop farming based on the entire sample was 2.42±0.93, whereas producers' answer was 2.65±0.85. The ratio was similar in orcharding – 2.49±1.04 to 2.98±0.73.

Orcharding reported the greatest damages – 30 to 50%. It is interesting to note that the 1^{st} and 3^{rd} quantiles coincided. This is not surprising, given that EHT and DR are believed to be the major consequence of climate change and because orcharding is mostly rainfed in Serbia and elsewhere. Hail events also affect fruit quality and price, as do LSFS, believed to be another important impact. The damages in field crop farming and vegetable growing in the open were rated as considerable (average rating of 2.65±0.84). The variation from moderate to considerable damages can be interpreted as a long-term observation, in view of actual fluctuations from year to year, because nearly all field crop farming and some vegetable growing (beans, peas, potatoes, onions, garlic, etc.) are rainfed. The damages in grapevine growing were deemed moderate (10–30%), with an average rating of 2.1±1.06. The impact of climate change on animal husbandry was attributed to forage production, such that the responses were in the moderate damage range (1.71±0.84). According to the farmers, climate change had the smallest impact on greenhousing (1.66±0.86).

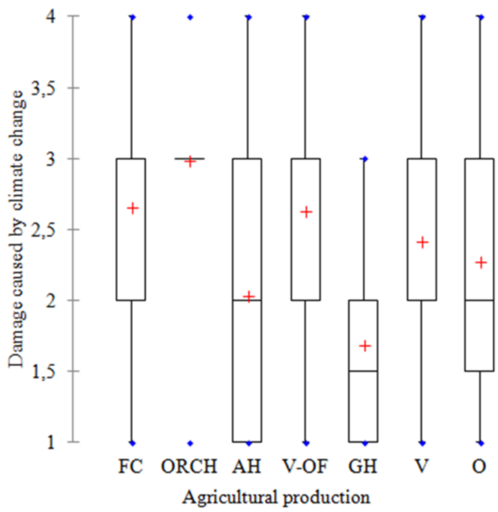

Figure 6. The loss due to climate change, compared to standard profits by type of agricultural activities (symbols explained in Table 1).

Most of the respondents (83.7%) believed that climate change awareness raising and training would be very useful. Twelve respondents did not think so, and 4.3% did not answer this question.

The differences among the various groups of respondents with regard to the two factors (climate change impacts and climate change damages) are shown in Table 2.

There was a statistically significant difference in the perceptions of the climate change impact between farmers engaged and not engaged in orcharding ($p<0.05$). Based on the average values of this factor among those engaged in orcharding (3.64±1.18) and those not engaged (3.18±1.33), it follows that orcharders perceived a higher level of exposure.

The higher score of the climate change damage factor was indicative of the level of loss sustained by the farmers. There were differences in respect of the region in question ($p<0.001$). Farmers from southern and eastern Serbia reported the largest losses due to climate change (2.28±0.76), followed by those from the Belgrade region (2.18±0.73), and Šumadija and western Serbia (2.14±0.55). Respondents from Vojvodina reported the smallest damages (1.72±0.53).

There was also a statistically significant difference between orcharders and non-orcharders ($p<0.01$). Orcharders sustained more damages (2.19±0.56) than non-orcharders (1.9±0.69).

In addition, there were differences in climate change damages with regard to farm topography ($p<0.001$). Farmers from hilly areas reported greater damages from climate change (2.22±0.63) than those in plains (1.81±0.58).

Table 2. Differences in perceptions of climate change impacts and damages among the various groups of respondents.

	Climate change impacts	p	Damages caused by climate change	p
Age				
<25	3.31±1.48	0.709[a]	2.21±0.7	0.375[a]
25–35	3.35±1.38		1.95±0.69	
35–55	3.59±1.09		2.08±0.57	
>55	3.27±1.1		1.94±0.61	
Education, n (%)				
Elementary and high school	3.52±1.06	0.448[b]	2.11±0.6	0.289[b]
University degree	3.35±1.36		1.99±0.67	
Region, n (%)				
SZS	3.39±1.19	0.519[a]	2.14±0.55	*0.001*[a]
VOJ	3.26±1.32		1.72±0.53	
BG	3.45±1.25		2.18±0.73	
SIS	3.72±1.38		2.28±0.76	
Average farm size (ha)				
<10	3.38±1.36	0.693[a]	2.07±0.68	0.704[a]
10–50	3.38±1.12		2.01±0.59	
>50	3.73±1.1		1.91±0.48	
Field crop production				
Yes	3.38±1.1	0.768[b]	2±0.59	0.340[b]
No	3.45±1.49		2.1±0.72	
Open-field vegetable production				
Yes	3.47±1.03	0.719[b]	1.98±0.54	0.508[b]
No	3.39±1.36		2.06±0.68	
Greenhousing				
Yes	3.2±1.22	0.485[b]	1.86±0.53	0.227[b]
No	3.44±1.28		2.06±0.65	
Orcharding				
Yes	3.64±1.18	*0.030*[b]	2.19±0.56	*0.007*[b]
No	3.18±1.33		1.9±0.69	
Vineyards				
Yes	3.43±0.96	0.957[b]	2.06±0.52	0.916[b]
No	3.41±1.31		2.04±0.66	
Animal husbandry				
Yes	3.26±1.37	0.086[b]	1.93±0.64	0.013[b]
No	3.64±1.08		2.21±0.61	
Other (nursery, herbs, etc.)				
Yes	3.17±1.5	0.491[b]	2.1±0.76	0.759[b]
No	3.43±1.25		2.04±0.63	
Farm topography				
Lowlands	3.21±1.29	0.118[b]	1.81±0.58	*0.000*[b]
Hills and mountains	3.55±1.23		2.22±0.63	
Years of farming experience				
Up to 10	3.41±1.2	0.882[a]	1.99±0.64	0.654[a]
10–20	3.5±1.43		1.97±0.66	
More than 20	3.35±1.17		2.09±0.52	

[a] ANOVA test; [b]Student's t-test; p – statistical significance. Note: Mean±standard deviation shown in Table 2.

Climate change impacts. The survey team also tested the statistical significance of orcharding on a regression model. Univariate regression analysis corroborated the previous finding. Orcharding explained 2% of the variance of the dependent variable ($p<0.05$). Orcharders perceived a higher level of impacts.

With regard to the climate change damage factor, the following variables exhibited statistically significant correlations: region, orcharding, topography, and altitude. All of them were statistically significant contributors to the explanation of the climate change damage factor. Region explained 9% of the variance of the dependent variable, topography also – 9%, orcharding – 4%, and altitude – 3% according to the coefficient of determination (R^2).

All the variables with more than two modalities were pre-classified so that each modality was a separate *dummy* variable. As a result, respondents from Vojvodina perceived a lower level of climate change damages than those from Šumadija and western Serbia (constant), as did orcharders and farmers from plains.

The average number of years of experience in agriculture, education, and level of general awareness of the respondents were relevant to the study. The seriousness is reflected in the fact that only three respondents gave identical answers to all the questions. The respondents' opinions about climate change manifestations coincide with actual climate parameters and trends observed during the period from 1960 to 2012 with regard to extreme high and low temperatures, droughts, and shortened growing cycles of crops. According to the SNC (2015) report, eight of the ten warmest years on record occurred after the year of 2000; the frequency of rainless periods has increased, the growing seasons were 4.5 days longer by decade, and there were 73 floods and flashfloods. According to the 2014 IPCC SRES scenarios, these trends will deteriorate in South East Europe, therefore in Serbia as well. The respondents' opinions differed only with regard to floods and erosion – they did not perceive them as a threat (or less of a threat at low elevations and moderate at high elevations). However, floods and erosion are frequent occurrences, as previously stated. Such responses can be explained by the fact that the respondents do not live in areas that have been flooded, or they have experienced only minor flood events.

The respondents' opinions about climate indicators, particularly extreme events (droughts, floods, heat waves, etc.), agree extremely well with the actual changes recorded in Serbia. Farmers tended to remember extreme events, as corroborated by a Canadian survey of farmers' recollection of droughts and floods (Marchildon et al., 2016).

Although some researchers are of the opinion that certain general indicators of the vulnerability of agriculture to climate change are too blunt and that they do not encompass the entire vulnerability context in Sweden (Neset, et al., 2018), the present research, conducted in a temperate, continental climate, provides a clear picture of the vulnerability. This pertains to both agricultural impacts and individual indicators that govern yields, such as new invasive species of pests and weeds or diseases, just like those identified by farmers in the Nordic countries (Juhola et al., 2017). It should especially be noted that microclimatic conditions, which depend on altitude, play an important role in the identification of vulnerability (Vitasse et al., 2018). Contrary to Nordic farmers, where climate change does not threaten agriculture to a level of considerable concern, this is not the case in the present research. Namely, Serbian farmers are very concerned and have realistically assessed the damages they have sustained as a result of extreme climate conditions. Studies that address the period from 1960 to 1990 show a 30–70% reduction in summer field crop yields due to drought (Avakumović et al., 2005). More recent research reports yield reductions of up to 35% for grasses, 60% for maize, and 55% for soy and sugar beets – relative to a favorable year, not the genetic potential (NAP, 2015) like in the previous studies. As such, the opinion that extreme climate events have the greatest impact on yields is realistic, as is the extent of damages that the farmers rated as considerable (30% and 50%). The concern of Serbian farmers is similar to that of farmers in Japan (Takahashi et al., 2016), Midwestern USA (Church et al., 2017) or New Zealand (Niles et al., 2015), with regard to risk and economic effectiveness.

The respondents to the present survey felt that they would benefit from awareness raising and training in connection with climate change, which would certainly have an effect on the implementation of potential adaptation measures. Even though this segment was not part of the study, it should be noted that a common trait of farmers worldwide is that they will implement adaptation measures and accept training, if available (Robinson et al., 2018; Masud et al., 2017; Khatri-Chhetri et al., 2017). Training should be organized on a regional level, to present the latest advances in climate-smart agriculture, which facilitate adapting to climate change. Such training should be arranged by the Ministry of Agriculture, in collaboration with agricultural faculties and regional agricultural advisory services.

Conclusion

The farmer survey concerning climate change manifestations coincided with actually observed climate parameters and trends during the period from 1960 to 2012, including those related to increases in extreme high and low temperatures, frequency of droughts, and shortening of crop growing cycles. The respondents assessed the impact of climate change and reported reduced yields in their respective agricultural activity. The survey provided a clear picture of the vulnerability, with regard to the overall agricultural impact and the effect on certain individual yield indicators, such as the appearance of new invasive species of pests, weeds and diseases under temperate continental climate conditions. Fully aware of the exposure and impacts, the respondents expressed readiness for additional training, in order to prepare for climate change impact adaptation and mitigation measures.

Acknowledgements

The paper was produced within the scope of the Project contract no. 451-03-68/2020-14/200116 between the University of Belgrade, Faculty of Agriculture and by the Serbian Ministry of Education, Science and Technology.

References

Avakumović, D., Stričević, R., Đurović, N., Stanić, M., Dašić, T., & Đukić, V. (2005). Contemporary analysis of irrigation water requirement. *Vodoprivreda, 37* (213-215), 11-20.

Azhoni, A., & Goyal, M.K. (2018). Diagnosing climate change impacts and identifying adaptation strategies by involving key stakeholder organisations and farmers in Sikkim, India: Challenges and opportunities. *Science of The Total Environment, 626*, 468-477.

Barkmann, T., Siebert, R., & Lange, A. (2017). Land-use experts' perception of regional climate change: an empirical analysis from the North German Plain. *Climatic Change, 144* (2), 287-301.

Church, S.P., Dunn, M., Babin, N., Mase, A.S., Haigh, T., & Prokopy, L.S. (2018). Do advisors perceive climate change as an agricultural risk? An in-depth examination of Midwestern US Ag advisors' views on drought, climate change, and risk management. *Agriculture and Human Values, 35* (2), 349-365.

Census of Agriculture (2012). Statistical Office of the Republic of Serbia. Retrieved February 3, 2019 from http://www.stat.gov.rs/sr-cyrl/publikacije/.

Ćosić, M., Lukić, M., Stričević, R., & Đurović, N., (2011). Irrigation development in Western Serbia. In Melioracije (Ed. University of Novi Sad, Faculty of Agriculture), *Proceedings of the Conference on soil and water management 11*. (pp. 122-128). Novi Sad, Serbia.

EEA - European Environment Agency, (2017). Retrieved November 28, 2018 from https://www.eea.europa.eu/data-and-maps/figures/key-past-and-projected-impacts-and-effects-on-sectors-for-the-main-biogeographic-regions-of-europe-3.

Forzieri, G., Feyen, L., Russo, S., Vousdoukas, M., Alfieri, L., Outten, S., & Cid, A. (2016). Multi-hazard assessment in Europe under climate change. *Climatic Change, 137* (1-2), 105-119.

Findlater, K.M., Satterfield, T., Kandlikar, M., Donner, S.D. (2018). Six languages for a risky climate: how farmers react to weather and climate change. *Climatic Change, 148* (4), 451-465.

Grimberg, B.I., Ahmed, S., Ellis, C., Miller, Z., & Menalled, F. (2018). Climate Change Perceptions and Observations of Agricultural Stakeholders in the Northern Great Plains. *Sustainability, 10* (5), 1687.

Grothmann, T., & Patt, A. (2005). Adaptive capacity and human cognition: the process of individual adaptation to climate change. *Global Environ. Change* 15 (3), 199-213.

Holland, M.B., Shamer, S.Z., Imbach, P., & Harvey, C.A., (2017). Mapping adaptive capacity and smallholder agriculture: applying expert knowledge at the landscape scale. *Climatic Change, 141* (1), 139-153.

IPCC (2014). Climate Change 2014: Impacts, Adaptation and Vulnerability. Part A: Global and Sectoral Aspects. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change [Field, C.B., V.R. Barros, D.J. Dokken, K.J. Mach, M.D. Mastrandrea, T.E. Billir, M. Chatterjee, K.L. Ebi, Y.O. Estrada, R.C. Geniova, B. Girma,

E.S. Kissel, A.N. Levy, S. MacCracken, P.R. Mastrandrea and L.L. White (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA, pp. 1132.
IPCC (2013). Climate Change 2013: The Physical Science Basis. Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change [Stocker, T.F., D. Qin, G.-K. Plattner, M. Tignor, S.K. Allen, J. Boschung, A. Nauels, Y. Xia, V. Bex and P.M. Midgley (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA, pp. 1535, doi:10.1017/CBO9781107415324.
IPCC (2019). Summary for Policymakers. In: Climate Change and Land: an IPCC special report on climate change, desertification, land degradation, sustainable land management, food security, and greenhouse gas fluxes in terrestrial ecosystems [P.R. Shukla, J. Skea, E. Calvo Buendia, V. Masson-Delmotte, H.- O. Pörtner, D. C. Roberts, P. Zhai, R. Slade, S. Connors, R. van Diemen, M. Ferrat, E. Haughey, S. Luz, S. Neogi, M. Pathak, J. Petzold, J. Portugal Pereira, P. Vyas, E. Huntley, K. Kissick, M. Belkacemi, J. Malley, (eds.)]. In press.
Jacob, D., Petersen, J., Eggert, B., Alias, A., & Georgopoulou, E. (2014). EURO-CORDEX: new high-resolution climate change projections for European impact research. *Regional Environmental Change* 1, *14* (2), 563-578.
Jancic, M., Lalic, B., Mihailovic, D.T., & Jacimovic, G. (2015). Impact of climate change and carbon dioxide fertilization effect on irrigation water demand and yield of soybean in Serbia. *The Journal of Agricultural Science*, *153* (08), 1365-1379.
Jankó, F., Németh, N., Bertalan, L., & Pappné Vancsó, J. (2017). Perceptions of climate change and adaptation in Hungarian agriculture: results of an interview study. *Studies in agricultural economics*, *119* (2), 55-61.
Juhola, S., Klein, N., Käyhkö, J., & Neset, T.S.S. (2017). Climate change transformations in Nordic agriculture?. *Journal of rural studies*, *51*, 28-36.
Khatri-Chhetri, A., Aggarwal, P.K., Joshi, P.K., & Vyas, S. (2017). Farmers' prioritization of climate-smart agriculture (CSA) technologies. *Agricultural systems*, *151*, 184-191.
Lalic, B., Eitzinger, J., Mihailovic, D.T., Thaler, S., & Jančić, M. (2013). Climate change impacts on winter wheat yield change – which climatic parameters are crucial in Pannonian lowland? *The Journal of Agricultural Science*, *151*, 757-774.
Li, C., Leal Filho, W., Wang, J., Yin, J., Fedoruk, M., Bao, G., & Hu, R. (2018). An assessment of the impacts of climate extremes on the vegetation in Mongolian Plateau: Using a scenarios-based analysis to support regional adaptation and mitigation options. *Ecological Indicators*, *95*, 805-814.
Marchildon, G.P., Wheaton, E., Fletcher, A.J., & Vanstone, J. (2016). Extreme drought and excessive moisture conditions in two Canadian watersheds: comparing the perception of farmers and ranchers with the scientific record. *Natural Hazards*, *82* (1), 245-266.
Masud, M.M., Azam, M.N., Mohiuddin, M., Banna, H., Akhtar, R., Alam, A.F., & Begum, H. (2017). Adaptation barriers and strategies towards climate change: Challenges in the agricultural sector. *Journal of Cleaner Production*, *156*, 698-706.
Mihailović, D.T., Lalić, B. Drešković, N., Mimić, G., Djurdjević, V., & Jančić, M. (2015). Climate change effects on crop yields in Serbia and related shifts of Köppen climate zones under the SRES-A1B and SRES-A2. *International Journal of Climatology*, *35*, 3320-3334.
NAP (2015). First national adaptation plan in climate change condition. Ministry of Agriculture and environmental protection. Retrieved December 3, 2018 from http://www.klimatskepromene.rs/wp-content/uploads/2017/09/NAP-UNDP-2015-srpski.pdf
Neset, T.S., Wiréhn, L., Opach, T., Glaas, E., & Linnér, B.O. (2018). Evaluation of indicators for agricultural vulnerability to climate change: The case of Swedish agriculture. *Ecological Indicators*. https://doi.org/10.1016/j.ecolind.2018.05.042.
Niles, M.T., Lubell, M., & Brown, M. (2015). How limiting factors drive agricultural adaptation to climate change. *Agriculture, Ecosystems & Environment*, *200*, 178-185.

Robinson, G.M., Bardsley, D.K., Raymond, C.M., & Bardsley, A.M. (2018). Adapting to Climate Change: Lessons from Farmers and Peri-Urban Fringe Residents in South Australia. *Environments*, *5* (3), 40.

Republic Hydrometeorological Service (Republic of Serbia). Retrieved April 1, 2019 from http://www.hidmet.gov.rs/ciril/meteorologija/klimatologija_srbije.php.

Ruml, M, Vuković, A., Vujadinović, M., Djurdjević, V., Ranković-Vasić, Z., Atanacković, Z., Sivčev, B., Marković, N., Matijašević, S., & Petrović, N. (2012). On the use of regional climate models: implications of climate change for viticulture in Serbia. *Agricultural and Forest Meteorology*, *158*, 53-62.

SNC (2015). Second report of the Republic of Serbia under the United Nations Framework Convention on Climate Change. Ministry of Agriculture of Republic of Serbia. Retirieved March 30, 2019 from http://www.klimatskepromene.rs/wp-content/uploads/2017/12/Drugi-izvestaj-o-promeni-klime-SNC_Srbija.pdf

Statistical year book (2018). Retrieved March 3, 2019 from http://www.stat.gov.rs/sr-cyrl/publikacije/publication/?p=11525.

Statistical office of R. Serbia Retrieved March 15, 2019 from http://publikacije.stat.gov.rs/G2017/Pdf/G201714014.pdf

Stričević, R.J., Djurović, N.Lj., Vuković, A.J., Vujadinović, M.P., Ćosić, M.D., & Pejić, B.S. (2014). Application of Aquacrop model for yield and irrigation requirement estimation of sugar beet under climate change conditions in Serbia. *Journal of Agricultural Sciences*, *59* (3), 301-317.

Stricevic, R., Stojakovic, N., Vujadinovic-Mandic, M., & Todorovic, M. (2018). Impact of climate change on yield, irrigation requirements and water productivity of maize cultivated under the moderate continental climate of Bosnia and Herzegovina. *The Journal of Agricultural Science, 156* (5), 618-627.

Takahashi, B., Burnham, M., Terracina-Hartman, C., Sopchak, A.R., & Selfa, T. (2016). Climate change perceptions of NY state farmers: the role of risk perceptions and adaptive capacity. *Environmental management*, *58* (6), 946-957.

Varela-Ortega, C., Blanco-Gutiérrez, I., Esteve, P., Bharwani, S., Fronzek, S., & Downing, T.E. (2016). How can irrigated agriculture adapt to climate change? Insights from the Guadiana Basin in Spain. *Regional environmental change*, *16* (1), 59-70.

Vitasse, Y., Schneider, L., Rixen, C., Christen, D., & Rebetez, M. (2018). Increase in the risk of exposure of forest and fruit trees to spring frosts at higher elevations in Switzerland over the last four decades. *Agricultural and Forest Meteorology*, *248*, 60-69.

Woods, B.A., Nielsen, H.Ø., Pedersen, A.B., & Kristofersson, D. (2017). Farmers' perceptions of climate change and their likely responses in Danish agriculture. *Land Use Policy*, *65*, 109-120

Received: February 20, 2020
Accepted: July 24, 2020

RANJIVOST POLJOPRIVREDE NA KLIMATSKE PROMENE U SRBIJI - PROCENA UTICAJA I ŠTETA PO MIŠLJENJU POLJOPRIVREDNIKA

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R e z i m e

U skladu sa već osmotrenim trendovima povećanja temperature vazduha, izmenjenog režima padavina i produžetka vegetacione sezone, kao i sa predviđanjima da će se klimatski uslovi u Srbiji izrazito pogoršavati, a rizici u poljoprivrednoj proizvodnji povećavati, cilj ovog rada je da se proceni ranjivost poljoprivredne proizvodnje u Srbiji pod uticajem klimatskih promena na osnovu percepcije poljoprivrednika. Tim eksperata iz svih oblasti poljoprivrede i upravljanja vodama i zemljištem, sastavio je pitanja za onlajn anketu, poluotvorenog tipa. Prikupljanje podataka je vršeno putem interneta, uglavnom se oslanjajući na društvene mreže. Na upitnik je odgovorio ukupno 141 ispitanik. Analiza podataka je vršena putem deskriptivne statistike, a primenjena je analiza glavnih kompomenti (PCA) sa Varimax rotacijom. Uočena su dva faktora: (i) uticaj klimatskih promena na rizike u poljoprivredi, i (ii) šteta izazvana klimatskim promenama. Analiza varijanse (ANOVA) i Studentov t test korišćeni su za ispitivanje uzoraka nezavisnih od razlike, dok je povezanost dve promenljive testirana Pirsonovim koeficijentom. Na osnovu dobijenih podataka, analizirane su štete koje poljoprivrednici trpe usled klimatskih promena i smanjenje prihoda u odnosu na uobičajene prihode, a shodno proizvodnji kojom se poljoprivrednici bave. Takođe su identifikovani pozitivni uticaji klimatskih promena. Sagledana je potreba za obukom u oblasti ublažavanja uticaja klimatskih promena. Po mišljenju poljoprivrednika, najznačaniji uticaji klimatskih promena su pojave ekstremno visoke temperature, suša i pojava kasnih prolećnih mrazeva i grada. Klimatske promene su se najviše odrazile na pad prinosa, pojavu novih bolesti i štetočina i na smanjenje tolerantnosti useva na postojeće štetočine i bolesti. Poljoprivrednici su pokazali veliku zainteresovanost za obuku o merama adaptacije i ublažavanja uticaja klimatskih promena u poljoprivredi.

Ključne reči: klimatske promene, osetljivost poljoprivrede, uticaji, upitnik.

Primljeno: 20. februara 2020.
Odobreno: 24. jula 2020.

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Journal of Agricultural Sciences (Belgrade)
Vol. 65, No. 3, 2020
Pages 283-296

https://doi.org/10.2298/JAS2003283M
UDC: 637.35(497.11)
Original scientific paper

ECONOMIC INDICATORS OF PRODUCTION OF SEMI-HARD AND HARD CHEESES IN SMALL CAPACITY DAIRIES IN SERBIA

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Abstract: Animal husbandry has a longstanding tradition in Serbia, and the production of milk and dairy products has a rich legacy. Cow's milk is used in the manufacture of all kinds of dairy products. Annual global cheese production is about 20 million tons, with cattle milk cheeses produced in large-scale processing plants constituting about 80% of that production. In Serbia, leaders of milk production are small family dairy farms, which contribute 92% of total production, while dairies with large capacity dominate in milk processing. There are 211 milk processing plants of varying capacities in Serbia. The largest amounts of milk are processed by dairy plants 'Imlek' and 'Subotica', while 188 small-scale dairies process 20% of total milk. The subject of this paper is the analysis of the economic indicators of production of semi-hard and hard cheeses in small-capacity dairies in Serbia. To determine the level and structure of production costs of dairy products, the analytical calculation method of per unit processing costs has been used. The study has revealed that the cost price of semi-hard and hard cheeses in small-capacity dairies amounts to 3.33 €/kg. With 90.83% in the structure of total costs of processing the milk into cheese, the cost of raw materials has the largest share, followed by labor costs with 6.54%. For small-capacity dairies to be able to compete with larger dairies, both in product quality and price, it is crucial to continuously monitor and minimize production costs.

Key words: hard cheese, semi-hard cheese, economic indicators of production, small-capacity dairy, competitiveness.

Introduction

Animal husbandry has a longstanding tradition in Serbia, and the production of milk and dairy products has a rich legacy. The potential growth of animal husbandry is dependent on several variables, the main ones being natural conditions, population, the acreage of agricultural land and the structure of the soil,

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the organization of agricultural production, the type of technology, breed of cattle and the overall level of economic development. As Steinfeld et al. (2006) state, animal production is changing rapidly in the world adapting to global requirements for the high quality of food products and continually adapting at the level of resource utilization and marketing activities. One of the trends is specialization in production. The specialization in production defines not only the structure of assortment of final products but also the revenues and expenses generated in production, which is reflected in the economic effects (Nedić et al., 2019). The development of the dairy industry in Serbia rests on its historical legacy and tradition of the use of milk and dairy products for domestic consumption. Milk has over time become a market commodity from a product of subsistence farming. Biotechnical factors such as animal selection, feeding and breeding technology, to name a few, have contributed significantly to the growth of the dairy industry. In addition, the development and manufacture of traditional products with protected geographical indication have improved their market visibility and positioning and ensured an enormous profit (Zekić et al., 2012). Also, the dairy sector generates employment and business opportunities, particularly in the rural and peri-urban areas. Many people in urban areas are also involved in the dairy-based business (Sekovska et al., 2015). From an economic point of view, milk production is interesting as it is a daily production which presupposes faster marketing, which accelerates capital movement in agriculture, which in turn enhances liquidity (Rosman et al., 2016).

Milk is used for the manufacture of a number of products: sour milk, yoghurt, cheeses, cream, butter, etc. Some dairy products can be prepared in elementary technical conditions while others require suitable technical equipment, usually of big capacity, found only in large-scale dairy plants. To be sold to final customers, milk has to be subjected to specific methods of control, processing and packaging.

In terms of quantity, cow's milk dominates in the market. On the other hand, even though despite the fact that goats produce only 2% of world milk production, health benefits of goat's milk have increasingly been highlighted, resulting in its increasing production over the past 20 years. There are 270 million milking cows in the world (FAO, 2019), and most of them are raised in Asia, with India's share of 45 million, which makes 16% of the total number of milking cows in the world. The global average for milk production is still very humble, amounting to 2.300 litres per cow (IFCN, 2019). Milk yields vary across the world, with animals having far higher yields in developed than in developing countries. One of the reasons why developed countries have higher milk yields is to be found in the fact that specialized dairy breeds such as Holstein dominate in their milk production whereas beef breeds with lower milk yields are prevalent in developing countries.

Cattle milk yield is the highest in North America, amounting to 9,700 litres, whereas Europe has 6 thousand litres per milking cow. High milk yield per head is present in the USA, Canada, Holland and Denmark, and the highest milk yield per head, amounting to just over 11 thousand liters, is achieved in Israel with a relatively small number of cattle (FAO, 2019).

Global milk production is 635 million tons, and Europe is the largest producer, constituting over 40 percent of the total milk production in the world (FAO, 2019). The world's leading milk producer is the USA, producing 92 million tons, and the largest milk processing companies, in addition to the USA, are located in New Zealand, France, Switzerland and Holland (FAO, 2019). A tiny amount of 12 million tons reaches the international trade of cattle consumer milk, which constitutes about 2% of global production. The value of milk exports is over $9 billion a year, and the export price varies due to a number of factors. The leading global exporter of consumer milk is Germany, followed by Italy, Belgium and Holland. The consumption of milk and dairy products is chiefly determined by factors such as the volume of production, level of market prices, and level of income (Veljković et al., 2015). With growing incomes, people typically increase their consumption of meat, milk and eggs until these products become fully integrated into the daily diet (Steinfeld et al., 2006). In developed countries, consumers buy more animal and dairy products.

Annual global cheese production is about 20 million tons (FAO, 2019), with cattle milk cheeses produced in large-scale processing plants constituting about 80% of that production. The remaining share is produced in households, of cattle, goat, sheep and buffalo milks. About 80% of global cheese production is made in Europe and North America. Average annual cheese trade is over 5 million tons, which constitutes about 26% of total global cheese production. The largest cheese exporters in the world are: Germany, France, Holland, Italy, Denmark, Australia, New Zealand, Belgium, Ireland and England. The USA is the largest producer of cheese but a small exporter, with 4.4% of the total output, because most of it is sold in the country. Leading world importers of cheese are: Germany, England and Italy. The largest cheese consumption is in France, Luxembourg, Germany and Iceland, above 24 kilograms per capita, while the smallest one is in China, with only 0.1 kilogram annually per capita. In the structure of cheese consumption, soft cheeses dominate over semi-hard and hard ones, mainly because of their lower retail price.

In Serbia, there are about 450 thousand milking cows and heifers (SORS, 2019). Regionally, the largest number of cows is raised in the Zlatibor region, which contributes about 10% of the total number of cows in Serbia. Compared to earlier periods, the number is decreasing. Milk is the second most important livestock product and accounts for about 30% of the total value of livestock production (Jakšić et al., 2015). The output of cattle milk per milking cow in Serbia is unsatisfactory and very low (Popović-Vranješ, 2015), amounting to an average of 3,200 litres, which is below the European average. Milk production is 1.5 billion litres, which is 207 litres per capita (SORS, 2019). Serbia is the regional leader in milk production, compared to other members of the former Yugoslavia. Its geographic location ensures favorable possibilities for the development of trade in milk and dairy products (Popović-Vranješ, 2015). The dairy industry in Serbia is more profitable than the Slovenian and Croatian dairy industry, despite comparatively worse conditions of the business environment. The profitability of the dairy industry in Serbia is a consequence of high prices, lower production costs and lack of EU legislation regarding competition and the free market (Muminović and Pavlović, 2012). Despite this, livestock products are not present in the top ten major agro-food products exported from Serbia (Đukić et al., 2017).

Further improvement of the structure of Serbian exports of agro-food products from Serbia should be based on greater participation of livestock products, as well as other agro-food products with a higher degree of processing (Đukić et al., 2017). A dual production structure characterizes Serbian agriculture. On the one hand, there is a large agricultural sector, and on the other hand, an individual production sector. The large agricultural sector represents the modern part of Serbian agriculture with a higher level of production intensity. Agricultural companies are highly market-oriented, and they are responsible for the food security of the country, but they also create significant surpluses which made Serbia a net exporter of agricultural products for the last ten years (Milić et al., 2018). Leaders of milk production, however, are small family dairy farms, which contribute 92% of total production. The supply of milk to processing plants is subject to seasonal variation. Uneven milk supply is due to several reasons, mainly that of food source during winter months. Variations in milk quality (seasonal variation of milk fat and protein) have a considerable influence on the amount of milk per product, and the final price of the product, which could lead to difficulties in the sale (Popović-Vranješ et al., 2017). There are 211 milk processing plants of varying capacity in Serbia. Research shows that large-scale companies in the milk industry in Serbia make a larger profit than small-scale companies (Milošević Avdalović, 2018). The largest amounts of milk are processed by dairy plants ‘Imlek’ and ‘Subotica’, with ‘Imlek’ having the largest milk processing capacity of over 500 thousand litres a day. ‘Imlek’ is followed by 188 small-scale dairies, which process 20% of milk, and 15 larger dairies with the share of 17%, the Šabac dairy plant processes 5.8%, the Somboled dairy plant from Sombor participates with 5.4% and ‘Mlekoprodukt’ from Zrenjanin with the share of 3.9%. According to data from Eurostat (2019), cheese production in Serbia is on the average of about 55 thousand tons with a slight increase. The most important export market is the Russian Federation, with an average annual sales of 6.8 thousand tons, or 63.5% of total exports (Vlahović et al., 2018). Serbia’s share in the global cheese exports and imports is symbolic: only 0.07% and 0.02% respectively. Serbia has a modest export of cheeses to the market of EU countries primarily due to high demands in terms of production standards, quality of cheese and specific assortment (Vlahović et al., 2018). Dairy products from Serbia are not always competitive in terms of production costs, prices and quality, which creates additional difficulties for their positioning in foreign markets. The most promising group of products is the production and export of cheese (Veljković et al., 2015). Currently, the export is dominated by fresh and soft cheeses that have a lower price than hard cheeses (Vlahović et al., 2018). Small-scale dairies have a small processing capacity while with respect to other functions, they are competitive to commercial dairy plants. For small-capacity dairies to be able to compete with larger dairies, both in product quality and price, it is crucial to monitor and minimize production costs continuously.

Based on the financial analysis of a representative small-scale dairy producer in Serbia, this paper aims to investigate economic indicators of processing the milk into semi-hard and hard cheeses in small-scale processors. The paper also aims to calculate the cost price taking into account milk processing costs required to produce two prevalent dairy products, semi-hard and hard cheeses, and to discover how and to what extent these costs affect the operation of small-scale processors.

Materials and Methods

The analytical calculation method of per unit processing costs has been used (Marko et al., 1998) for the identification of production costs (total costs, costs structure). These costs were included in the analysis: the direct material costs (the cost of raw materials, packaging and labelling), depreciation costs, labor costs (wages) and transport costs. Total costs are calculated by summarizing fixed and variable costs and calculating total and individual costs per unit.

The representative small-scale dairy producer keeps 100 Simmental and Holstein dairy cattle in freestall barns with a deep bedding system. The range of milk products is about 25, and it includes pasteurized milk, fermented products, kashkaval, plastic-curd cheeses, processed cheeses, fresh cheeses and semi-hard cheeses. Based on its production capacity and annual results, this dairy is taken as a representative one in Serbia for this study.

The period of analysis ranges from 2014 to 2016. The data are based on field research and the official data and publications of The Statistical Office of the Republic of Serbia, Euro and FAO statistics.

Results and Discussion

Processing Milk into Dairy Products

Today, the market increasingly offers new and enriched dairy products, thus resulting in the development of a new generation of dairy products with different properties and improved nutritional values and health benefits. As a staple food, cheese is a fresh or ripened product which is a result of coagulation of proteins in milk, with whey remaining after the separation of curd. Cheeses can be classified according to various criteria such as the type of milk used in cheese production, fat in dry matter, consistency, texture, methods of production, etc. There are fresh soft and cottage cheeses, brined cheeses, which are typically found in the Balkans, etc. Semi-hard cheeses like Gouda and Edamer are the most widespread group of cheeses in the world, and they are produced in all countries by using both traditional and modern methods (Popović – Vranješ et al., 2017).

Production costs and cost price structure

Manufacturers of milk products have no control over selling prices of their products because prices are determined at the market and are subject to supply and demand, but they have control over production costs and cost price of their products. Since production costs are a segment that manufacturers can directly control, it is necessary to analyze their level, structure and impact on the total production. Reducing unnecessary costs increases profit. In this study, the following costs have been analyzed: direct material costs, labor costs, transport costs, depreciation costs and other overhead costs.

The direct material cost is the monetary value of physical amounts of materials used to make certain products. Milk and other raw materials, packaging and labelling material are the main raw materials used for cheese production.

The prices of analyzed products are calculated based on their purchase price in 2016 (Table 1). The total cost of raw materials of semi-hard cheese with a minimum of 45% fat amounts to 3.02 € per one kilogram of the product. The study has revealed that the total cost of hard cheese with a minimum of 35% fat amounts to 3.02 € per one kilogram of the product, which is the same as in the production of semi-hard cheese.

Table 1. Prices of milk and cheese in the period 2014–2016 (€).

Year	2014		2015		2016	
Product name	Product price (€/kg)	Average milk price (€/l)	Product price (€/kg)	Average milk price (€/l)	Product price (€/kg)	Average milk price (€/l)
Semi-hard cheese with a minimum of 45% fat	3.10	0.233	3.04	0.229	3.02	0.227
Hard cheese with a minimum of 35% fat	3.10	0.233	3.04	0.229	3.02	0.227

Source: Authors’ calculation.

The share of the cost of raw materials in the total cost of the production of semi-hard cheese with a minimum of 45% fat and hard cheese with a minimum of 35% fat is shown in Figure 1.

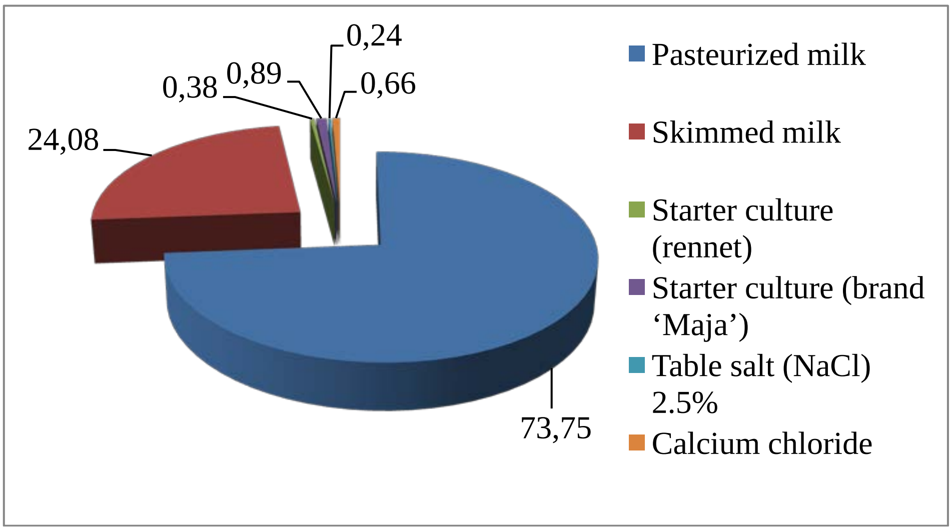

Figure 1. The structure of raw material costs in cheese production.

As shown above, the largest share in total raw material costs is found in pasteurized milk (73.75%), skimmed milk (24.08%) and starter cultures (1.27% and 1.87%). The production of semi-hard and hard cheeses requires 13 litres of milk, whereas yogurt and sour milk require smaller amounts (1 litre and 0.7 litre). The same raw materials at the same prices are used for the production of both semi-hard and hard cheeses, but the manufacturing method and technology are different. Milk has the largest share in total costs of production and its price impacts the price of the final product. The change in the cost of raw materials used to manufacture the product will have an impact on the final cost of the product, and therein lies the particularity of the production and costs, because every product consists of a number of components all of which have their market value (Milić et al., 2019b). In the analyzed period, the price of dairy products remains the same, which is a result of the steady average price of milk. Differences in milk collection cause slight differences in the average prices of milk in the observed three years.

As shown above, prices of milk have not changed dramatically in the analyzed period and have not influenced the cost price and selling price of the final product.

The previous table shows that the price of semi-hard and hard cheeses increases by 0.11 € per kilogram, which is a 3.5% increase. Every price increase leads to an increase of the final product price. An increase of 3.57% (for 1 RSD or

0.008 €) of the price of any other raw material does not lead to a significant increase in the price of final products.

Table 2. The influence of the milk price on the price of semi-hard and hard cheeses.

The name of a dairy product	The amount of milk in dairy products (l)	The price of dairy products in 2016 (€/kg)	The price of dairy products after the price of milk increased by 3.57% (€/kg)	The difference in the price after the increase (€)
Semi-hard cheese with a minimum of 45% fat	13	0.229	3.13	0.11
Hard cheese with a minimum of 35% fat	13	0.229	3.13	0.11

Source: Authors' calculation.

Packaging materials and conditions of packaging are important factors which have an impact on the quality of the product in storage (Milić et al., 2019a). Bags which are in direct contact with the product have to observe food safety standards and regulations, which entails not allowing their substances to migrate into the product or to migrate in allowed amounts and enter into chemical reactions with the product. Materials used in food bags today are polymeric materials, and materials most commonly used for milk and dairy product bags and containers are polyethylene, polyethylene terephthalate, polypropylene, polyvinyl chloride and others. Although it is generally required for bags to be inert and not to interact with the packed dairy product, current trends are focused on the development of bags that include certain interactions in order to extend the shelf life. This provides the so-called active, smart or intelligent packaging concept (Ščetar et al., 2018).

The bags and labels are different for different products and influence the cost price. Semi-hard cheese comes in pieces of 600g and 1.2kg, and it is packaged in cheese bags. Hard cheese comes in pieces of 300g and 600g and blocks of 1.2kg, and it is also packaged in cheese bags.

The price of cheese bags ranges from 0.014 to 0.016 €, which constitutes 0.30% to 1.11% of the final price of the product. The purchase price of the label ranges from 0.014 to 0.015 €, depending on what is emphasized on the label, quantity and color, which constitutes 0.29% to 1.04% of the final price of the product. For analyzed products, the highest costs are in the production of cheese in 300g bags.

Transport costs can vary depending on many factors (types of vehicles, products, transport distances, locations, etc). In the analyzed small-capacity diaries, their own transport vehicles with a capacity of 3.5 tones were taken into account. Transport costs amount to about 0.68% or 0.023 € per kilogram of produced cheese. It can be concluded that transport costs depend mostly on the transport destination, the quantity and price of fuel and can significantly affect the price of the final product.

Table 3. The cost of bags and labels of semi-hard and hard cheeses.

Item	Purchase price [€]	Share in the total product price [%]
	Semi-hard cheese – 600 g	
Bag	0.015	0.57
Label	0.014	0.54
	Semi-hard cheese – 1.2 kg	
Bag	0.016	0.32
Label	0.015	0.30
	Hard cheese – 300 g	
Bag	0.015	1.11
Label	0.014	1.04
	Hard cheese – 600 g	
Bag	0.015	0.55
Label	0.014	0.52
	Hard cheese – 1.2 kg	
Bag	0.016	0.30
Label	0.015	0.29

Source: Authors' calculation.

Depreciation costs are calculated for buildings, machinery and equipment. The analysis assumes that the dairy is comprised of the following buildings: an administration building, a processing plant, a warehouse for finished products, a warehouse for intermediate goods, a collection centre, a collection point in the dairy and a laboratory. Machinery and equipment consist of the milk processing line, vehicles for transportation of milk and finished dairy products, milk processing equipment, and fillers.

Labor costs refer to gross wages, which means the amount before any obligatory deductions are made from employee paychecks. To calculate labor costs of the observed dairy, it is taken that it has 90 employees, with 16 of them employed in administrative tasks and 74 in the hands-on production and transportation of dairy products. In the analyzed period, an average share of gross wages is 0.30 €/l or 0.22 €/kg of the dairy product.

Overhead costs amount to about 1% of total costs and cannot be taken as significant in the analysis compared with other costs. These costs include: electricity costs, telecommunication costs, indirect material costs, depreciation costs and other costs. In this case, overhead costs amount to 0.033 € annually and per kilogram. Overhead costs indirectly affect the cost price of the final product, through the costs of the entire production line. Labor costs and overhead costs are relatively constant, and they do not fluctuate considerably (Milić et al., 2019a).

Table 4 shows the structure of the cost price of two types of cheese.

Table 4. The structure of the cost price of semi-hard and hard cheeses.

Costs		Semi-hard cheese with a minimum of 45% fat (€/kg)	Hard cheese with a minimum of 35% fat (€/kg)	Share (%)
1	Raw materials	3.02	3.02	90.83
2	Transportation	0.023	0.023	0.68
3	Packaging	0.034	0.034	0.95
4	Labor costs	0.22	0.22	6.54
5	Overhead costs	0.033	0.033	1.00
Total:		3.33	3.33	100

Source: Authors' calculation.

As shown above, costs of 1 kilogram of semi-hard and hard cheeses are 3.33 €/kg without the VAT.

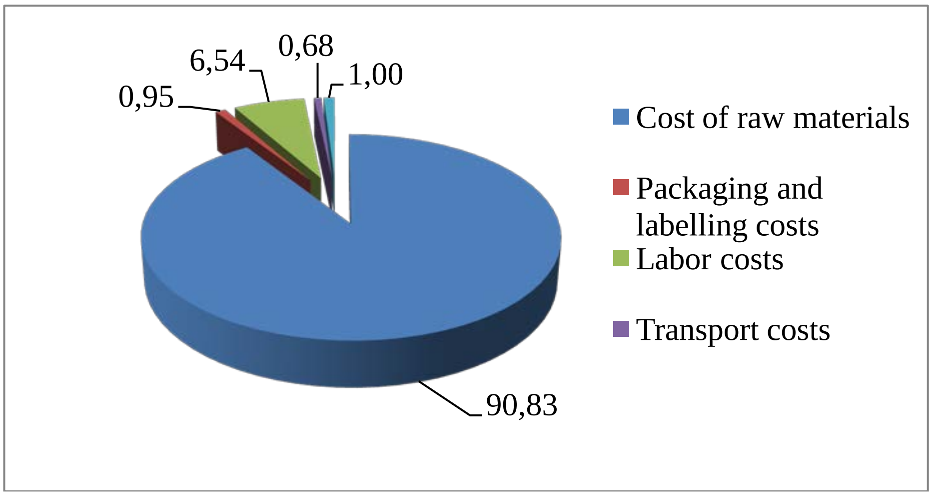

Figure 2. The structure of individual costs in total costs of cheese production.

The costs of raw materials for the production of both types of cheese have the largest share and amount to 90.83% because raw materials are the main ingredients of the final product. In terms of the share and importance, the cost of raw materials is followed by labor costs of 6.53%, overhead costs of 1% and transport costs of 0.68%.

In order to achieve a higher market share than the competition, small-capacity dairies should pay special attention to the level of each production cost (especially costs of raw material) without compromising the quality of the final product.

Conclusion

The production of milk and its processing into dairy products is one of the significant areas of agricultural development in Serbia. There are 211 dairy processing plants in Serbia, and most milk is processed by large-scale dairies ‘Imlek’ and ‘Subotica’. On the other hand, the number of small-scale dairies is growing, and currently, they are manufacturing 20% of all dairy products, with an increasing tendency. Among all dairy products, the production of semi-hard and hard cheeses requires an extended period of production and ripening, and these two types of cheese have a higher selling price than other dairy products, but also a longer realization period and durability in the market. In the structure of cheese consumption, soft cheeses are more dominant than semi-hard and hard cheeses, mainly due to their lower retail price. There is a fierce rivalry among producers of milk and dairy products in the market. In order to be competitive, all producers should continuously monitor production costs and strive to minimize them.

The analysis has shown that the cost price of semi-hard and hard cheeses in a small-capacity dairies amounts to 3.33 € per kilogram. As the calculations show, processing milk into semi-hard and hard cheeses is reasonable, when compared with the sales of raw milk, but the structure of production costs which determine the cost price of the finished product should be scrutinized in order to keep these costs low. The costs of raw materials for the production of both types of cheese have the largest share and amount to 90.83% because they are the main ingredients of the final product. In terms of the share and importance, the cost of raw materials is followed by labor costs of 6.53% (0.22 € per kilogram of cheese), overhead costs of 1% and transport costs of 0.68%. Labour cost could be lowered by modern techniques, number of workers, hours of work, production volumes, etc.

It has been ascertained that an increase of 3.57% (1 RSD or 0.008 €) of the milk price results in a 3.5% increase in the production price of semi-hard and hard cheeses. In the analyzed period, the price of dairy products remains constant due to the steady average price of milk. Small differences in the average milk prices in the analyzed period are a consequence of differences in milk collection.

The costs of bags and labels participate with 0.95% in the cost price of semi-hard and hard cheeses. These costs have the largest share in the bags of 300g of hard cheese. Transport costs participate with 0.68% or 0.23 € per kilogram of cheese. Manufacturing overhead costs of semi-hard and hard cheese constitute 1% of total costs or 0.033 € per kilogram of the product. Overhead costs indirectly affect the cost price of the final product, through the costs of the entire production line.

Since the production of milk and its processing into dairy products have significant potential, it can be concluded that dairy producers should work to improve quality, reduce prices, widen the range of products, and intensify marketing activities which will help them retain existing customers and attract new ones, be competitive and be profitable. This is of utmost importance, especially when viewed in the light of future European integration, because only the most competitive dairy farms and plants are expected to survive. For small capacity dairies to be able to compete with larger dairies, both in product quality and price, it is crucial to monitor and minimize production costs continuously.

Acknowledgements

The paper is a part of the research financed by the Ministry of Education, Science and Technological Development of the Republic of Serbia (Agreement No. 451-03-68/2020-14/ 200117).

References

Đukić, S., Tomaš-Simin, M., & Glavaš – Trbić, D. (2017). The competitiveness of Serbian agro-food sector. *Economics of Agriculture, 64* (2), 723-737.

European statistics (EUROSTAT) Electronic database, Retrieved from: https://ec.europa.eu/eurostat/ (July 17, 2019).

FAOSTAT, Electronic database, Retrieved from: www.fao.org/faostat/en/#data (July 10, 2019).

IFCN Dairy Report, Retrieved from: https://ifcndairy.org/(July 02, 2019).

Jakšić, D., Mijić, K., Zekić, S., & Poljašević, J. (2015). Comparative profitability analysis of milk production companies to milk processing companies in Serbia. *Custos e @gronegovion on line, 11* (3), 206-226.

Marko, J., Jovanović, M, & Tica, N. (1998). *Kalkulacije u poljoprivredi.* Poljoprivredni fakultet, Novi Sad.

Milić, D., Glavaš-Trbić, D., Tomaš Simin, M., Zekić, V., & Novaković, T. (2019). Ekonomska obeležja proizvodnje jogurta u mlekarama malog kapaciteta u Srbiji. *Agroekonomika, 84,* 65-75.

Milić, D., Glavaš-Trbić, D., Tomaš Simin, M., Zekić, V., Novaković, T., & Popov, M. (2019). Economic characteristics of sour cream production in small-scale dairy processors in Serbia. *Economics of Agriculture, 66* (3), 787-798.

Milić, D., Mijić, K., & Jakšić, D. (2018). Opportunistic management behavior in reporting earnings of agricultural companies. *Custos e @gronegovion on line, 14* (1), 125-142.

Milošević Avdalović, S. (2018). Determinante profitabilnosti u mlekarskoj industriji. *Agroekonomika, 47* (79), 1-10.

Muminović, S., & Pavlović, V. (2012). Profitability of Dairy Industry in Slovenia, Croatia and Serbia. *Mljekarstvo, 62* (2), 96-110.

Nedić, N., Nikolić, M., & Hopić, S. (2019). Economic justification of honey production in Serbia. *Journal of Agricultural Sciences, 64* (1), 85-99.

Popović - Vranješ, A. (2015). *Specijalno sirarstvo.* Poljoprivredni fakultet, Novi Sad.

Popović Vranješ, A., Krstović, S., Jurakić, Ž., Popović, M., Šaran, M., & Vlahović, B. (2017). Modeli malih pogona za proizvodnju sira. *Agroekonomika, 46* (76), 67-78.

Rozman, Č., Grgić, Z., Maksimović, A., Ćejvanović, F., Puška, A., & Šakić Bobić, B. (2016). Multiple-criteria approach of evaluation of milk farm models in Bosnia and Herzegovina. *Mljekarstvo, 66* (3), 206-214.

Sekovksa, B., Todoroska, M., & Risteska-Jovanovska, S. (2015). Dairy sector in Republic of Macedonia – yesterday, today, tomarrow. *Economics of Agriculture, 4/2015,* 1109-1116.

Steinfeld, H., Wassenaar, T., & Jutzi, S. (2006). Livestock production systems in developing countries: status, drivers, trends. *Revue Scientifique et technique – Office International des Epizooties, 25* (2), 505-516.

Ščetar, M., Barukčić, I., Kurek, M., Jakopović, K.L., Božanić, R., & Galić, K. (2018). Packaging perspective of milk and dairy products. *Mljekarstvo, 69* (1), 3-20.

The Statistical Office of the Republic of Serbia, Electronic database, Retrieved from: www.stat.gov.rs (July 24, 2019).

Veljković, B., Koprivica, R., Radivojević, D., & Mileusnić, Z. (2015). Mleko i mlečni proizvodi u spoljnotrgovinskom bilansu Srbije. *Agroekonomika, 44* (66), 1-12.

Vlahović, B., Puškarić, A., & Mugoša, I. (2018). Izvoz sira iz Republike Srbije – aktuelno stanje i perspective. *Agroekonomika, 47* (81), 59-70.

Zekić, V., Tomović, V., Milić, D., & Lukač, D. (2012). Comparision of economic characteristics of porkers of mangalitsa and Yorkshire rase. *Economics of Agriculture, 59* (4), 649-656.

Received: November 6, 2019
Accepted: June 29, 2020

EKONOMSKI POKAZATELJI PROIZVODNJE POLUTVRDOG I TVRDOG SIRA U MLEKARAMA MALOG KAPACITETA U SRBIJI

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R e z i m e

Stočarstvo u Srbiji ima dugu tradiciju, a proizvodnja mleka i mlečnih proizvoda bogato nasleđe. Kravlje konzumno mleko koristi se u proizvodnji svih vrsta mlečnih proizvoda. Svetska proizvodnja sira je oko 20 miliona tona godišnje, od čega je 80% sireva od kravljeg mleka proizvedenih u industrijskim mlekarama. U Srbiji su glavni proizvođači mleka mala porodična gazdinstva, dok u preradi mleka i mlečnih proizvoda dominiraju mlekare sa velikim kapacitetom. U Srbiji ima 211 kapaciteta za preradu mleka, većina mleka se prerađuje u mlekarama „Imlek" i „Subotica", dok 188 mlekara malog kapaciteta prerade 20% ukupnog mleka. Predmet istraživanja u ovom radu su ekonomski pokazatelji prerade mleka u polutvrdi i tvrdi sir u mlekarama malog kapaciteta u Srbiji. Istraživanje je pokazalo da cena koštanja polutvrdog i tvrdog sira iznosi 3,33 evra po kilogramu. Najveći udeo u ukupnim troškovima imaju troškovi sirovina sa 90,83%, a potom slede troškovi rada sa 6,54%. Da bi mlekare malog kapaciteta mogle da konkurišu većim mlekarama kako u pogledu kvaliteta proizvoda tako i u pogledu njihove cene, neophodno je pre svega u kontinuitetu pratiti i u što većoj meri minimalizovati troškove proizvodnje.

Ključne reči: tvrdi sir, polutvrdi sir, ekonomski pokazatelji proizvodnje, mlekare malog kapaciteta, konkurentnost.

Primljeno: 6. novembra 2019.
Odobreno: 29. juna 2020.

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Journal of Agricultural Sciences (Belgrade)
Vol. 65, No. 3, 2020
Pages 297-310
https://doi.org/10.2298/JAS2003297O
UDC: 338.54:633.16(560)
Original scientific paper

MARKETING PRICES OF BARLEY IN SOUTHEASTERN ANATOLIA: BLACK VS. WHITE HULLED BARLEY

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Abstract: This study aimed to assess the presence of various ratios of black and white hulled grains in barley grain lots and mixture impacts on marketing prices. The study was carried out in the Sanlıurfa commodity market in the autumn of 2005 in Sanlıurfa and Diyarbakir in 2015 and Sanliurfa, Adıyaman and Gaziantep local commodity markets in 2017. The seven barley grain samples were prepared (100% White [W], 10% Black [B]+90% White [W], 20%B+80%W, 30%B+70%W, 40%B+60%W, 50%B+50%W and 100% Black) and presented to four randomly selected grain purchasers in all commodity markets and marketing price offers were scored. Increasing ratios of black-hulled barley (BHB) reduced marketing price gradually in 2005. In 2015, marketing prices were 0.337 US$ kg^{-1} for white and 0.365 US$ kg^{-1} for black in Sanliurfa and 0.334 US$ kg^{-1} for white and 0.352 US$ kg^{-1} for black barley in Diyarbakir. In 2017, except for Adıyaman, marketing price offers were in favour of BHB and it received 0.37 US$ kg^{-1} and 0.321 US$ kg^{-1} marketing price offers in Gaziantep and Diyarbakır, respectively. In 2017, WHB marketing prices were 0.325 US$ kg^{-1} and 0.315 US$ kg^{-1} in Gaziantep and Diyarbakır locations, respectively.

It was concluded that, except for Adıyaman, barley marketing prices traditionally in favour of white hulled barley turned out to be in favour of black type in a decade in south eastern Anatolia.

Key words: SE Anatolia, black-hulled barley, landraces, marketing price, white-hulled barley.

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Introduction

The modern territories of South eastern Turkey, Syria, Iraq, Jordan, Lebanon, Palestine and Western Iran encompass the region often referred to as the Fertile Crescent. Here, many of the species of temperate-zone agriculture originated and were first domesticated. Their wild relatives and landraces are still found in the region (Harlan, 1992; Zohary and Hopf, 1993). The Fertile Crescent is at the core of the West Asia and North Africa (WANA) region. Many major crops, including cereals, pulses, spices, oil crops, fibre plants, pasture, forage species, fruits and nut trees trace their origins to different parts of WANA (Harlan, 1975, 1992). The highest plant diversity occurs in Turkey (with 163 plant families, 1225 genera, 9000 species and 3000 taxa as endemic) and Morocco (Jaradat, 1997). The WANA region is the centre of origin and diversity of *Hordeum* spp. (wild and cultivated barley). Landraces of barley (*Hordeum vulgare* L.) with purple or black grain are grown in south eastern Turkey, Iraq and Northern Syria extensively (Ozberk and Ozberk, 1993; Tolbert et al., 1979; Ceccarelli and Grando, 1999). Lemmas and paleas of these types of barley landraces turn purple and black due to the presence of anthocyanins or melanin-like pigments respectively. Yerli Siyah, Arabi Aswad, local black and Arivad are major black-hulled barley landraces grown in south eastern Turkey, Northern Syria and Iraq, respectively (Ozberk and Ozberk, 1993; Bassam and Al-Omary, 1994; Bishaw, 2004). Barley based farming systems exist in wide areas along the dry margins (200–300mm of annual rainfall) of cultivation in most countries of the Fertile Crescent (Jaradat, 1997).

Multiple farmer concerns (e.g., yield, risk, and quality), environmental heterogeneity and missing markets contribute to the persistence of landraces (Brush and Meng, 1998). Most farmers in Syria had positive perceptions of the barley local landraces where one third reported no disadvantage in growing local Black-Hulled Barley (BHB). The entire barley area (99%) was planted with the black landrace Arabi Aswad in Northern Syria. The same phenomenon is valid for Iraq. In the Turkish site, all barley growing regions close to the Syrian border are devoted to the black-hulled landrace ‘Yerli Siyah’ or ‘Yerli Çakır’. Towards the inland areas, the WHB acreage dominates over BHB in Turkey. Namely, 15% of total barley acreage of Turkey builds up from SE Anatolia. Nearly 283 000 ha of the area is devoted to barley production with a yield of 261 0 kg ha^{-1}. Total production is about 738.000 tons (TUİK, 2017). Syrian farmers believe that the grain and straw quality of BHB provides more palatable feed for sheep than yellow barley (Ceccarelli and Grando, 1999; Nygaard, 1983). The decision to cultivate a traditional variety is determined by the household perceptions of its ability to fulfil the household requirements relative to alternative options (Brush and Meng, 1998). Turkish farmers and cattle owners prefer to grow black-hulled barley for good feeding characteristics. They claim that black-hulled barley is relatively soft and can be given to sheep and dairy cattle without grinding. This type of feeding is cost saving. Furthermore, if it is ground, it becomes a flour-like product. When it is given to sheep and cows, tiny flour dust makes the animals sneeze while breathing during feeding. The nutritional value of BHB is quite satisfactory compared to that of yellow kernels. BHB contains more protein and more lignin than yellow barley (Choo et al., 2005). More protein content is a desirable characteristic of the feeding value. Grain weights of BHB were 19% lower than those of yellow grain landraces (Choo et al., 2005; Ceccarelli and Grando, 1999). The BHB has yield stability against all kinds of biotic and abiotic stress factors and has survived under the natural selection pressure over the years. It is a very early maturing type and escapes from severe drought and sunn pest damage under dryland conditions in the region (Ozberk and Ozberk, 1993). BHB landraces are also more tolerant to salinity (Hazem et al., 2011). White-hulled landrace barley is higher yielding than BHB under supplementary irrigated conditions. However, BHB was better performing under dryland conditions (Yassen and Al-Omary, 1993; Ozberk and Ozberk, 1993). BHB, although having short height, lodges completely under rainfed and supplementary irrigated conditions. Protein content (%) of BHB was lower than that of white landrace barley giving 12.5% and 13.1%, respectively (Ozberk and Ozberk, 1993). On the other hand, reverse situations are also reported (Choo et al., 2005).

BHB was discarded from 6-row malting barley standards in the USA in 1956 (http://www. gipsa.usda. gov/reference-library/standards/history/barley, Pdf). It was put into the class of ‘other grains’ (Anonymous, 1999) and allowed the 2% presence in 6-row malting barley in No.1 (best grading) class. Turkish Grain Board purchases the BHB in the same class with purple aleuronic barley and offers lower prices than for WHB (Anonymous, 2005). S.Urfa commodity market is in the third range after Polatlı and Konya for annual marketing capacity and the most important BHB marketing arena in the region (Ozberk et al., 2005). The Diyarbakir commodity market is also emerging. In these commodity markets, pure white and BHB are rarely found separately. They are usually found as a mixture.

This study aimed to assess ‘if the current trend of barley marketing prices traditionally in favour of white grains turns out in favour of black-hulled barley in recent years and its impacts on net returns’ in south eastern Anatolia.

Materials and Methods

2005: Tokak 157/37 was widely grown (Akıncı et al., 1999) white-hulled feeding barley variety in 2005 and subjected to the study. A dockage cleaned grain sample was utilised in the study. 1000-kernel weight and hectolitre weight of Tokak 157/37 were 48.223 g and 72.10 kg, respectively. BHB landrace (Yerli Siyah) with 47.264 g of 1000-kernel weight and 71.46 kg of hectolitre weight was another variety used in the study. The study was carried out in the Sanliurfa local commodity market in September 2005.

2015: The dockage cleaned WHB landrace of Yerli Beyaz and the BHB landrace of 'Yerli Siyah' were used as plant material. The dockage cleaned material was subjected to quality analysis before the study (Table 1). Marketing price studies were carried out in September of 2015 in Sanliurfa and Diyarbakir local commodity markets, respectively.

2017: Akhisar-98 and Yerli Siyah were employed for white and black hulled feeding barley cultivars, respectively. Dockage cleaned seed samples of both cultivars were employed for the study. Protein (%), hectolitre (kg) and 1000-kernel weights (g) and sieving characteristics were scored initially (Table 1). The study was carried out in Adıyaman, Şanlıurfa and Gaziantep local commodity markets in May 2017.

Table 1. Some quality characteristics of white (Akhisar-98) and BHB (landrace) and mixtures in 2015 and 2017.

Entries 2015	Protein (%)	Hectolitre weights (kg)	1000 Kernel weights (g)	Starch (%)	Above % sieve>2.5 mm	Above % sieve>2.8 mm
100% White	11.8	59.3	40.0	70.6	68.7	47.1
90% WHB + 10% BHB	11.9	60,8	40.5	70.,7	64.0	37.4
80% WHB + 20% BHB	12.2	59.8	38.25	69.7	62.9	36.5
70% WHB + 30% BHB	12.2	59.8	38.75	70.4	57.3	29.1
60% WHB + 40% BHB	12.8	62.4	40.5	68.9	49.9	28.5
59% WHB + 50% BHB	12.8	60.6	37.5	68.7	49.9	22.4
100% BHB	14.3	67.0	32.0	65.9	26.8	2.5
Entries 2017	Protein (%)	Hectolitre weights (kg)	1000 Kernel weights (g)	Starch (%)	Above % sieve>2.5 mm	Above % sieve>2.8 mm
100% White	12.4	66.8	42.5	na	41.8	36.7
90% WHB + 10% BHB	12.5	68.4	40.0	na	41.9	32.7
80% WHB + 20%BHB	12.6	68.4	40.0	na	39.2	30.6
70% WHB + 30% BHB	12.3	69.2	40.0	na	34.8	28.7
60% WHB + 40%BHB	12.2	69.6	42.5	na	33.6	28.0
59% WHB + 50% BHB	13.2	71.2	37.5	na	31.7	25.0
100% BHB	13.6	73.2	37.0	na	30.5	12.9

Statistical methods

2005: A randomised complete block design with 7 treatments and 5 replications (purchasers) was employed for statistical analysis. Seven different mixture ratios of BHB and WHB (A: 100% White, B: 10% Black (B) + 90% White (W), C: 20% B+80% W, D: 30%B+70%W, E: 40%B+60%W, F: 50% B+50%W and G: 100% Black) were considered as treatments. Replications were the randomly selected grain buyers in the commodity market. Grain samples were presented to the randomly selected grain purchasers in the commodity market for marketing price estimations. Data obtained from the study were subjected to the analysis of variance using the JMP-5 statistical software (SAS Institute) and Totemstat (Açıkgoz et al., 2004). The relationships between average market prices and all treatments were further investigated through regression analysis (Finlay and Wilkinson, 1963; Eberhard and Russel, 1966) using the same statistical software.

2015: Two grain samples of black and white barley landraces were cleaned by dockage tester, and two sets of 7 treatments (as mixtures with a total weight of 1 kg) like that of 2005 were prepared from those samples. Seven treatments were presented to five randomly selected grain purchasers in both Sanliurfa and Diyarbakir commodity markets employing a randomised complete block design with 5 replications (purchasers).

Individual ANOVAs for Sanliurfa and Diyarbakır were performed and the marketing price offers were grouped by LSD test. The coefficients of correlation between some quality traits versus marketing prices were also performed. The coefficients of correlation between marketing prices versus various quality traits were assessed through correlation analysis. Regression analyses were further performed to assess the relationships between mixture ratios versus marketing prices in both commodity markets. The equations obtained from regression analysis with a high coefficient of determinations are considered reliable for further price estimations for mixed grain lots.

2017: Dockage cleaned grain samples were prepared as in the previous years, with given ratios building up a mixture with a total of 1 kg. Three sets of grain mixtures were presented to randomly selected grain purchasers in local commodity markets in neighbouring Sanliurfa, Adiyaman and Gaziantep provinces in SE Anatolia. Results were subjected to analysis of variance employing a randomised complete block design with 4 (purchasers) replications by the JMP-5 statistical software. Individual ANOVAs for each location were performed and the marketing price offers were grouped by LSD test. The coefficients of correlation between some quality traits versus marketing prices were assessed. Statistically significant correlations were further investigated through regression analysis.

Quality analysis

1000-kernel weights (g) (Ozkaya and Kahveci, 1990), hectolitre weights (kg) and starch (%) (Uluöz, 1965), and sieving characteristics (William et al., 1986) were scored. Protein rate (%) was scored by NIT (Near Infrared Transmitting) employing Anonymous (1990).

Results and Discussion

2005: The results of ANOVA indicated that both treatments and replications (purchasers) were found to be significant, giving F=17.86** and F=4.78** respectively. It was revealed that grain buyers had special preferences. Treatments were compared by LSD test, and the groups are shown in Table 2a. The pure (100%) WHB was offered the highest marketing price (0.180 US$ kg^{-1}) and the pure (100%) BHB received the lowest one (0.168 US$ kg^{-1}). Other mixtures took place in between ranking showing the less BHB the more marketing price. The effect of mixture ratios on market prices was further investigated through linear regression analysis. Regression was found to be significant, giving F=74.73**. The regression equation was calculated as follows:

Marketing price(Y) = 245.286 – 2.764 (X=BHB %).

Table 2a. LSD groups for marketing prices of treatments in Sanliurfa in 2005.

Marketing Prices and Groups (TL kg^{-1} and US$ kg^{-1})		
100% White-hulled barley	0.2440a	($ 0.180)
90% White-hulled barley + 10% Black-hulled barley	0.2384b	($ 0.177)
80% White-hulled barley + 20% Black-hulled barley	0.2362b	($ 0.175)
70% White-hulled barley + 30% Black-hulled barley	0.2350bc	($ 0.174)
60% White-hulled barley + 40% Black-hulled barley	0.2310cd	($ 0.171)
50% White-hulled barley + 50% Black-hulled barley	0.2284de	($ 0.169)
% 100 Black-hulled barley	0.2266e	($ 0.168)

LSD=4.25; 1US$=1.37YTL.

The coefficient of determination (R^2 %) was found to be 69.4%. This indicated the reliability of the equation given above. The regression line and the confidence interval are given in Figure 1.

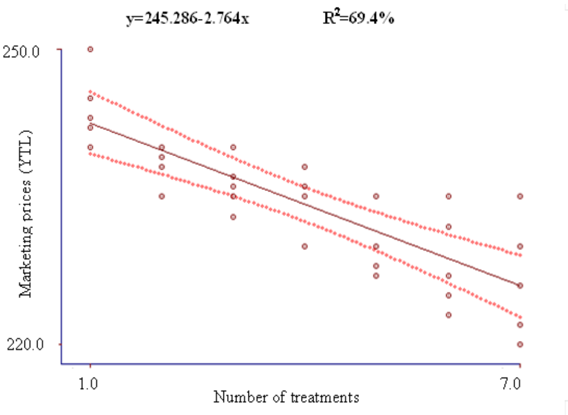

Figure 1.The linear regression line confidence interval of 95% in Sanliurfa in 2005.

2015: Individual ANOVAs for the marketing price were performed for Sanliurfa and Diyarbakir locations and treatments were found significant, giving F=188.16 and F=31.21**, respectively. Replications (purchasers) were also significant, giving F=0.009*and F=10.87** respectively. Means of treatments were grouped employing the LSD test (Table 2b).

Table 2b. Entries and means of LSD groups for marketing prices of treatments in Şanlıurfa and Diyarbakir in 2015.

	Şanlıurfa		Diyarbakır	
Pure white	0.762d	($0.170)	0.752e	$0.168
90%W + 10%B	0.755e	($0.169)	0.754de	$0.168
80%W + 20%B	0.759de	($.0.170)	0.756de	$0.169
70%W + 30%B	0.762d	($.0.170)	0.759cd	$0.169
60%W + 40%B	0.768cbc	($0.172)	0.763c	$0.170
50%W + 50%B	0.778b	($0.174)	0.770b	$0.172
Pure Black	0.818a	($0.183)	0.788a	$0.176

LSD=0.3; LSD=0.049; 1US$=2.24TL.

Pure BHB received the highest marketing price offers with 0.183 US$ kg^{-1} and 0.176 US$ kg^{-1} respectively. Those of pure white had the lowest marketing price offer with 0.170 US$ kg^{-1} and 0.168 US$ kg^{-1} respectively. The lower presence of white barley in the mixtures, the higher marketing prices received. An orthogonal comparison indicated the presence of a linear relation between mixture ratios and marketing prices. Correlations between marketing prices versus some of the quality characteristics for both locations were assessed by correlation analysis, and the coefficients of correlation between marketing prices versus some quality characteristics were given in Table 3.

The coefficients of correlation for protein ratio (%) and hectolitre weights (g) versus marketing prices were positive and significant for Sanliurfa and Diyarbakir. However, these turned out to be negative and significant for1000-kernel weights (g), starch (%) and above sieving characteristics. Hence, regression analysis was further performed to obtain the best equation for marketing price estimates. Regressions were significant for both Sanliurfa and Diyarbakir, giving F=18.35** and F=24.94** respectively. The regression equation was: y=74.62**+3.99**x (R^2%=35.7) in Sanliurfa (Figure 2). This was y=74.46** + 2.86**x (R^2%=43) in Diyarbakir (Figure 3).

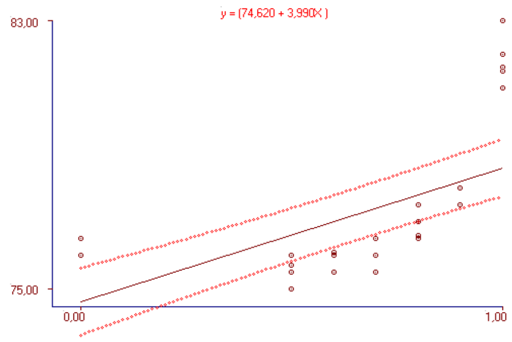

Figure 2. The regression line and confidence interval for Sanliurfa in 2015.

This was y=74.46** + 2.86**x (R^2%=43) in Diyarbakir (Figure 3).

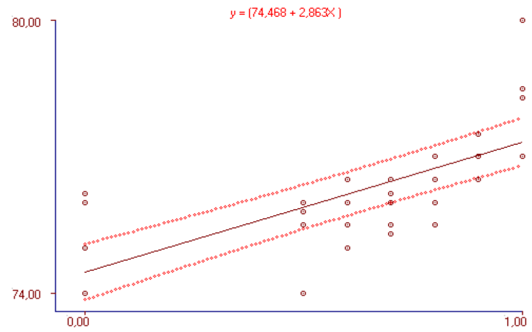

Figure 3. The regression line and confidence interval for Diyarbakir in 2015.

2017: Individual ANOVAs were performed and the treatments were found to be significant for Adıyaman (F=2. 76*), Sanliurfa (F=22. 61**) and Gaziantep (F=20. 8**) respectively. WHB (100%) received the highest marketing price ($\$kg^{-1}$ 0.292) in Adiyaman, whereas, in Sanliurfa and Gaziantep, BHB received the highest marketing prices of $\$kg^{-1}$ 0.370 and $\$kg^{-1}$ 0.321 respectively (Table 2c).

The coefficients of correlation between protein ratio (%), hectolitre weight (kg), 1000-kernel weights (g) and sieving characteristics vs. marketing prices are given in Table 3.

Table 2c. Entries and means of LSD groups for marketing prices of treatments in Şanlıurfa, Gaziantep, and Adıyaman in 2017.

Marketing prices and groups (TL kg^{-1} and US$ kg^{-1})						
	Şanlıurfa		Gaziantep		Adıyaman	
Pure white	1.155f	($0.325)	1.118e	($0.315)	1.038a	($0.292)
90%W + 10%B	1.188e	($0.335)	1.125d	($0.317)	0.990b	($0.279)
80%W + 20%B	1.193de	($0.336)	1.128cd	($0.318)	0.990b	($0.279)
70%W + 30%B	1.220cd	($0.344)	1.133bc	($0.319)	0.985b	($0.277)
60%W + 40%B	1.233bc	($0.347)	1.134b	($0.319)	0.985b	($0.277)
50%W + 50%B	1.258b	($0.354)	1.136ab	($0.320)	0.980b	($0.276)
Pure Black	1.313a	($0.370)	1.141a	($0.321)	0.973b	($0.274)

LSD: 0.03; LSD=0.005; LSD=0.03; US$=3.55TL.

Table 3. The coefficients of correlations between marketing prices versus some quality characteristics in Sanliurfa and Diyarbakir in 2015 and Sanliurfa, Gaziantep and Adıyaman in 2017.

Characteristics	Sanliurfa	Diyarbakir	
2015			
Protein %	0.960**	0.984**	
Hl	0.909**	0.898**	
1000-kernel weights	-0.934**	-0.908**	
Starch%	-0.962**	-0.972**	
Above sieve > 2.5.mm	-0.944**	-0.983**	
Above sieve > 2.8 mm	-0.911*	-0.975**	
2017	Sanlıurfa	Gaziantep	Adiyaman
Protein %	0.789*	0.799*	-0.548
Hl	0.995***	0.928**	-0.814*
1000-kernel weights	-0.761*	-0.891**	0.740*
Above sew > 2.5.mm	-0.923*	-0.807**	0.697
Above sew > 2.8 mm	-0.974**	-0.851*	0.768*

Except for Adiyaman, the coefficients of correlation between proteins (%) versus marketing prices turned out to be significant for Sanliurfa and Gaziantep, giving r=0.789* and 0.799* respectively. On the other hand, the coefficients of correlation between hectolitre weights versus and marketing prices for all commodity markets were found to be significant, giving r=0.995**, r=0.928* and r= -0.814* respectively. However, there was a negative correlation between ‘hectolitre’ weights versus marketing prices in Adıyaman, indicating the high ‘hl’ weight giving the less marketing price unexpectedly. The coefficients of correlation between grain weights (%) over 2.5 and 2.8 mm. sieving marketing prices were mostly negative and significant for all three commodity markets. Regression analysis between mixture ratios (%) versus marketing prices was further performed and regression was found significant for all commodity markets, giving F=69.04*** for Sanliurfa, 76.05*** for Gaziantep and 7.73** for Adıyaman respectively. Regression equations between mixture ratios versus marketing prices were: Y (marketing price) = 1.02**-0.0078**x (mixture ratio) for Adıyaman (%R^2=22.9) (Figure 4); y=1.129**+0.0035**x for Sanliurfa (%R^2=72.6) (Figure 5) and y= 1.116**+0.00357x** for Gaziantep (%R^2=74.5) (Figure 6).

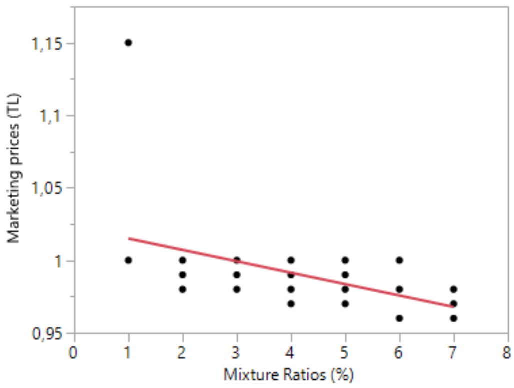

Figure 4. The regression line and equation for Adıyaman in 2017.

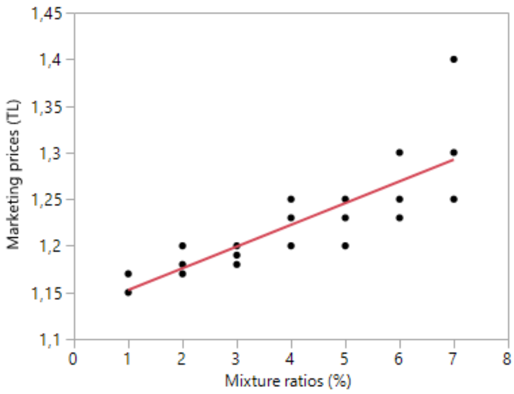

Figure 5. The regression line and equation for Sanliurfa in 2017.

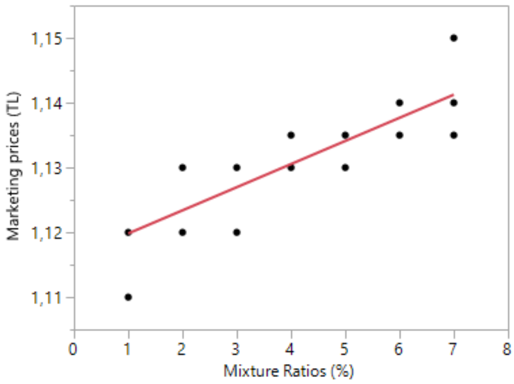

Figure 6. The regression line and equation for Gaziantep in 2017.

Black barley grains were abundant and used to be offered lower marketing prices traditionally by both local purchasers and Turkish Grain Board (TGB). The research findings for marketing prices for 2005 confirmed the marketing price standards of TGB (Anonymous, 2005). TGB offered 0.281US$ kg^{-1} for white No.1 barley and 0.270 $ kg^{-1} for black No.1 barley in October, 2005. Namely, 0.011 $ kg^{-1} less purchasing price was offered for BHB than that for WHB. This was a traditional trend for barley marketing. BHB acreage and production were larger and higher than those of white due to relatively low irrigation possibilities in the region. Therefore, marketing prices of black type were lower than those of white barley. In 2008, an early drought occurred in February and March in south eastern Anatolia. BHB traditionally grown under rain-fed conditions in semi-fertile soils was affected severely and production was upside down in favour of white. The following year, farmers brought some similar types of black landraces from western transitional zones of Turkey. They were all alternative growing habit type cultivars and performed poorly and produced shrivelled grain in spring-type growing zones. They disappeared shortly. The scarcity of a genuine spring type of BHB in the region resulted in an increase in marketing prices. In 2015, BHB marketing prices were higher than those of WHB. Protein (%) and hectolitre weights (kg) were positively correlated with marketing prices, whereas 1000-kernel weights (g), starch (%), above sieve (%)>2.5 mm and above sieve (%)>2.8mm had negative correlations versus marketing prices. The same trend occurred in both Sanliurfa and Gaziantep locations in 2017. In Adıyaman, a reverse situation was detected, where protein ratio (%) and hectolitre weights (kg) affected marketing prices negatively.

Adıyaman is the most rainfall receiving area with an average of 700 mm per year and located in the northern zone of SE Anatolia with about 700 m elevation from sea level. It is called the malting barley zone of Turkey. WHB dominates the

BHB with its high yield and high net return. So, BHB cannot compete with WHB in little colder and high rainfall zones. Some of the overlapping coefficients of correlation of some quality characteristics onto purchasing prices must be assessed carefully. Partial coefficients of correlations might turn from negative to positive or reverse. Taking into account the increasing acreage of irrigation opportunities in the region, in the near future, all the landrace BHB growing zones could be devoted to white-hulled landraces and modern WHB cultivars depending on lower yielding ability and susceptibility of BHB to lodging. This means that higher marketing prices of BHB may last longer due to the scarcity of adequate production. However, in the long term, the extinction of BHB in the region might occur. Therefore, from now on, the erect type and palatable BHB breeding must be initiated employing landraces. Moreover, BHB barley landraces must be released and conserved by gene banks for sustainable protection. Finally, regression equations between marketing prices versus mixture ratios in 2017 can be used for marketing price estimates reliably with higher coefficients of determinations in the region.

Conclusion

It was concluded that BHB, although having higher marketing prices than those of WHB, may not survive in the long term due to low yielding ability and consequently low net return. Furthermore, the WHB planting tendency of farmers and the increased irrigation facilities in south eastern Anatolia might speed up this inevitable end.

References

Açıkgöz N., İlker E., & Gökçöl A. (2004). Totemstat Statistics Packages. Bornova, Izmir: Aegean University Seed Technology Center Publication no:2.

Akıncı, C., Gül, İ., & Çölkesen, M. (1999). Diyarbakır koşullarında bazı arpa çeşitlerinin tane ve ot verimi ile bazı verim unsurlarının belirlenmesi. 3. *Tarla Bitkileri Kongresi,* (s.405-410). Adana.

Anonymous (2005). Turkish Grain Board inland Sale Prices 2005. http://www.tmo.gov.tr.

Anonymous (1999). US Standards for Barley. http://www.gipsa.usda.gov./reference-library/standards/810 barley97.pdf.

Anonim (1990). AACC Standart, American Assocition of Cereal Chemistry, USA.

Bassam, T.Y., & Al-Omary, S.S. (1994). Analysis of the effects of water stress on leaf growth and yield of three barley cultivars. *Irrigation Science.V.14* (3), 157-162.

Bishaw, Z.J. (2004). *Wheat and barley seed systems in Ethiopia and Syria*. PhD dissertation no: 3575. Wageningen University.

Brush, StB., & Meng, E. (1998). Farmer's valuation and conservation of crop genetic resources. *Genetics Resources and Crop Evolution, 45*, 139-150.

Ceccarelli, S., & Grando, S. (1999). Barley landraces from the Fertile Crescent: A lesson for plant breeders. In: Brush S.B. (ed), *Genes in the Field: On-farm Conservation of Crop Diversity,* IBGRI/IDRC/Lewis Publishers, (pp. 51-76). Boca Raton, FL.

Choo, T.M., Vigier, B., Ceccarelli, S., Grando, S., & Frankowiak, J.D. (2005). Comparison of black, purple, and yellow barleys. *Genetic Resources and Crop Evalution, 52*,121-126.

Eberhard, S.A., & Russel, W.A. (1966). Stability parameters for comparing varieties, *Crop Science, 6*, 36-40.

Finlay, K.W., & Wilkinson, G.N. (1963). The analysis of adaptation in a plant breeding programme. *Avustralian Journal of Agricultural Research, 29*, 897-912.

Harlan, J.R. (1975). Our vanishing genetic resources; modern varieties replace ancient populations that have provide variability for plant breeding programs. *Science, 188,* 618-621.

Harlan, J.R. (1992). *Crops and man*, WI.; ASA, CSSA (2^{nd}.ed).

Jaradat, A.A. (1997). Biodiversity and sustainable agriculture in the Fertile Crescent. Panel: Agriculture, Pastoralism and Development, In the conference Transformations of Middle Eastern Natural Environments: Legacies and Lessons, (pp. 31-55). Yale Univ. USA.

Nygaard, D. (1983). Tests on farmer's fields: The ICARDA experience. *Proceedings of the first farming system research symposium,* (pp.76-81). Kansas State University, USA.

Ozberk, I., Atlı, A., Pfeiffer, W., Ozberk, F., & Coskun, Y. (2005). The effect of sunn pest (*Eurigaster integriceps)* damage on durum wheat: impact in the market place. *Crop Protection, 24*, 267-274.

Ozberk, I., & Ozberk, F. (1993). Bread wheat, durum wheat and barley improvement project in the GAP region, *Result report.* Southeastern Anatolia Agr. Res. Diyarbakir, Turkey.

Özkaya, H., & Kahveci, B., (1990). Tahıl ve Ürünleri Analiz Yöntemleri. *Gıda Teknolojisi Derneği Yayınları,* No:14, (s. 1-152). Ankara.

Tolbert, D.M., Qualset, C.O., Jain, S.K., & Craddock, J.R. (1979). A diversity analysis of a world collection of barley. *Crop Science 19*, 789-794.

TUİK, (2017). Türkiye bitkisel üretim verileri. http://biruni.tuik.gov.tr/bitkiselapp/bitkisel.zul.

Uluöz, M. (1965). *Wheat, flour and bread analysis methods*. Publication no: 57. Aegean University, Bornova, Izmir.

Williams, P., El-Heramain, F. V., Nakkaul, H., & Rihawi, S., (1986). Crop Quality Evaluation Methods and Guide. ICARDA, Aleppo, Syria

Zohary, D., & Hopf, M. (1993). *Domestication of plants in the old World*. Oxford: Clerandon Press.

Received: October 28, 2019
Accepted: June 10, 2020

TRŽIŠNE CENE BELOG I CRNOG OLJUŠTENOG JEČMA U JUGOISTOČNOJ ANATOLIJI

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R e z i m e

Ovo istraživanje je imalo za cilj da proceni prisustvo različitih odnosa crnih i belih oljuštenih zrna u isporukama ječma i njhov uticaj na tržišne cene. Istraživanje je sprovedeno na tržištu u Sanliurfi u jesen 2005. godine, na lokalnim robnim tržištima u Sanliurfi i Dijarbakiru u 2015. godini i u Sanliurfi, Adijamanu i Gaziantepu u 2017. godini. Pripremljeno je sedam uzoraka zrna ječma (100% belog [engl. *white* – W], 10% crnog [engl. *black* – B]+90% belog [W], 20%B+80%W, 30%B+70%W, 40%B+60%W, 50%B+50%W i 100% crnog). Uzorci su predstavljeni četvorici kupaca koji su slučajno izabrani sa svih robnih tržišta i oni su imali zadatak da boduju ponuđene cene. Sve veća ponuda crnog oljuštenog ječma postepeno je smanjila tržišnu cenu u 2005. godini. U 2015. godini, tržišne cene u Sanliurfi su bile 0,337 USD kg^{-1} za beli i 0,365 USD kg^{-1} za crni ječam, a u Dijarbakiru su bile 0,334 USD kg^{-1} za beli i 0,352 USD kg^{-1} za crni. U 2017. godini, osim u Adıjamanu, tržišnih cena bile su više za BHB i iznosile 0,37 USD kg^{-1} odnosno 0,321 USD kg^{-1} u Gaziantepu odnosno Dijarbakiru. U 2017. godini, tržišne cene belog oljuštenog ječma iznosile su 0,325 USD kg^{-1} odnosno 0,315 USD kg^{-1} u Gaziantepu odnosno Dijarbakiru. Zaključeno je da su u jugoistočnoj Anatoliji, osim u Adijamanu, u posmatranoj deceniji, tržišne cene ječma koje su tradiocionalno bile više za beli oljušteni ječam, bile više za crni oljušteni ječam.

Ključne reči: JI Anatolija, crni oljušteni ječam, lokalne sorte, tržišna cena, beli oljušteni ječam.

Primljeno: 28. oktobra 2019.
Odobreno: 10. juna 2020.

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Gvozdenović, S., Saftić Panković, D., Jocić, S., & Radić, V. (2009). Correlation between heterosis and genetic distance based on SSR markers in sunflower (Helianthus annuus L.). *Journal of Agricultural Sciences*, *54*, 1-10.

Books
Steel, R.G.D., & Torrie, J.H. (1980). *Principles and procedures of statistics*. New York: McGraw-Hill Book Company.

Book chapter

Bell, R.L., Quamme, H.A., Layne, R.E.C., & Skirvin, R. M. (1996). Pears. In J. Janick & J.N. Moore (Eds.), *Fruit breeding, Volume I: Tree and tropical fruits.* (pp. 441-514). New York: John Wiley and Sons, Inc.

Proceedings

Behera, T.K., Staub, J.E., Behera, S., Rao, A.R., & Mason, S. (2008). One cycle of phenotypic selection combined with marker assisted selection for improving yield and quality in cucumber. In M. Pitrat (Ed.), *Proceedings of the IXth EUCARPIA meeting on genetics and breeding of Cucurbitaceae* (pp. 115-121). Avignon, France.

Thesis

Singh, N.K. (1985). *The structure and genetic control of endosperm proteins in wheat and rye*. University of Adelaide.

Report

Ballard, J. (1998). *Some significant apple breeding stations around the world*. Selah, Washington.

Web site

Platnick, N.I. (2010). The world spider catalog, version 10.5. *American Museum of Natural History*. Retrieved February 12, 2016, from http://research.amnh.org/entomology/spiders/catalog/index.html

Summary

The summary in Serbian is given at the end of the paper and should comprise 200 to 250 words. Before the main text of the summary, as well as in English, the title of the paper, first name, middle initial(s) and last (family) name of all authors and the names and addresses of affiliations should be given. The title of the summary is centred and written separately. Below the title, the text of the summary should follow, without any indentation, and immediately after the text of the summary, the key words are given with the full stop at the end. The e-mail address of the corresponding author should be given at the bottom of the page.

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Tables numbered with Arabic numerals (1, 2, etc.), followed by the title should be placed in the text using 9 font size and a maximum width of 13 cm. They should be clear, simple and unambiguous. The vertical sections should be avoided, and the number of columns should be limited so that the table is not too wide. Also, an unnecessary usage of horizontal sections should be avoided. The title of the table, single spaced above the table, justified, and with the full stop at the end should be given. The detailed explanation of abbreviations, symbols and signs used in the table should be provided below the table. Each table must be mentioned in the text.

Illustrations
All graphs, diagrams and photographs should be titled "Figure" (1, 2, etc.). They should be placed in the text. Graphs and diagrams should be computer drawn, using 9 font size and a maximum width of 13 cm, so that they can be legible and distinct after the size reduction. The overuse of colours and hues should be avoided for aesthetic reasons. The detailed legend without abbreviations for each graph and diagram should be given. The photographs must be of high quality so that they can technically be well reproduced. They should be submitted in "TIF" or "JPG" format, and they will be printed in black and white. The title of the illustration should be justified, with a full stop at the end, single spaced from the illustration and given below it. Each illustration should be mentioned in the text.

Abbreviations and units
Only standardised abbreviations should be used in the paper. Measure units should be expressed using International System of Units (SI). The abbreviations can be used for other expressions provided these expressions are stated in the full form when appear for the first time with the abbreviated form in the brackets. Values from 1 to 9 can be written in letters, but others numerically.

Nomenclature
The complete nomenclature (chemical and biochemical, taxonomical, genetic etc.) must be adjusted to international codes and commissions, such as *International Union of Pure and Applied Chemistry, IUPAC-IUB Combined Commission on Biochemical Nomenclature, Enzyme Nomenclature, International Code of Botanical Nomenclature, International Code of Nomenclature of Bacteria* etc.

Formulae
All formulae and equations in the paper should be worked out by means of the programme "WORD Equation". An ample space should be left around the formulae for the sake of visibility. Subscripts and superscripts should be clear. Greek letters and other non-Latin symbols should be explained when they are first used. The meaning of all symbols should be given immediately after the equation where these symbols are first used. Equations should be numbered by Arabic numerals, serially in brackets, at the right-hand side. Each equation must be mentioned in the text as Eq. (1), Eq. (2), etc.

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Journal of Agricultural Sciences

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Originalan naučni rad – Rad koji sadrži prethodno neobjavljivane rezultate sopstvenih istraživanja. Obim ovog rada treba da iznosi od 6 do 12 strana.

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Ključne reči
Ključne reči su termini ili fraze koje najbolje opisuju sadržaj članka za potrebe indeksiranja i pretraživanja. Broj ključnih reči može biti od 3 do 10. Navode se ispod sažetka. Naslov „Ključne reči“ piše se boldovano i uvlači jednim

tabulatorom. Nakon toga slede dve tačke, a zatim nabrajanje ključnih reči malim slovima, sa tačkom na kraju. Treba izbegavati korišćenje ključnih reči koje se nalaze u naslovu rada. Ključne reči se dostavljaju na srpskom i engleskom jeziku posle sažetaka na oba jezika.

Uvod

Uvod treba da sadrži informacije o dosadašnjim istraživanjima po navedenom pitanju i šta se datim istraživanjem želi postići. Prilikom osvrta na literaturu, navesti autora i godinu, a autora citirati u spisku literature. Naslov „Uvod“ piše se sa prvim velikim slovom, centrirano i boldovano, nakon čega sa jednim razmakom ispod naslova sledi tekst uvoda poravnat po levoj i desnoj margini. Svaki novi pasus uvlači se jednim tabulatorom. Ova pravila važe i za sva ostala poglavlja.

Materijal i metode

Materijal i metode treba izložiti jasno uz objašnjenje svih primenjenih postupaka u radu. Opšte poznate metode izložiti kratko, a detaljnije ih objasniti ukoliko se odstupa od ranije objavljenih postupaka. Za radove eksperimentalnog karaktera obavezno navesti način statističke obrade podataka. U ovom poglavlju, kao i u poglavlju „Rezultati i diskusija“, po potrebi se mogu dati i određena podpoglavlja.

Rezultati i diskusija

U poglavlju „Rezultati i diskusija“ interpretiraju se podaci dobijeni na osnovu zapažanja i izvršenih eksperimenata. U komentaru rezultata treba se pozivati na literaturu koja se navodi na kraju rada, čime se obezbeđuje poređenje dobijenih rezultata sa dosadašnjim saznanjima u toj oblasti.

Zaključak

U zaključku treba ukratko navesti najznačajnije rezultate dobijene u radu. Izbegavati nabrajanje svih rezultata istraživanja sa ponavljanjem brojčanih vrednosti koje su prethodno već navedene u poglavlju „Rezultati i diskusija“. Zaključak ne sme da sadrži reference.

Zahvalnica

Zahvalnica treba da sadrži naziv i broj projekta, odnosno naziv programa u okviru koga je rad nastao, kao i naziv institucije koja je finansirala projekat ili program.

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Literatura koja je citirana u tekstu navodi se u spisku referenci u originalnom obliku, po abecednom redu, bez numeracije. Ako se citira veći broj radova istog autora najpre se navode radovi kada je autor sam, a zatim kada su prisutna dva i više autora. Ako se u nekoj od ovih kategorija javlja veći broj radova, treba ih hronološki srediti po godinama (1997, 2002, 2006, itd.), a ako se u istoj godini javlja veći broj radova dodaju se slova (2005a, 2005b, 2005c, itd.). Literaturni podatak treba da sadrži: prezime autora, početno slovo imena, godinu izdanja u zagradi, naslov rada, naziv časopisa, volumen i broj stranica (prva-poslednja). Prilikom citiranja knjiga navodi se izdavač i mesto izdavanja. Redovi svake reference posle prvog reda moraju biti uvučeni. U časopisu se koristi APA - Publication Manual of the American Psychological Association citatni stil.

Primeri navođenja referenci su sledeći:

Periodičan časopis
Gvozdenović, S., Saftić Panković, D., Jocić, S., & Radić, V. (2009). Correlation between heterosis and genetic distance based on SSR markers in sunflower (Helianthus annuus L.). *Journal of Agricultural Sciences, 54,* 1-10.

Knjiga
Steel, R.G.D., & Torrie, J.H. (1980). *Principles and procedures of statistics*. New York: McGraw-Hill Book Company.

Poglavlje u knjizi
Bell, R.L., Quamme, H.A., Layne, R.E.C., & Skirvin, R.M. (1996). Pears. In J. Janick & J.N. Moore (Eds.), *Fruit breeding, Volume I: Tree and tropical fruits.* (pp. 441-514). New York: John Wiley and Sons, Inc.

Zbornik
Behera, T.K., Staub, J.E., Behera, S., Rao, A.R., & Mason, S. (2008). One cycle of phenotypic selection combined with marker assisted selection for improving yield and quality in cucumber. In M. Pitrat (Ed.), *Proceedings of the IXth EUCARPIA meeting on genetics and breeding of Cucurbitaceae* (pp. 115-121). Avignon.

Teza
Singh, N.K. (1985). *The structure and genetic control of endosperm proteins in wheat and rye*. University of Adelaide.

Izveštaj

Ballard, J. (1998). *Some significant apple breeding stations around the world*. Selah, Washington.

Veb sajt

Platnick, N.I. (2010). The world spider catalog, version 10.5. *American Museum of Natural History*. Retrieved February 12, 2016, from http://research.amnh.org/entomology/spiders/catalog/index.html

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Tabele

Tabele obeležene arapskim brojevima (1, 2, itd.) praćene naslovom treba da se nalaze na odgovarajućem mestu u tekstu, u fontu 9. Maksimalna širina tabela treba da bude 13 cm. One treba da budu jasne, što jednostavnije i pregledne. Treba izbegavati vertikalne crte, a broj kolona ograničiti tako da tabela ne bi bila preširoka. Takođe, treba izbegavati nepotrebnu upotrebu horizontalnih crta. Naslov tabele, poravnat po levoj i desnoj margini, sa tačkom na kraju, navodi se sa jednim razmakom iznad tabele. Ispod tabele treba dati detaljno objašnjenje skraćenica, simbola i znakova korišćenih u samoj tabeli. Svaka tabela mora biti pomenuta u tekstu.

Ilustracije

Svi grafikoni, dijagrami i fotografije treba da se nazovu „Slika“ (1, 2, itd.). Prilažu se na odgovarajućem mestu u tekstu. Grafikone i dijagrame treba uraditi fontom 9, u crno-beloj tehnici i sa maksimalnom širinom od 13 cm. Voditi računa da oni budu čitki i jasni i nakon redukcije veličine. Za svaki grafikon i dijagram treba obezbediti detaljnu legendu bez skraćenica. Fotografije moraju biti visokog kvaliteta da bi se tehnički mogle dobro reprodukovati. Prilažu se u „TIF“ ili „JPG“ formatu, u crno-beloj tehnici. Naslov ilustracije, poravnat po levoj i desnoj margini, sa tačkom na kraju, navodi se sa jednim razmakom ispod ilustracije. Svaka ilustracija mora biti pomenuta u tekstu.

Skraćenice i jedinice

U radu treba koristiti samo standardne skraćenice. Merne jedinice treba izražavati u internacionalnom sistemu jedinica (SI). Kod navođenja jedinica posle broja treba da stoji razmak (osim za % i °C). Skraćenice se mogu koristiti i za druge izraze pod uslovom da se ti izrazi navedu u punom obliku prilikom prvog pominjanja, sa skraćenim oblikom u zagradi. Vrednosti od 1 do 9 mogu se izražavati slovima, a ostali brojevi isključivo numerički.

Nomenklatura
Celokupna nomenklatura (hemijska i biohemijska, taksonomska, genetička itd.) mora biti usklađena sa međunarodnim kodeksima i komisijama, kao što su *International Union of Pure and Applied Chemistry, IUPAC-IUB Combined Commission on Biochemical Nomenclature, Enzyme Nomenclature, International Code of Botanical Nomenclature, International Code of Nomenclature of Bacteria* itd.

Formule
Sve formule i jednačine u radu moraju biti urađene pomoću programa „Word Equation“. Pri pisanju formula, radi preglednosti, ostaviti dovoljno praznog prostora oko same formule. Subskripti i superskripti treba da budu jasni. Prilikom pisanja jednačina treba dati smisao svih simbola odmah posle jednačine u kojoj se simbol prvi put koristi. Jednačine treba da budu numerisane arapskim brojevima, serijski u zagradama, na desnoj strani linije. Svaka jednačina mora biti pomenuta u tekstu kao Eq. (1), Eq. (2), itd.

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JOURNAL of Agricultural Sciences / editor-in-chief Snežana Oljača. - [Štampano izd.]. - Vol. 44, no. 1 (1999)- . - Belgrade : University of Belgrade, Faculty of Agriculture, 1999- (Belgrade-Zemun : Faculty of Agriculture). - 24 cm

Tromesečno. - Je nastavak: Review of Research work at the Faculty of Agriculture = ISSN 0354-3498. - Drugo izdanje na drugom medijumu: Journal
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