UDC: 63 ISSN 1450-8109

JOURNAL OF AGRICULTURAL SCIENCES BELGRADE

Vol. 64, No. 3, 2019

Published by University of Belgrade
Faculty of Agriculture
Republic of Serbia

UDC: 63 ISSN 1450-8109

JOURNAL OF AGRICULTURAL SCIENCES BELGRADE

Vol. 64, No. 3, 2019

Published by University of Belgrade
Faculty of Agriculture
Republic of Serbia

Journal of Agricultural Sciences www.joas.agrif.bg.ac.rs
J. Agric. Sci.

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

Number of institutions the Journal is exchanged with: 80

JOURNAL OF AGRICULTURAL SCIENCES BELGRADE
Vol. 64, No. 3, 2019

CONTENTS

JOURNAL OF AGRICULTURAL SCIENCES BELGRADE
Vol. 64, No. 3, 2019

S A D R Ž A J

Journal of Agricultural Sciences
Vol. 64, No. 3, 2019
Pages 215-224

https://doi.org/10.2298/JAS1903215D
UDC: 631.51:631.559
635.655-155.9
Original scientific paper

PLOUGHING DOWN HARVEST RESIDUES OF PRECEDING CROPS FOR THE PURPOSE OF SOYBEAN YIELD IMPROVEMENT

Vojin H. Đukić[1*], Zlatica J. Miladinov[1], Gordana K. Dozet[2], Svetlana N. Balešević-Tubić[1], Jegor A. Miladinović[1], Vladan M. Ugrenović[3] and Jelena B. Marinković[1]

[1]Institute of Field and Vegetable Crops,
Maksima Gorkog 30, 21000 Novi Sad, Serbia
[2]Megatrend University, Faculty of Biofarming,
Bačka Topola, Maršala Tita 39, 24300 Bačka Topola, Serbia
[3]Institute Tamiš Pančevo, Novoseljanski put 33, 26000 Pančevo, Serbia

Abstract: Soybean yield depends on the choice of cultivar, soil fertility, cultivation practices, and weather conditions in different years. Ploughing down crop residues increases the content of soil organic matter, and thereby positively affects soil fertility. The use of crop residues as an energy source has been promoted in recent years. It would be wrong to refer to this as a renewable energy source as the removal of crop residues from agricultural fields reduces and ultimately damages soil fertility, which in turn leads to reduced yield and a crop residue decrease in the future. Due to the reduced application of manure and organic fertilisers, it is necessary to return crop residues to the soil to preserve soil structure and prevent soil fertility decline. The effect of ploughing down crop residues of preceding crops on soybean yield has been the focus of studies for eleven years. Ploughing down maize crop residues resulted in the soybean yield increase by about 11.69%, i.e. the annual yield increase ranged from 2.89% to 15.94%.

Key words: crop residues, crop rotation, *Glycine max* L., yield.

Introduction

Soybean (*Glycine max* (L.) Merr.) is the most important source of edible oil and high-quality plant protein for feeding both humans and animals worldwide (Friedman and Brandon, 2001). Industrial development placed soybean among the most important industrial plants, serving as a source for 20,000 different products (Давыденко et al., 2004). Aside from its increased production in the 20th century,

[*]Corresponding author: e-mail: vojin.djukic@ifvcns.ns.ac.rs

soybean is certainly the plant of the future, gaining its importance due to a world population increase (Đukić, 2009a).

Returning crop residues to the soil is widely recognised as a useful approach to recycle nutrients, increase soil fertility, and prevent the impoverishment of organic carbon in the soil (Rengel, 2007). Crop residues can be returned to the soil for nutrient recycling, and they are an important source of organic matter to improve soil physical, chemical and biological properties (Kumar and Goh, 2003). Ploughing down crop residues contributes to the increase in soil biogenic elements, with a positive effect on the succeeding crop, whereas the application of increased nitrogen doses on preceding crops reduces the number of microorganisms in soybean rhizosphere (Dozet, 2009). The decomposition of crop residues is governed by both quantity and quality of the residue (Yu et al., 2015), climatic conditions such as temperature and moisture (Allmaras et al., 1996), and soil properties (Frouz et al., 2015).

Soybean is the most usually rotated crop with maize, and a yield benefit for rotation has been widely reported, with results from 28 field trial studies on crop rotation exhibiting, on average, a 7.8% increase in yield (Erickson, 2008). Much is known about the principal mechanisms responsible for these benefits, including effects on disease control, improved nitrogen nutrition and water supply, although researchers continue to be challenged by inexplicable “rotation effects” that have yet to be documented or fully understood (Kirkegaard et al., 2008). Maize produces a large number of crop residues, which should be powdered and incorporated into the soil through autumn primary tillage. Crop residues maintain the physicochemical conditions of the soil and improve the overall ecological balance of the crop production system (Tan et al., 2007). Incorporation of crop residues into soil significantly prevents soil erosion and enhances the soil quality (Wilhelm et al., 2007). Bhagat and Verma (1992) showed that the incorporation of crop straws for five years significantly increased the crop yield and improved the soil properties. Incorporation of crop rotation into the soil cannot cause a sudden and rapid increase of the amount of humus, as that process is long and slow, but it can improve soil structure, especially important in soils of heavy mechanical composition. It provides better soil-water-air regime, helps absorb and retain soil moisture, and enables the formation of favourable soil structure and biological maturity, which in turn leads to easier and better tillage with reduced fuel consumption (Jaćimović et al., 2009).

Material and Methods

In order to investigate the effect of ploughing down maize crop residues on soybean yield, the trial was carried in the period 2005 to 2015 at the experimental field of the Institute of Field and Vegetable Crops at Rimski Šančevi (45°20′ N

19°51′ E) near Novi Sad. The trial was organised as the three-crop rotation (maize-soybean-winter wheat) with four replications, where maize was used as a preceding crop to soybean. Trials were conducted using the two variants: ploughing down maize crop residues and removing crop residues from plots. Sowing was conducted mechanically on designated plots, while standard soybean cultivation practices were applied throughout the whole course of the study – autumn primary tillage to the depth of 25 cm, pre-sowing cultivation, inter-row cultivation, inter-row tillage and weeding.

A total of 80 kg ha^{-1} P_2O_5 and K_2O (superphosphate 18%, potassium salt 40%), as well as 100 kg $ha^{-1}$of nitrogen fertilizer KAN (27%) were incorporated into the soil as a primary tillage operation, while 100 kg $ha^{-1}$of nitrogen fertilizer KAN was incorporated in the spring as primary tillage before maize sowing. Fertilisation was not applied during soybean cultivation, except for microbial preparation NS Nitrogen used as a seed inoculant immediately before sowing.

The study included early maturing soybean cultivars from the 0 maturity group, with the vegetation period of 120 days and genetic potential above 4500 kg ha^{-1}. The cultivar Proteinka was sown in the period 2005–2009, whereas the cultivar Valjevka was sown in the period 2010–2015. The recommended planting density for this maturity group is 500,000 plants per hectare.

The basic plot was 5 m long, 3 m wide, i.e. 15 m^2 in size. Planting density was 50 x 3.5 cm, or 571,430 plants per hectare. Mechanical harvesting was conducted with a harvester (Wintersteiger elite). After basic plot harvesting, grain weight and moisture were measured, and yield was calculated (kg ha^{-1}) with the moisture level of 14%.

Research results were statistically analysed by the two-way analysis of variance (ANOVA), while the LSD test was used to check significant differences (the statistical program “Statistica 10.0”).

Weather conditions in the period from 2005 to 2015

Temperature. The average temperature during vegetation in the period from 2005 to 2015 was 18.98°C. It is 0.90°C more than the multiyear average for the period from 1964 to 2015 (18.08ºC). If we observe the average monthly temperatures in the vegetation period by years, it can be noticed that in 2005 average monthly temperatures were lower compared to the multiyear average (17.70°C), while in the remaining years of the research, they were higher. The highest value was recorded in 2012 (20.52°C), which was 2.44°C higher than the annual average (Table 1).

Observed by some months, it can be seen that the average monthly temperature in the eleven-year period was higher than the values for the multiyear period. April and May were the warmest in 2009 (14.6°C and 18.6°C), while in

2012 the highest values were recorded for the average monthly temperatures in June (23.0°C), July (25.2°C) and August (24.6°C).

Table 1. Average monthly temperatures during the soybean vegetation period 2005–2015 (°C).

Mean monthly temperature (C)							
Month / Year	IV	V	VI	VII	VIII	IX	Average
2005	11.8	17.0	19.3	21.4	19.4	17.3	17.70
2006	12.7	16.5	19.7	23.6	19.6	17.9	18.33
2007	13.4	18.5	22.1	23.3	22.7	14.6	19.10
2008	13.0	18.4	21.8	21.7	22.7	15.2	18.80
2009	14.6	18.6	19.6	22.8	22.9	19.2	19.62
2010	12.3	16.9	20.2	23.1	21.9	16.1	18.42
2011	13.2	16.8	20.9	22.1	23.1	20.4	19.42
2012	13.0	17.5	23.0	25.2	24.6	19.8	20.52
2013	13.4	17.4	20.5	22.3	22.9	15.7	18.70
2014	13.2	16.3	20.5	21.9	20.9	17.2	18.33
2015	12.0	18.0	20.7	24.9	24.5	18.7	19.80
Average 2005–2015	12.96	17.45	20.75	22.94	22.29	17.46	18.98
Average 1964–2015	11.70	17.00	20.00	21.70	21.20	16.90	18.08

Precipitation. Mean monthly rainfall during the vegetation period from 2005 to 2015 was 408.33 mm, which is 33.33 mm more than the multiyear average or the period from 1964 to 2015 (375.00 mm). After the sum of precipitation in the vegetation period, it can be seen that the years of 2008 (333.2 mm), 2009 (271.5 mm), 2011 (210.5 mm) and 2012 (226.8 mm) were with a pronounced precipitation deficit. In addition to the amount of rainfall during the growing season, favourable rainfall is important to obtain a high yield of soybean. A critical period in relation to water for achieving high yield of soybean is the period of formation of pods and grains, as well as the filling of soybean, respectively in July and August. Thus, it can be noticed that in addition to the above mentioned years, there was a lack of precipitation in the critical period for soybean in 2013 and 2015 (Table 2).

Evapotranspiration. For a more detailed analysis of meteorological conditions in certain years on the soybean yields achieved, the values of potential and actual evapotranspiration were calculated for the period from emergence to maturity of soybean crops in certain years. These values were calculated on the basis of hydrophytothermic soybean indices, mean daily air temperatures, daily values of precipitation, and the measured soil moisture values at the time of soybean seeding were taken as the baseline. The difference between real and potential evapotranspiration at the time of maturity defines the value of the deficit, i.e. more precipitation as the date when potential evapotranspiration surpasses the value of real evapotranspiration marks the beginning of the drought. All these parameters also affect the length of the vegetation period. There was a decrease in yields in 2013, although no precipitation deficit was identified. The reason for this is the soybean damage caused by hail on June 22 (Table 3).

Table 2. Average monthly rainfall during the soybean vegetation period 2005–2015 (mm).

	Precipitation (mm)						
Month / Year	IV	V	VI	VII	VIII	IX	Total
2005	33.0	38.1	135.4	122.5	133.9	67.0	529.9
2006	66.0	70.1	104.3	30.9	124.9	23.8	420.0
2007	0.0	98.6	71.1	38.8	79.6	78.8	366.9
2008	21.9	46.2	115.9	41.6	14.0	93.6	333.2
2009	3.6	50.4	127.2	58.1	19.1	13.1	271.5
2010	63.7	113.7	171.8	99.0	168.5	67.7	684.4
2011	22.8	62.4	36.9	61.5	1.5	25.4	210.5
2012	82.8	52.2	27.5	47.7	3.5	13.1	226.8
2013	35.8	118.1	125.7	34.1	26.7	107.8	448.2
2014	51.2	202.1	38.2	141.1	78.7	99.7	611.0
2015	15.9	191.7	26.7	2.6	99.7	52.6	389.2
Average 2005–2015	36.06	94.87	89.15	61.63	68.19	58.42	408.33
Average 1964–2015	46.90	67.10	86.50	67.40	59.30	47.80	375.00

Table 3. Potential and actual evapotranspiration during soybean vegetation from 2005 to 2015 (mm).

Year	SM	PV	PE	AE	PD	DS	LVP
2005	46.20	430.1	393	476	83	-	125
2006	41.60	326.7	404	370	-34	03.07.	120
2007	32.00	267.2	390	299	-91	02.07.	113
2008	49.20	207.8	412	256	-156	05.07.	114
2009	36.94	242.5	402	279	-123	23.07.	117
2010	51.32	557.4	436	587	151	-	121
2011	48.66	163.6	381	211	-170	21.06.	114
2012	28.20	127.4	403	156	-247	07.06.	106
2013	37.05	298.6	413	336	-77	04.08.	116
2014	35.32	498.2	416	533	117	-	126
2015	39.17	231.1	381	263	-118	18.07.	105

SM – Soil moisture reserves during the sowing time; PV– Precipitation during the vegetation period; PE – Potential evapotranspiration; AE – Evapotranspiration; PD –Precipitation deficit; DS – Drought start, LVP – Length of the vegetation period.

Results and Discussion

Water is the primary limiting factor controlling production. Loss of water through evaporation (E) is large, especially in less intensive cropping systems (Farahani et al., 1998). One way in which water may be conserved is through crop residue management. It is generally believed that increasing crop residue levels leads to water conservation (van Donk et al., 2012). Ploughing down crop residues of maize preceding crops resulted in a yield increase in all years of study, compared to variants in which crop residues were removed from plots. Average yield was increased by 11.69% over the course of eleven years. The highest average yield (4635.50 kg ha^{-1}) was recorded in the 2014 season in which there was no precipitation deficit resulting in an increase and development of soybean, and the lowest was recorded in 2012 (2107.63 kg ha^{-1}) in which precipitation deficit was 247mm during soybean vegetation (Table 4). Retention of a layer of crop residues following harvesting can have considerable yield responses in low-rainfall areas and few or negative responses in super-humid and low-temperature areas (Kingston et al., 2005). During unfavourable seasons, the highest yield increase was recorded on plots where ploughing down harvest residues was applied (13.43% in 2012, 15.94% in 2015). Considering the average annual yields, no significant difference was observed between 2006 and 2009 (3272.88 kg $ha^{-1}$and 3291.88 kg ha^{-1}), but highly significant differences in yields were recorded in all other years of study.

Table 4. Average soybean grain yield (kg ha^{-1}).

Factors	Harvest residue (B)		Average (A)	Yield increase (%)
Year (A)	With CR	Without CR		
2005	4009.00	3721.75	3865.38	7.72
2006	3408.75	3137.00	3272.88	8.66
2007	3454.75	3357.75	3406.25	2.89
2008	3711.75	3304.25	3508.00	12.33
2009	3486.00	3097.75	3291.88	12.53
2010	4592.25	4147.25	4369.75	10.73
2011	3507.00	3214.75	3360.88	9.09
2012	2240.25	1975.00	2107.63	13.43
2013	3182.25	2831.25	3006.75	12.40
2014	4793.00	4478.00	4635.50	7.03
2015	3318.25	2862.00	3090.13	15.94
Average (B)	3609.39	3284.25	3446.82	11.69

Factor	$LSD_{0.05}$	$LSD_{0.01}$
A	3062	4123
B	1467	1971
AxB	4866	6538
BxA	4517	6004

The average yield obtained in trials where maize crop residues were ploughed down (3609.39 kg ha^{-1}) had significant differences compared to trials which included crop residue removal (3284.25 $kgha^{-1}$). Ploughing down maize crop residues has a positive effect on soybean yield (Meki et al., 2013). Soybean yield was 24% lower when sorghum residues were removed than when the residue was left on the soil surface. This yield reduction with residue removal is due to low content of available soil water, high soil temperatures on the surface, and poor canopy development (Doran et al., 1984). Yield increases by ploughing down crop residues of preceding crops were evident in each year of research, while oscillations in yield over the years of the study confirm that soybean yield was highly affected by weather conditions during the vegetation period. Organic matter increases microorganism activity in the arable layer which binds nitrogen, thereby reducing the possibility of nutrient leaching into deeper soil layers (Đukić et al., 2009b).

Considering the trials which included ploughing down crop residues across different study years, no significant differences in soybean yields were recorded between 2007 (3454.75 kg ha^{-1}) and 2009 (3486.00 kg ha^{-1}), or between 2009 and 2011 (3507.00 kg ha^{-1}). Maize residue remaining in the field may have reduced soil water evaporation, increased soil water availability, and improved soybean productivity during the drought year (Riedell et al., 2017).

The difference in yields was significant between 2006 (3408.75 kg ha^{-1}) and 2007, while highly significant differences in yields were recorded in all other years of study. Observing the trials where ploughing down harvest residues was not used across different years of study, soybean yields showed no significant difference between 2006 (3137.00 kg ha^{-1}) and 2009 (3097.75 kg ha^{-1}), or between 2013 (2831.25 kg ha^{-1}) and 2015 (2862.00 kg ha^{-1}). The difference in soybean yields was significant between 2007 (3357.75 kg ha^{-1}) and 2008 (3304.25 kg ha^{-1}), while the differences between yields in other years of study were highly significant. Crop residue is also a valuable resource in terms of soil quality (Wilhelm et al., 2007). Research has shown that crop residue is directly related to characteristics beneficial to soil quality and crop yields, including nutrient cycling, soil organic matter, and soil organic carbon (Blanco-Canqui and Lal, 2009). Crop residue is directly related to many soil physical and chemical properties that affect plant growth, and the removal of crop residue may adversely affect these properties.

Conclusion

Ploughing down maize harvest residues had a positive effect on soybean yield. Crop residue removal from plots reduced soybean yield and ultimately disturbed soil structure and soil biogenic elements. Removal of crop residues from the plots reduced the yield of soybean and disrupted soil structure and soil biogenes. In order to obtain high and stable yields, ploughing down harvest residues of preceding crops should be applied as a mandatory soybean cultivation practice.

References

Allmaras, R.R., Copeland, S.M., Copeland, P.J., & Oussible, M. (1996). Spatial relations between oat residue and ceramic spheres when incorporated sequentially by tillage. *Soil Science Society of America Journal, 60,* 1209-1216.

Blanco-Canqui, H., & Lal, R. (2009a). Crop residue removal impacts on soil productivity and environmental quality. *Critical Reviews in Plant Sciences, 28* (3), 139-163.

Давыденко, О.Г., Голоенко, Д.В., & Розенцвейг, В.Е. (2004). Соя для умеренного климата, "Тэхналогія“ Минск, Беларусь, 173.

Doran, J.W., Wilhelm, W.W., & Power, J.F. (1984). Crop residue removal and soil productivity with no–till corn, sorghum, and soybean. *Soil Science Society of America Journal, 48,* 640-645.

Dozet, G. (2009). Uticaj đubrenja predkulture azotom i primene Co i Mo na prinos i osobine zrna soje. Doktorska disertacija, Megatrend univerzitet Beograd, Fakultet za biofarming Bačka Topola.

Đukić, V. (2009a). Morfološke i proizvodne osobine soje ispitivane u plodoredu sa pšenicom i kukuruzom. Doktorska disertacija, Univerzitet u Beogradu, Poljoprivredni fakultet Zemun.

Đukić, V., Đorđević, V., Popović, V., Kostić, M., Ilić, A., & Dozet, G. (2009b). Uticaj đubrenja na prinos soje. *Zbornik radova Instituta za ratarstvo i povrtarstvo, 46,* 17-22.

Erickson, B. (2008). Corn/soybean rotation literature summary. Dep. of Agric. Econ., Purdue Univ.,West Lafayette, In. http://www.agecon.purdue.edu/pdf/Crop_Rotation_Lit_Review.pdf.

Farahani, H.J., Peterson, G.A., & Westfall, D.G. (1998). Dryland cropping intensification: A fundamental solution to efficient useof precipitation. *Advances in Agronomy, 64,* 197-223.

Friedman, M., & Brandon, D.L. (2001). Nutritional and Health Benefits of Soy Proteins. *Journal of Agricultural and Food Chemistry, 49,* 1069-1086.

Frouz, J., Spaldonov, A., Lhotakova, Z., & Cajthaml, T. (2015). Major mechanisms contributing to the macrofauna-mediated slow down of litter decomposition. *Soil Biology* & *Biochemistry, 91,* 23-31.

Jaćimović, G., Malešević, M., Bogdanović, D., Marinković, B., Crnobarac, J., Latković, D., & Aćin, V. (2009). Prinos pšenice u zavisnosti od dugogodišnjeg zaoravanja žetvenih ostataka. *Annals of Agronomy, 33* (1), 85-92.

Kingston, G., Donzelli, J.L., Meyer, J.H., Richard, E.P., Seeruttun, S., Torres, J., & Van Antwerpen, R. (2005). Impact of green cane harvest and production system on the agronomy of sugarcane. *Proceedings - International Society of Sugar Cane Technologists, 25,* 184-190.

Kirkegaard, J., Christen, O., Krupinsky, J., & Layzell, D. (2008). Break crop benefits in temperate wheat production. *Field Crops Research, 107,* 185-195.

Kumar, K., & Goh, K.M. (2003). Nitrogen release from crop residues and organic amendments as affected by biochemical composition. *Communications in Soil Science and Plant Analysis, 34,* 2441-2460.

Meki, M.N., Atwood, J.D., Norfleet, L.M., Williams, J.R., Gerik, T.J., & Kiniry, J.R. (2013). Corn residue removal effects on soybean yield and nitrogen dynamics in the Upper Mississippi River basin. *Agroecology and Sustainable Food Systems, 37,* 379-400.

Rengel, Z. (2007). The role of crop residues in improving soil fertility In: Marschner P, Rengel Z, (Eds.), *Nutrient cycling in terrestrial ecosystems.* (pp. 183-214). Spring–Verlag; Berlin Heidelberg.

Riedell, W.E., Osborne, S.L., & Dagel, K.J. (2017). Maize Residue Removal and Cover Crop Effects on Subsequent Soybean Crops. *Agronomy Journal, 109* (6), 2762-2770.

Seifert, C., Roberts, M., & Lobell, D. (2017). Continuous corn and soybean yield penalties across hundreds of thousands of fields. *Agronomy Journal*, *109* (2), 541-548.
Tan, D.S., Jin, J.Y., Huang, S.W., Li, S.T., & He, P. (2007). Effect of long–term application of K fertilizer and wheat straw to soil on crop yield and soil K under different planting systems. A*gricultural Sciences in China*, *6*, 200-207.
Van Donk, S.J., Shaver, T.M., Petersen, J.L., & Davison, D.R. (2012). Effects of crop residue removal on soil water content and yield of deficit–irrigated soybean. *Transactions the ASABE, 55*, 149-157.
Verma, T.S., & Bhagat, R.M. (1992). Impact of rice straw management practices on yield, nitrogen uptake and soil properties in a wheat-rice rotation in northern India. *Fertilizer Research, 33*, 97-106.
Wilhelm, W., Johnson, J. Karlen, D., & Lightle, D. (2007). Corn stover to sustain soil organic carbon further constrains biomass supply. *Agronomy Journal*, *99* (6), 1665-1667.
Yu, Z., Huang, Z., Wang, M., Liu, R., Zheng, L., Wan, X., Hu, Z., Davis, M.R., & Lin, T-C. (2015). Nitrogen addition enhances home-field advantage during litter decomposition in subtropical forest plantations. *Soil Biology & Biochemistry, 90*, 188-196.

Received: February 16, 2019
Accepted: August 21, 2019

ZAORAVANJE ŽETVENIH OSTATAKA PREDUSEVA U CILJU POVEĆANJA PRINOSA SOJE

Vojin H. Đukić[1*], Zlatica J. Miladinov[1], Gordana K. Dozet[2], Svetlana N. Balešević-Tubić[1], Jegor A. Miladinović[1], Vladan M. Ugrenović[3] i Jelena B. Marinković[1]

[1]Institut za ratarstvo i povrtarstvo,
Maksima Gorkog 30, 21000 Novi Sad, Srbija
[2]Megatrend Univerzitet, Fakultet za biofarming,
Bačka Topola, Maršala Tita 39, 24300 Bačka Topola, Srbija
[3]PSS Institut Tamiš Pančevo,
Novoseljanski put 33, 26000 Pančevo, Srbija

R e z i m e

Prinos soje zavisi od izbora sorte, plodnosti zemljišta, agrotehničkih mera, kao i od vremenskih uslova u pojedinim godinama. Zaoravanjem žetvenih ostataka preduseva povećava se sadržaj organske materije u zemljištu, što ima pozitivan uticaj na plodnost zemljišta. U jedanaestogodišnjim istraživanjima proučavan je uticaj zaoravanja žetvenih ostataka preduseva kukuruza na prinos soje. Poslednjih nekoliko godina sve više se promoviše korišćenje žetvenih ostataka za dobijanje energije. Pogrešno je nazivati ovaj vid dobijene energije kao obnovljivu energiju, pošto se na duži period odnošenjem žetvenih ostataka sa poljoprivrednih površina pogoršava i trajno narušava plodnost zemljišta, što će dovesti u budućnosti do smanjenja prinosa gajenih biljaka, a samim tim i do smanjenja žetvenih ostataka. Zbog sve manje primene stajnjaka i organskih đubriva, neophodno je bar deo žetvenih ostataka gajenih biljaka vratiti u zemljište, kako bi se sačuvala struktura zemljišta i usporilo opadanje njegove plodnosti. Zaoravanje žetvenih ostataka preduseva kukuruza dovelo je do povećanja prinosa soje u proseku za 11,69%, odnosno po pojedinim godinama povećanje prinosa je bilo od 2,89% do 15,94%.

Ključne reči: predusev, prinos, soja, žetveni ostaci.

Primljeno: 16. febuara 2019.
Odobreno: 21. avgusta 2019.

*Autor za kontakt: e-mail: vojin.djukic@ifvcns.ns.ac.rs

Journal of Agricultural Sciences
Vol. 64, No. 3, 2019
Pages 225-238

https://doi.org/10.2298/JAS1903225S
UDC: 633.11-184:631.55(55)
633.11-155(55)
Original scientific paper

EFFECT OF MICRONUTRIENT FOLIAR APPLICATION ON MORPHOLOGY, YIELD AND IRON AND ZINC GRAIN CONCENTRATION OF DURUM WHEAT GENOTYPES

Manochehr Shiri[1*], Asghar Mehraban[2] and Ahmad Tobe[1]

[1]University of Mohaghegh Ardabili, Ardabil, Iran
[2]Asghar Mehrban, Ardabil Agricultural and Natural Resources Research and Education Center, Agricultural Research, Education and Extension Organization (AREEO), Ardabil, Iran

Abstract: Durum wheat has a comparative adaptive advantage over bread wheat under hot and dry conditions. Accordingly, it feeds millions of people in the Middle East and North Africa. Under these conditions, the deficiency of nutrients, including micronutrients, is a major concern for many reasons, including calcareous soil under drought stress conditions. Therefore, growth, yield, iron (Fe) and zinc (Zn) concentration in durum wheat cultivar grains were investigated. A factorial experiment based on a randomized complete block design with three replications was conducted in the Dryland Agricultural Research Institute (DARI) – Moghan. The first factor comprised spraying at four levels, including the control and foliar spraying with Fe, Zn, and Fe+Zn and the second factor consisted of genotypes at four levels: Dehdasht (G1), Seymareh (G2), and two new genotypes (G3 and G4). Solutions of Fe and Zn fertilizers were sprayed at the tillering, early ear emergence, and milk stages, with a ratio of 2 and 1.5 g fertilizer/1000 ml solution (W/V), respectively. The results showed that genotypes G1, G3 and G4 produced higher grain yield per square meter than G2. This increase was due to the higher weight of 1000 grains in G3 and G4 genotypes and 1000-grain weight with a higher grain number in G1. G1 and G2 had greater spike length, number of grains per spike and spikelet than G3 and G4 genotypes. In all studied traits, except Fe and Zn concentration, the combination of Fe+Zn showed the highest and control had the lowest performance. Also, the application of Zn was superior to Fe. The highest Fe concentration of G1, G2, G3, and G4 was observed at Fe+Zn, control, Zn, and Fe levels, respectively. The highest Zn concentrations were observed in the G3 genotype when only Zn was used or in combination with Fe. According to the results, the Fe and Zn spray application increased durum wheat yield on Fe and Zn deficient soil.

Key words: durum wheat, foliar spray, mineral concentration, yield.

[*]Corresponding author: e-mail: shiri.m@uma.ac.ir

Introduction

Wheat is the most important crop grown in Iran and provides more than 45% of protein and 55% of the calories needed by the people (Malakouti, 2007). Compared to bread wheat, durum wheat (*Triticum turgidum* L.) tends to store more Zn and Fe in grains (Conti et al., 2000). Durum wheat, as the hardiest wheat species, is well adapted to semi-arid and dryland climates and it is superior to bread wheat in hot and dry conditions (Elias and Manthey, 2005). The reasons for the low availability of Fe and Zn are high pH, high calcium carbonate content, heavy texture, low organic matter and low soil moisture (Cakmak et al., 1996). Most of these factors are present in rain-fed conditions. It is estimated that 80 percent of the Iran's farms are potentially deficient in Zn (Malakouti, 2007). In another study, 37% of wheat fields had severe Fe deficiency and 40% of wheat fields had severe Zn deficiency (Dorostkar et al., 2013). Recent researches support the hypothesis of declining the concentration of micronutrients in new wheat cultivars over time (Fan et al., 2008). In developing countries, the decline in micronutrient concentration is more intense due to poor crop management and soil degradation. The average Zn concentration of modern wheat is low compared to the early and wild wheat (Cakmak, 2000). For instance, Nikolic et al. (2016) concluded that the levels of Zn and Fe in the grain of two bread wheat cultivars grown in Serbia were rather low, whereas only 13% of the soil samples were Zn deficient and none was Fe deficient. However, the study of 57 durum wheat cultivars grown under field conditions in Italy showed a low genetic variation in Zn (29 to 46 mg kg^{-1}) and Fe (34–67 mg kg^{-1}) (Ficco et al., 2009). The amount of Zn in durum wheat grains was 8 to 12 mg kg^{-1} under lower Zn availability and 15 to 25 mg kg^{-1} under higher Zn availability conditions (Erdal et al., 2002). The concentration of Zn may also be reduced to 10 mg kg^{-1}, which is not enough to meet human needs (Cakmak, 2008). Research over the past two decades has proven that there is a close relationship between healthy soil, healthy plants and healthy humans, and malnutrition is often associated with illnesses in humans (Sanchez and Swaminathan, 2005). The use of micronutrients to improve crop yield and human health is greatly increased (Alloway, 2008).

Fe deficiency disrupts the synthesis of chlorophyll, electron transfer chain, photosynthesis (Ziaeian and Malakouti, 2006), and decreases leaf green pigments (Kumar and Sool, 2000), and the aboveground growth (Mohamed and Ali, 2004). These traits have a close relationship with the yield of crops. The application of Zn increased leaf and stem growth (Brennan, 2007), the number of grains per spike (Yilmaz et al., 1997) and 1000-grain weight of wheat (Malakoti and Hasanpor, 2003; Yilmaz et al., 1997). Seadh et al. (2009) reported that among the micronutrient elements, Zn had a major role in plant height, spike length, number of spikelets per spike, number of grains per spike, 1000-grain weight, grain yield, straw yield, protein and carbohydrates. Ziaeian and Malakouti (2001) have described that the application of micronutrient elements increases grain yield, straw yield, 1000-grain weight and protein content of the grains. The experiment conducted on wheat crop in 25 locations of Iran included Zn, Fe, manganese (Mn) and copper (Cu) showed that Zn application significantly increased grain yield (about 15%), 1000-grain weight, grain number per spikelet, Zn concentration and protein content (Ziaeian and Malakouti 2001). Hussain et al. (2005) have stated that the use of a micronutrient spray at the tillering, boot and milk stages increases wheat grain yields by increasing plant height, number of grains per spike and 1000-grain weight. The soil and foliar application of Zn-containing fertilizers improved Zn concentrations in bread and durum wheat (Cakmak, 2008). The application of zinc sulphate in Zn-deficient soil increased Zn concentration and grain yield (Yilmaz et al., 1997). An increase in Zn concentrations was reported by Graham et al. (1992) and Shivay et al. (2008) under field conditions. Ming and Yin (1992) have found that Zn application reduces Fe concentration. Cakmak et al. (1999) concluded that lines with high Zn efficiency had higher Zn uptake by roots, but not higher Zn concentration in grains because increased Zn uptake is used to increase dry matter production. An increase in grain Fe concentration with a foliar spray of FeSO4 was reported by Zhang et al. (2010) and Singh et al. (2004). On the other hand, Gupta (1991) identified that foliar Fe fertilizers did not affect grain Fe concentration. There are mostly antagonistic (Saha et al., 2015; Tiwari and Pathak, 1982) and seldom synergistic (Zeidan et al., 2010) relationships between Zn and Fe concentrations in cereals. Monasterio and Graham (2000) and Grusak and Cakmak (2005) believe that grain Fe and Zn concentrations are positively correlated in cereals, biofortification is independent of environment, and raised grain Fe and Zn concentrations can be combined with improved agronomic traits. Thus, breeding for biofortification of Fe and Zn in cereals is feasible. Generally, tetraploid (ssp. durum) varieties showed less genetic variability for Fe and Zn concentrations (Monasterio and Graham, 2000; Grusak and Cakmak, 2005). An increase in inorganic concentrations might be a consequence of slower growth, reduced yield, low harvest index or smaller seeds (Monasterio and Graham, 2000). Yield increase led to a decline in nutrient concentration named the yield dilution effect.

The purpose of this study was to investigate the effect of Zn and Fe foliar application on the yield and quality of durum wheat grains.

Material and Methods

This study was carried out as a factorial experiment in a randomized complete block design with three replications at the Dryland Agricultural Research Institute (DAIR) – Moghan during the 2015–2016 cropping season. Soil characteristics of the study farm are given in Table 1. The DTPA micronutrient extraction method was used to estimate the potential soil availability of Zn and Fe. Critical levels of soil Fe and Zn were 8.5 and 0.55 mg/kg, respectively (Feiziasl, 2006). Therefore, the level of the two elements was lower (Table 1). The first factor comprised foliar spraying at four levels including control and spraying with Fe, Zn and Fe+Zn. The second factor consisted of different genotypes of durum wheat at four levels including Dehdasht (G1), Seimareh (G2) and two new genotypes (G3 and G4). The genealogy and the code of the genotypes are shown in Table 2. Each experiment plot consisted of 6 rows with 5-meter length and 20-cm inter-row space. The seeds were disinfected with carboxin thiram then cultivated with an automatic planter (Wintersteiger) at depths of 5 to 7 cm. Sowing time and harvest time were 6 November 2015 and 5 June 2016, respectively. Seed density within one square meter was 300. Approximately 28.5 kg/ha N and 12 kg/ha P were utilized before planting.

Table 1. Soil test results (depth of 0 to 30 cm).

$K_{ava.}$ (ppm)	$P_{ava.}$ (ppm)	$N_{t.}$ (%)	OM (%)	EC $_{(ds.m-1)}$	pH	Zn (ppm)	Fe (ppm)	Mn (ppm)	Cu (ppm)
307	23.6	0.01	0.98	0.79	7.9	0.45	5.6	3.2	0.21

Table 2. The pedigree of genotypes cultivated for the experiment.

Genotype No.	Genotypes
G1	Dehdasht
G2	Seymareh
G3	SILK_3/DIPPER_6/3/ACO89/DUKEM_4//5*ACO89/4/PLATA_7/ILBOR_1//SOMAT_3/5/LLARETA INIA/YEBAS_8/3/MINIMUS_6/PLATA_16//IMMER/4/D86135/ACO89//PORRON_4/3/SNITANCDSS07Y00046S-099Y-099M-18Y-2M-04Y-0B
G4	BCRIS/BICUM//LLARETAINIA/3/DUKEM_12/2*RASCON_21/5/1A.1D5+1-06/3*MOJO//RCOL/4/ARMENT//SRN_3/NIGRIS_4/3/CANELO_9.1CDSS07Y00068S-099Y-099M-4Y-3M-04Y-0B

The Zn and Fe nano-chelate fertilizer of Khazra Company was sprayed with a ratio of 1.5 and 2 g fertilizer/1000 ml solution (w/v), respectively, at the tillering, early ear emergence and milk stages. Main stems from one square meter were harvested and then plant height, peduncle length, spike length, number of spikelets per spike, number of grains per spike, number of grains per spikelet, and 1000-grain weight of main spikes were assessed. Grain yields comprised the weight of grains of all plants harvested in a square meter. After cleaning the grain samples, they were dried at 70°C for 2 h, then were milled into flour and passed through a sieve of one millimeter. All samples of flour were digested by using the HNO_3-HCl mixture, and Fe and Zn concentrations were measured by an atomic absorption spectrometer (Shimdzu, AA-6300) at wavelengths of 248.3 and 233.9 nm, respectively.

SAS software was used for the analysis of variance (ANOVA). Duncan's multiple range test at $p < 0.05$ was used to determine differences between treatment means.

Results and Discussion

Stem height

Stem height was affected by spraying and genotypes (Table 3). Mean comparisons showed that Zn and Fe+Zn treatments gave significantly greater stem height in comparison to control. The difference between Zn and Fe treatments was insignificant. Genotype G2 had the lowest stem height, and G3 and G4 showed a significant advantage over others (Table 4). El-Magid et al. (2000) concluded that the Fe and Zn foliar application increased the height of the wheat plants. Khan et al. (2008) achieved a similar result by the zinc sulfate soil application for wheat. Seadh et al. (2009) reported that the highest wheat plant height was related to Zn treatment among micronutrient elements applied.

Table 3. The analysis of variance of the effect of spraying and genotype on stem height, peduncle length, spike length, spikelet number/spike and grain number/spike.

Source of variation	df	MS				
		Stem height	Peduncle length	Spike length	Spikelet number/spike	Grain number/spike
Replication	2	0.56	3.19	0.28	1.61	0.005
Spraying (A)	3	101.5**	56.3**	1.19**	11.98**	0.18**
Genotype (B)	3	195.5**	37.8**	2.86**	9.22**	1.105**
A×B	9	8.27^{ns}	2.6^{ns}	0.05^{ns}	0.67^{ns}	0.023^{ns}
Experimental error	30	6.48	1.25	0.05	0.49	0.027
C.V (%)		2.81	3.1	3.95	3.94	6.97

** and *are significant at 1% and 5% probability levels, respectively.

Peduncle length

The effect of spraying and genotypes on peduncle length was significant (Table 3). The foliar application of Fe+Zn gave the largest peduncle length and Zn, Fe and control treatments had lower values, respectively. Genotypes G1, G3 and G4 had the greatest peduncle length and genotype G2, with the lowest stem length, produced the minimum peduncle length (Table 4). Genotypes G3 and G4 also had the greatest stem height.

Table 4. Mean comparison of the effect of genotype and spraying on stem height, peduncle length, spike length, spikelet number/spike and grain number/spike.

		Stem height (cm)	Peduncle length (cm)	Spike length (cm)	Spikelet number/spike	Grain number/spike
Genotype	G1	90.24b	37.69a	6.38a	18.69a	45.69a
	G2	84.58c	33.88b	6.00b	17.88b	43.72a
	G3	93.30a	37.05a	5.47c	17.95b	40.94b
	G4	92.97a	37.41a	5.36c	16.58c	38.08c
Spraying	Control	87.61c	34.11d	5.52c	16.63d	36.91d
	Fe	88.76bc	35.63c	5.61c	17.41c	40.66c
	Zn	90.43b	37.11b	5.97b	18.05b	43.14b
	Fe+Zn	94.70a	39.19a	6.20a	19.00a	47.72a

Means with the same letter are not significantly different based on Duncan's test ($p \leq 0.05$).

Spike length

Plants from control plots produced the least spike length, and there were no significant differences between control and Fe treatment (Table 4). Zn and Fe+Zn foliar application meaningfully increased spike length compared to control, and the greatest spike length was observed for Fe+Zn application. Genotypes G3 and G4 had the lowest spike length, and the highest length was related to the genotype G1. Genotypes G3 and G4 produced the least length of the spike, although they had the greatest stem and peduncle length. Hemantaranjan and Grey (1988) also observed that soil Fe and Zn application increased spike length. Sultana et al. (2016) reported that 0.02% and 0.006% Zn foliar application significantly increased spike length in comparison to control.

Number of spikelets per spike

Comparison of the means (Table 4) showed that the control level produced the lowest number of spikelets per spike. Fe, Zn and Fe+Zn foliar sprays significantly increased the spikelet number per spike over the control. Combined Fe and Zn foliar application caused the highest number of spikelets in each spike. The genotype G4 formed the lowest number of spikelets per spike, and the highest spikelets belonged to the genotype G1. The genotypes G2 and G3 were intermediate. Seadh et al. (2009) found that Zn treatment produced the highest number of spikelets per spike. Khan et al. (2008) also stated that zinc sulfate application increased the number of spikelets per spike in wheat.

Number of grains per spike

Control treatment had the least number of kernels per spike (Table 4). Foliar application of Fe, Zn and Fe+Zn significantly increased the number of kernels per spike over the control. Fe+Zn treatment, which had a significant difference with Fe and Zn sprays, produced the greatest number of kernels per spike. The genotype G4 produced the lowest number of kernels per spike, but genotypes G2 and G1 which had greater spike length and spikelet number per spike significantly improved the number of kernels per spike. An increase in the number of kernels per spike (Hemantaranjan and Grey, 1988; Yilmaz et al. 1997; Malakoti and Hasanpor, 2003) as a result of Zn application has been reported. Seadh et al. (2009) found that Zn application produced the highest number of kernels per spike in wheat.

Number of grains per spikelet

The results of the analysis of variance (Table 5) and mean comparisons (Table 6) are presented. The results showed that the control had the least number of kernels per spikelet and the application of Fe alone and especially in combination with Zn significantly amplified the kernel number. Genotypes G1 and G2 had significantly more kernels than genotypes G3 and G4. A significant increase in the number of kernels per spikelet was reported by Ziaeian and Malakouti (2001).

Table 5. The analysis of variance of the effect of spraying and genotype on grain yield attributes and grain Fe and Zn concentration.

Source of variation	MS					
	df	Grain number/ spikelet	Grain yield/m^2	1000-grain weight	Grain Zn concentration (mg kg^{-1})	Grain Fe concentration (mg kg^{-1})
Replication	2	0.005	3547.12	2.27	0.12	4.4
Spraying (A)	3	0.18**	59761.7**	6.12^{ns}	9.52**	30.3^{ns}
Genotype (B)	3	0.105*	13233.4**	248.4**	8.37**	0.86**
A×B	9	0.023^{ns}	2731.1^{ns}	3.6^{ns}	18.61**	89.32**
Experimental error	30	0.027	2865.4	10.6	0.44	3.04
C.V (%)		6.97	9.69	8.63	2.61	1.96

** and * are significant at 1% and 5% probability levels, respectively.

The weight of 1000 grains

The results showed that the genotype G2 had the lowest 1000-grain weight (32.6) and the other genotypes G1 (35.7), G3 (39.3) and G4 (43.1) significantly enhanced 1000-grain weight (Table 6). The genotype G4 had fewer kernels per spikelet and spike than the rest of the genotypes (Table 4), and as a result, fewer kernels absorbed more photosynthetic material and increased their weight. The high yield of genotypes G3 and G4 was associated with higher kernel weight of them. Hussain et al. (2005) have reported that a micronutrient spray increases the weight of 1000 grains at the tillering, boot and milk stages. In the present study, as the application of the micronutrients has increased the number of spikelets and the number of kernels in both spikelets and spikes, more kernels as a sink have been produced and photosynthetic materials have been allocated among more kernels and thus there was no significant difference among spray treatments.

Table 6. The effect of genotype and foliar spraying on grain number/spike, grain yield and 1000-grain weight.

		Grain number/spikelet	Grain yield/m^2	1000-grain weight (g)
Genotype	G1	2.44a	568.7a	35.7c
	G2	2.42a	502.9b	32.6d
	G3	2.27b	561.2a	39.3b
	G4	2.28b	575.2a	43.1a
Spraying	Control	2.21c	472.5c	-
	Fe	2.33bc	529.4b	-
	Zn	2.39ab	565.3b	-
	Fe+Zn	2.51a	641/0a	-

Means with the same letter are not significantly different based on Duncan's test ($p \leq 0.05$).

Grain yield per square meter

Plants from control plots had the lowest grain yield. Spraying with Fe and Zn significantly improved grain yield compared to control. The highest grain yield was obtained from plants sprayed with Fe+Zn, which had a significant advantage over Fe and Zn foliar spray. Genotypes G1, G3 and G4 had significantly higher grain yield than the genotype G2 which had the lowest grain yield. Ziaeian and Malakouti (2001) reported that wheat grain and straw yields were increased by the foliar spray of Fe and Zn. Experiments on wheat in 25 locations in Iran with treatments including Zn, Fe, Mn and Cu revealed that Zn application significantly improved grain yield (about 15%). Seadh et al. (2009) found that among the micronutrient elements, the Zn treatment produced the highest grain yield. Hussain et al. (2005) reported that the micronutrient spray at tillering, boot and milk stages enhanced wheat grain yield by increasing plant height, number of kernels per spike and 1000-grain weight. Pahlavan-Rad and Pessarakli (2009) stated that the application of 80 kg zinc sulfate per hectare increased the number of kernels per spike and grain yield. Different varieties of wheat not only have different growth potentials, but may also be different in terms of the response to fertilizers

(Hemantaranjan and Gray, 1988). Khoshgoftarmanesh et al. (2005) have concluded that wheat cultivars respond differently to the application of zinc sulfate. Rengel and Graham (1995) also showed that Zn fertilizer increased wheat grain and straw yield, and the wheat cultivars showed different responses.

Fe grain concentration

Grain Fe concentration was affected by the interaction of spraying × cultivars (Table 5). The G1 and G2 genotypes accumulated more Fe in comparison with the G3 and G4 genotypes when they were not sprayed with micronutrient fertilizers. The application of Fe and Zn increased the Fe concentration in genotypes G3 and G4 over control but decreased their concentration in genotype G2. A single spray of Fe and Zn in comparison with control reduced the Fe content of grains in the G1 genotype, but Fe combined with Zn increased it. Therefore, in new genotypes, contrary to cultivars, the spray of micronutrients increased the Fe concentration (Figure 1). Findings of previous studies differ in Fe concentration. Abbas et al. (2009) found that the application of 8 kg Zn/ha increased the amount of Fe absorbed, while the higher levels had a decreasing effect. Khan et al. (2014) reported the highest concentrations of Fe at Fe treatment and Yassen et al. (2010) at the micronutrient combination treatment.

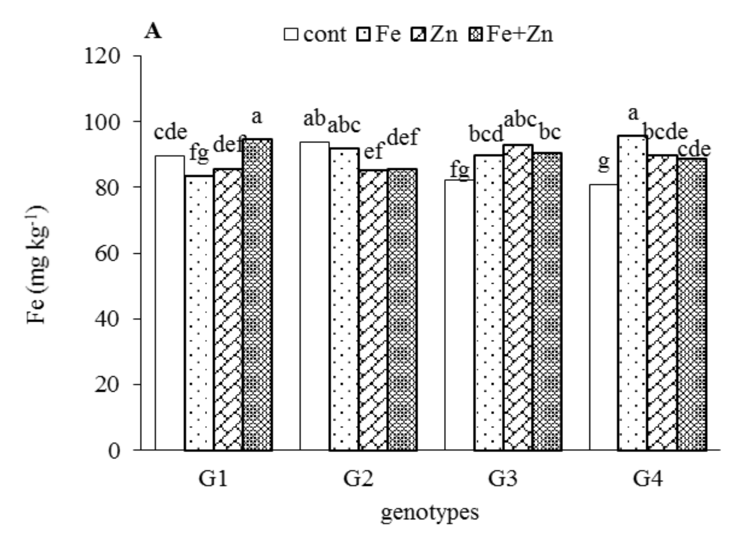

Figure 1. Fe concentration variation under different treatments.

Zn grain concentration

In the G1 genotype, the application of Fe alone and in combination with Zn concentration significantly reduced grain Zn concentration compared to control. Also, Zn concentrations for Zn treatment and control were similar. The Zn and Fe application significantly reduced the Zn concentration of the genotype G2 in comparison with control, but the combined application of Zn and Fe caused a slight reduction in grain Zn concentration. Spraying of micronutrients, especially Zn alone or in combination with Fe, significantly increased grain Zn concentration of the genotype G3 in comparison to the control. Grain Zn concentration of the G4 genotype was the same among different levels of the foliar spray (Figure 2). Wang et al. (2012) found that the Zn foliar application, not soil application, increased the amount of Zn in wheat grains. Ravi et al. (2008) concluded that the combined application of Zn and Fe increased grain Zn concentration. It has been stated that micronutrient concentration in wheat grains mainly depends on environmental factors and interactions between the genotypes and the environment (Morgounov et al., 2007; Nan et al., 2002). Biofortification strategies include the application of mineral nutrients and the development of genotypes that take up more Zn from the soil and collect it in edible organs (White and Broadley, 2011). There are genotypes with a higher concentration of nutrients (White and Broadley, 2005). In our study, foliar spraying treatments clearly increased Zn concentration of G3 over control. It is notable that G3 along with G1 and G4 had higher grain yield. Therefore, there was no relation between grain nutrient concentration and grain yield. A decrease in nutrient concentration at sprayed treatments might be due to the dilution effect since grain yield has been increased by foliar treatments at the tillering stage.

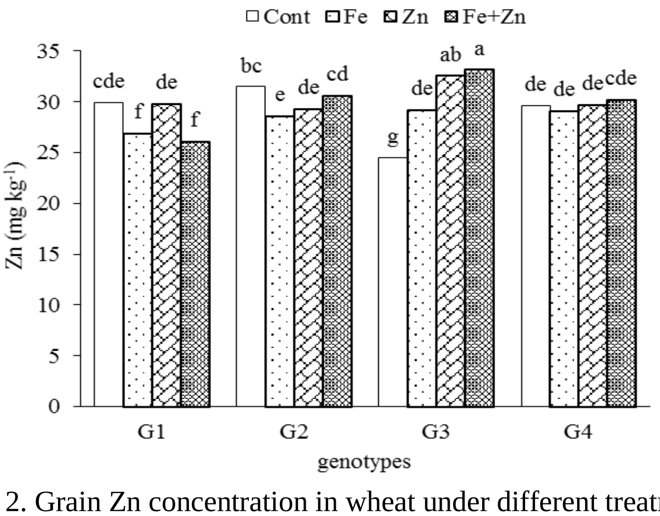

Figure 2. Grain Zn concentration in wheat under different treatments.

Conclusion

New genotypes (G3 and G4) produced greater stem length, peduncle length, number of kernels per spike and 1000-grain weight than cultivars (G1 and G2) grown in the 2015–2016 cropping system. Grain yield of the genotypes G3 and G4 was equal to or higher than that of the genotypes G1 and G2. The foliar application of Fe and Zn, especially the combined application of Fe+Zn, improved the number of grains per spike and grain yields compared to control. Also, the treatment with Zn achieved better results than the treatment with Fe. The foliar application of Fe for the G4 genotype and Fe+Zn for the G3 genotype caused the highest concentrations of Fe and Zn, respectively. Due to the high ratio of Fe to Zn (2.7 to 3/3), it seems necessary to increase the quality of wheat. Efforts should be made to raise Zn concentration in grains, since this ratio should be less than 2.

References

Abbas, G., Khan, M.Q., Jamil, M., Tahir, M., & Hussain, F. (2009). Nutrient uptake, growth and yield of wheat (*Triticum aestivum*) as affected by zinc application rates. *International Journal of Agriculture and Biology, 11* (4), 389-396.

Alloway, B.J. (2008). *Zinc in soils and crop nutrition.* Second edition, published by IZA and IFA, Brussels, Belgium and Paris, France.

Brennan, R.F. (2007). Effectiveness of zinc sulfate and zinc chelate as foliar sprays in alleviating zinc deficiency of wheat grown on zinc–deficient soils in Western Australia. *Australian Journal of Experimental Agriculture*, *31*, 831-834.

Cakmak, I. (2000). Plant nutrition research priorities to meet human needs for food in sustainable ways. *Plant Science*, *247*, 3-24.

Cakmak, I. (2008). Enrichment of cereal grains with zinc: Agronomic or genetic biofortification? *Plant and Soil*, *302*, 1-17.

Cakmak, I., Kalaycy, M., Ekiz, H., Braun, H.J., Kilinc, Y., & Yilmaz, A. (1999). Zinc deficiency as a practical problem in plant and human nutrition in Turkey: A NATO-science for stability project. *Field Crops Research*, *60*, 175-188.

Conti, M.E., Cubadda, F., & Carcea, M., (2000). Trace metals in soft and durum wheat from Italy. *Food Additives and Contaminants*, *17*, 45-53.

Dorostkar, V., Afyuni, M., & Khoshgoftarmanesh, A. (2013). Effects of preceding crop residues on total and bio-available zinc concentration and phytic acid concentration in wheat grain. *Journal of Water and Soil Science, 17* (64), 81-93. (In Persian with English abstract).

Elias, E.M., & Manthey, F.A. (2005). End products: Present and future uses. In: C. Royo, M.M. Nachit, N. Di Fonzo, & J.L. Araus, (Eds.), *Durum Wheat Breeding Current Approaches and Future Strategies* (pp. 63-86).

El-Magid, A.A.A., Knany, R.E., & El-Fotoh, H.G.A. (2000). Effect of foliar application of some micronutrients on wheat yield and quality. *Annals of Agricultural Science Cairo, 1*, 301-313.

Erdal, I., Yilmaz, A., Taban, S., Eker, S., Torun, B. & Cakmak, I. (2002). Phytic acid and phosphorus concentrations in seeds of wheat cultivars grown with and without zinc fertilization. *Journal of Plant Nutrition*, *25*, 113-127.

Fan, M.S., Zhao, F.J., Fairweather-Tait, S.J., Poulton, P.R., Dunham, S.J., & McGrath, S.P. (2008). Evidence of decreasing mineral density in wheat grain over the last 160 years. *Journal of Trace Elements in Medicine and Biology*, *22*, 315-24.

Feiziasl, V. (2006). Determination of Fe, Mn, Zn and Cu critical levels and classification for dryland wheat (*T. aestivum.* L.) in north western of Iran. *Iranian Journal of Agricultural Sciences* (*Journal of Agriculture*), *37* (1), 389-401.

Ficco, D.B.M., Riefolo, C., Nicastro, G., De Simone, V., Di Gesù, A.M., Beleggia, R., Platani, C., Cattivelli, L., & De Vita, P. (2009). Phytate and mineral elements concentration in a collection of Italian durum wheat cultivars. *Field Crops Research*, *111*, 235-242.

Graham, R.D., Ascher, J.S., & Hynes, S.C. (1992). Selection of zinc efficient cereal genotypes for soils of low zinc status. *Plant and Soil*, *146*, 241-250.

Grusak, M.A., & Cakmak, I. (2005). Methods to improve the crop delivery of minerals to humans and livestock. In M.R. Broadley & P.J. White (Eds.), *Plant Nutritional Genomics.* (pp. 265-286). Blackwell.

Gupta, U.C. (1991). Iron statues of crops in Prince-Edward-Island and effect of soil-pH on plant iron concentration. *Canadian Journal of Soil Science*, *71*, 197-202.

Hemantaranjan, A., & Grey, O.K. (1988). Iron and zinc fertilization with reference to the grain quality of *Triticum aestivum* L. *Journal of plant nutrition*, *11*, 1439-1450.

Hussain, N, Khan, M.A., & Javad, M.A. (2005). Effect of foliar application of plant micronutrient mixture on growth and yield of wheat (*Triticum aestivum* L.). *Pakistan Journal of Biological Sciences*, *8* (8), 1096-1099.

Khan, M.A., Fuller, M.P., & Baloch, F.S. (2008). Effect of soil applied zinc sulfate on wheat (*Triticum aestivum* L.) grown on a calcareous soil, Pakistan. *Cereal Research Communications*, *36* (4), 571-582.

Khan, N., Tariq, M., Ullah, K., Muhammad, D., Khan, I., Rahatullah, K., Ahmed, N., & Ahmed, S. (2014). The Effect of molybdenum and iron on nodulation, nitrogen fixation and yield of chickpea genotypes (*Cicer arietinum* L). *IOSR Journal of Agriculture and Veterinary Science*, *7* (1), 63-79.

Khoshgoftarmanesh, H., Shariatmadari, H., Karimian, N., Kalbasi, M., & Khajehpour, M.R. (2005). Zinc efficiency of wheat cultivars grown on a saline calcareous soil. *Journal of Plant Nutrition*, *27* (11), 1953-1962

Kumar, A.M., & Soll, D. (2000). Antisense HEMA1 RNA expression inhibits heme and chlorophyll biosynthesis in fertilizati. *Plant Physiologists*, *122*, 49-56.

Malakoti, M.J., & Hasanpor, A. (2003). *The role of optimum use of fertilizers on time of Agricultural production harvest*. Technical issue No. 292. Ministry of Jahade Agriculture. 92p. (In Persian)

Malakouti, M.J. (2007). Zinc is a neglected element in the life cycle of plants. *Middle Eastern and Russian Journal of Plant Science and Biotechnology*, *1* (1), 1-12.

Ming, C., & Yin, C.R. (1992). Effect of Mn and Zn-fertilizers on nutrient balance and deficiency diagnosis of winter wheat crop in pot experiment. In: S. Portch (Ed.), *International Symposium on the Role of Sulphur, Magnesium, and Micronutrients in Balanced Plant Nutrition* (pp. 369-379). Washington, DC.

Mohamed, A.A., & Ali, A.A. (2004). Iron deficiency stimulated some enzymes activity, lipid peroxidation and free radicals production in *Borago officinalis* induced in vitro. *International Journal of Agriculture & Biology, 6*, 179-184.

Monasterio, I., & Graham, R.D. (2000). Breeding for trace minerals in wheat. *Food Nutrition Bulletin, 21*, 392-396.

Morgounov, A., Gomez-Becerra, H.F., Abugalieva, A., Dzhunusova, M., Yessimbekova, M., Muminjanov, H., Zelenskiy, Y., Ozturk, L., & Cakmak, I. (2007). Iron and zinc grain density in common wheat grown in Central Asia. *Euphytica*, *2007, 155*, 193-203.

Nan, Z., Li, J., Zhang, J., & Cheng, G. (2002). Cadmium and zinc interactions and their transfer in soil-crop system under actual field conditions. *Science* of the *Total Environment*, *285,* 187-195.

Nikolic, M., Nikolic, N., Kostic, L., Pavlovic, J., Bosnic, P., Stevic, N., Savic, J., & Hristov, N. (2016). The assessment of soil availability and wheat grain status of zinc and iron in Serbia: Implications for human nutrition. *Science of the Total Environment, 553*, 141-148.

Pahlavan-Rad, M.R., & Pessarakli, M. (2009). Response of wheat plants to zinc, iron, and manganese applications and uptake and concentration of zinc, iron, and manganese in wheat grains. *Communications in Soil Science and Plant Analysis*, *40*, 1322-1332.

Ravi, S., Channal, H.T., Hebsur, N.S., Patil, B.N., & Dharmatti, P.R. (2008). Effect of sulphur, zinc and iron nutrition on growth, yield, nutrient uptake and quality of safflower (*Carthamus tinctorius* L.). *Karnataka Journal of Agricultural Sciences*, *21* (3), 382-385.

Rengel, Z., & Graham, R.D. (1995). Importance of seed Zn content for wheat growth on Zn-deficient soil. I. Vegetative growth. *Plant Soil*, *173*, 259-266.

Saha, S., Mandal, B., Hazra, G.C., Dey, A., Chakraborty, M., Adhikari, B., Mukhopadhyay, S.K., & Sadhukhan, R. (2015). Can agronomic biofortification of zinc be benign for iron in cereals? *Journal of Cereal Science*, *65*, 186-191.

Sanchez, P.A., & Swaminathan, M.S. (2005). Hunger in Africa: The link between unhealthy people and unhealthy soils. *Lancet*, *365*, 442-444.

Seadh, S.E., El-Abady, M.I., El-Ghamry, A.M., & Farouk, S. (2009). Influence of micronutrients foliar application and nitrogen fertilization on wheat yield and quality of grain and seed. *Journal of Biological Sciences*, *9* (8), 851-858.

Shivay, Y.S., Kumar, D., & Prasad, R. (2008). Effect of zinc- enriched urea on productivity, zinc uptake and efficiency of an aromatic rice-wheat cropping system. *Nutrient Cycling in Agroecosystems*, *81*, 229-243.

Singh, M., Chaudhary, S.R., Sharma, S.R., & Rathore, M.S. (2004). Effect of some micronutrients on content and uptake by chickpea (*Cicer arietinum*). *Agricultural Science Digest*, *24* (4), 268-270.

Sultana, S., Naser, H.M., Shil, N.C., Akhter, S., & Begum, R.A. (2016). Effect of foliar application of zinc on yield of wheat grown by avoiding irrigation at different growth stages. *Bangladesh Journal of Agricultural Research*, *41* (2), 323-334.

Tiwari, K.N., & Pathak, A.N. (1982). Studies on Fe-Zn interrelationships in rice under flooded and unflooded condition. *Journal of Plant Nutrition*, *5* (4-7), 741-742.

Wang, J.W., Mao, H., Zhao, H.B., Huang, D.L., & Wang, Z.H. (2012). Different increases in maize and wheat grain zinc concentrations caused by soil and foliar applications of zinc in Loess Plateau. *China Field Crop Research*, *135*, 89-96.

White, P.J., & Broadley, M.R. (2005). Biofortifying crops with essential mineral elements. *Trends in Plant Science*, *10* (12), 586-593.

White, P.J., & Broadley, M.R. (2011). Physiological limits to zinc biofortification of edible crops. *Frontiers in Plant Science*, *2*, 80. doi: 10.3389/fpls.2011.00080.

Yassen, A., Abou, El-Nour, E.A.A., & Shedeed, S. (2010). Response of wheat to foliar spray with urea and micronutrients. *Journal of American Science*, *6* (9), 14-22.

Yilmaz, A.H., Ekiz, B., Torun, I., Gultekin, S., Karanlik, S.A., Bagci, A., & Cakmak, I. (1997). Effect of different zinc application methods on grain yield and zinc concentration in wheat grown on zinc-deficient calcareous soils in central Anatolia. *Journal of Plant Nutrition*, *20*, 461-471.

Zeidan, M.S., Mohamed, M.F., & Hamouda, H.A. (2010). Effect of foliar fertilization of Fe, Mn and Zn on wheat yield and quality in low sandy soils fertility. *World Journal of Agricultural Sciences*, *6*, 696-699.

Zhang, Y., Shi, R., Rezaul, K.M., Zhang, F., & Zou, C. (2010). Iron and zinc concentrations in grain and flour of winter wheat as affected by foliar application. *Journal of Agricultural and Food Chemistry*, *58* (23), 12268-12274.

Ziaeian, A.H., & Malakouti, M.J. (2001). Effects of Fe, Mn, Zn and Cu fertilization on the yield and grain quality of wheat in the calcareous soils of Iran. In W.J. Horst et al. (Eds.), *Plant Nutrition-Food Security and Sustainability of Agro-Ecosystems, 92*, (pp. 840-841). Springer, Dordrecht.

Received: January 8, 2019
Accepted: May 13, 2019

UTICAJ FOLIJARNE PRIMENE MIKROELEMENATA NA MORFOLOGIJU, PRINOS I KONCENTRACIJU GVOŽĐA I CINKA U ZRNU GENOTIPOVA TVRDE PŠENICE

Manochehr Shiri[1*], Asghar Mehraban[2] i Ahmad Tobe[1]

[1]Univerzitet Mohaghegh Ardabili, Ardabil, Iran
[2]Asghar Mehrban, Centar za istraživanje i obrazovanje u oblasti poljoprivrede i prirodnih resursa u Ardabilu, Organizacija za poljoprivredna istraživanja, obrazovanje i savetodavstvo, Ardabil, Iran

R e z i m e

Tvrda pšenica se prilagođava toplim i sušnim uslovima bolje nego hlebna pšenica. Prema tome, služi za ishranu miliona ljudi na Srednjem istoku i u severnoj Africi. U ovakvim uslovima, nedostatak hraniva, uključujući mikroelemente, od velikog je interesa iz mnogih razloga, uključujući karbonatna zemljišta u uslovima stresa izazvanog sušom. Stoga su ispitivani rast, prinos, koncentracija gvožđa (Fe) i cinka (Zn) u zrnima sorti tvrde pšenice. Faktorijalni ekperiment zasnovan na potpuno slučajnom blok sistemu sa tri ponavljanja sproveden je na Institutu za poljoprivredna istraživanja u uslovima suvog ratarenja (engl. *Dryland Agricultural Research Institute – DARI*) u Moghanu. Prvi faktor je uključivao četiri tretmana, i to kontrolu i folijarne tretmane gvožđem, cinkom, i kombinaciju Fe+Zn, a drugi faktor je podrazumevao četiri genotipa: Dehdasht (G1), Seymareh (G2), i dva nova genotipa (G3 i G4). Rastvori đubriva sa gvožđem i cinkom primenjivani su u fazama bokorenja, ranog klasanja i mlečne zrelosti, u odnosu 2 g odnosno 1,5 g đubriva/1000 ml rastvora (w/v). Rezultati su pokazali da su genotipovi G1, G3 i G4 dali viši prinos zrna po metru kvadratnom nego genotip G2. Ovo povećanje je posledica veće mase 1000 zrna kod genotipova G3 i G4 i veće mase 1000 zrna sa većim brojem zrna kod genotipa G1. Genotipovi G1 i G2 su imali veću dužinu klasa, broj zrna po klasu i klasiću nego genotipovi G3 i G4. Kod svih ispitivanih osobina, osim koncentracije gvožđa i cinka u zrnu, kombinacija Fe+Zn pokazala je najveći a kontrola najniži učinak. Takođe, primena cinka je dala bolje rezultate u odnosu na gvožđe. Najviša koncentracija gvožđa kod genotipova G1, G2, G3, i G4 uočena je kod kombinacije Fe+Zn, kontrole, Zn, odnosno Fe. Najviše koncentracije cinka su zabeležene kod genotipa G3 kada je korišćen samo Zn ili u kombinaciji sa Fe. Prema rezultatima, folijarna primena gvožđa i cinka povećala je prinos tvrde pšenice na zemljištu deficitarnom u cinku i gvožđu.

Ključne reči: tvrda pšenica, folijarno prskanje, koncentracija minerala, prinos.

Primljeno: 8. januara 2019.
Odobreno: 13. maja 2019.

[*]Autor za kontakt: e-mail: shiri.m@uma.ac.ir

Journal of Agricultural Sciences
Vol. 64, No. 3, 2019
Pages 239-253

https://doi.org/10.2298/JAS1903239S
UDC: 662.636:633.18
633.18-155.9
Original scientific paper

CHANGES IN MICROBIAL BIOMASS AND GRAIN YIELD OF RICE VARIETIES IN RESPONSE TO THE ALTERNATE WET AND DRY WATER REGIME IN THE INLAND VALLEY OF DERIVED SAVANNA

Adeniyi A. Soretire[1*], Olalekan S. Sakariyawo[2], Oyinkansola S. Yewande[1], John K. Adesodun[1], Aderonke K. Akintokun[3], Paul A.S. Soremi[2] and Sunday G. Aderibigbe[2]

[1]Department of Soil Science and Land Management, Federal University of Agriculture, Abeokuta (FUNAAB), Abeokuta, Ogun State, Nigeria
[2]Department of Plant Physiology and Crop Production, FUNAAB, Abeokuta, Ogun State, Nigeria
[3]Department of Microbiology, FUNAAB, Abeokuta, Ogun State, Nigeria

Abstract: This investigation tested the hypothesis that the alternate wet and dry (AWD) water regime would increase soil microbial biomass carbon (MBC), microbial biomass nitrogen (MBN) and microbial count. Variations in MBC, MBN and grain yield could be due to varietal differences in a derived savanna. Experiments (both pot and field ones) were conducted at the Federal University of Agriculture, Abeokuta (Latitude 7° 12' to 7° 20' N and Longitude 3° 20' to 3° 28' E), Nigeria in 2015. In both trials, the treatments consisted of water regimes (continuous flooding [control] and AWD imposed on lowland rice varieties [NERICA® L-19] and Ofada [local check]) at the vegetative growth stage in three cycles. The design in both trials was a completely randomised and randomised complete block design for the pot and field experiments respectively, with three replicates. In the screen house, MBC and MBN were significantly higher in AWD than in continuously flooded soil, especially at the beginning of the AWD cycles. This could have caused nutrient pulses to sustain the improved performance of lowland rice under AWD. A converse pattern was observed in the field in the third cycle. Ofada rice had a significantly higher microbial count and MBC (cycle 1) than NERICA L-19, however, a converse pattern was observed in MBC (cycles 2 and 3) and MBN (cycle 1). Composition of their rhizodeposition and timing of cycles could explain the observed varietal differences in MBC and MBN.

Key words: biomass, cycles, grain yield, lowland, soils.

[*]Corresponding author: e-mail: soretireaa@funaab.edu.ng

Introduction

It was estimated that over 75% of the world's rice is produced under continuously flooded conditions (Van der Hoek et al., 2001). Under such water management practices, microbial activities are down-regulated with reduced soil microbial biomass (SMB), mineralisation and nutrient release from the soil complexes (Uphoff and Randriamiharisoa, 2002). In another study, it was observed that irrigation had no effect on soil microbial biomass except on the seasonal variation on the ratio of microbial C to N (Rangel-Vasconcelos et al., 2015). SMB forms an integral living component of the soil organic matter through which soil quality could be evaluated (Silva et al., 2010). SMB acts as a source or a sink of mineral nutrients (Qu and Wang, 2008). SMB acting as a sink together with the soil organic matter have been implicated in the formation of cation exchange capacity of the soil (Loureiro et al., 2010). Microbial biomass is a source of mineral nutrients in the soil (Dare et al., 2014). Therefore, it could be inferred that there is a nexus between SMB and crop productivity.

Alternate technologies have been proposed to ameliorate the negative effect of continuous flooding on SMB and lowland rice productivity. One of such is the alternate wet and dry technology. Crops established under AWD were reported to have higher water use efficiency, better root architecture and biology, and higher harvest index than those grown under continuously flooded conditions (Yang and Zhang, 2010). Nutrient pulses due to microbial activities (the Birch effect) had also been reported (Jarvis et al., 2007). These nutrient pulses were reported to be dependent on the frequency of AWD, the environmental conditions and the crop species (Fierer and Schimel, 2002). New Rice for Africa (NERICA) is an interspecific variety that combines the comparatively high yielding trait of *O. sativa* and the hardiness of *O. glaberrima* (Jones, 1997). Together with Ofada rice (the popular farmer's variety), these varieties have been reported to be more tolerant to adverse environmental conditions than the more popular *Oryza sativa* varieties in Africa. The response of lowland NERICA and Ofada rice varieties to AWD is not well documented in the literature to the best of our knowledge. The use of AWD on rice has been limited to growth stages other than vegetative. However, utilisation of this technology at the vegetative growth stage would provide an understanding of their effect on the initiation of reproductive structures in rice and SMB, especially in the derived savanna agroecology. Furthermore, it has been reported that there is a significant varietal variation in the SMB through rhizodeposition, especially C (Tian et al., 2013). The presence of the root exudates could also alter the rhizosphere, subsequently affecting the soil microbial activities in nutrient cycling. Hence, the experiments tested the hypothesis that lowland NERICA rice established under the AWD water regime would have a higher microbial count, microbial biomass C and N and yield performance than those under continuously flooded conditions in a derived savanna.

Material and Methods

Description of the experimental location

Two trials (pot and field experiments) were carried out in the year of 2015. The pot trial was conducted in the Screen house, College of Plant Science and Crop Production, Federal University of Agriculture, Abeokuta (FUNAAB), Nigeria. A field trial was conducted in the inland valley of the Teaching and Research Farm of FUNAAB, Nigeria. FUNAAB (Latitude 7° 12’ to 7° 20’ N and Longitude 3° 20’ to 3° 28’ E) is located in the derived savanna agroecology. The rainy season extends from April/May to September/October.

Treatments and design

In the screen house, the treatment consisted of water regime (continuous flooding and alternate wet and dry [AWD]) imposed on lowland rice varieties (NERICA® L-19 and Ofada [local variety]) at the vegetative growth stage, which was laid out in a completely randomised design, replicated three times. The AWD water regime was achieved through intermittent flooding in three cycles at the vegetative growth stage. A cycle had a duration of 10 days that commenced with wetting to keep the soil in each pot saturated but not flooded. Thereafter, the pots were left to dry until the tenth day, before the commencement of another cycle of AWD. The field experiment had similar treatments that were arranged in a completely randomised block design, replicated three times. On the field, AWD was achieved under rainfed conditions. Due to the nature of this condition, water was controlled in each plot through the construction of bunds and a valve around it. Even distribution of water in each plot was ensured through levelling. The release and entrapment of water in each plot were achieved through the opening and closing of the valve placed by its side. AWD in the field had the same duration and number of cycles as obtained in the pot experiment. Water in each plot was maintained in a saturated condition at each cycle under wet conditions. If downpour was observed, then the valve by the side of each plot was released to avoid flooding. Under the same conditions and in the absence of precipitation, the valve was left closed to keep each plot under saturated conditions in the wet phase of AWD. At each AWD cycle, soil samples were collected from each plot. In case downpour was observed, soil sampling was conducted prior to its commencement. All the plots were flooded (through rainfall) after the vegetative growth stage. Continuous flooding was maintained in each plot thereafter until 15 days before harvesting. All plots were fully drained at harvesting. In both experiments, poultry manure was incorporated into the soil two weeks before transplanting at the recommended rate of 80 kg N $ha^{-1}$for this agroecological system that translated into 16,326.5 kg ha^{-1} of applied quantity. The gross plot size was 4 × 5 m (20 m^2), while the net plot was 4 × 3 m (12 m^2). The field trial was established on the 10^{th} of July, 2015. The seeding method for both trials was transplanting of the 21-day-old seedlings that were earlier established in a nursery. The spacing for the field trial was 20 cm × 20 cm. The plant density was 500 plants per plot. Weeding was done manually as at when due.

Sampling and data collection

Soil samples were collected randomly from the experimental site before planting at a depth of 0–0.2 m, air-dried and passed through a 2-mm sieve for the evaluation of their physical and chemical properties. In both trials, soil samples were randomly collected at intervals of 10 days and analysed to evaluate microbial biomass carbon (MBC), microbial biomass nitrogen (MBN) and soil microbial population.

Microbial biomass carbon and nitrogen

MBC and MBN were determined by the chloroform fumigation-incubation technique (Jenkinson and Ladd, 1981). Two sub-samples of 10g of soil were poured into 50-ml beakers and a third sub-sample of the same weight into a 125-ml watertight bottle (s_0). One of the sample beakers was placed in a vacuum desiccator containing 30 ml alcohol-free chloroform in a shallow dish. The lid of the desiccator was closed, and the vacuum was applied until the chloroform evaporated. The desiccator (with the tap closed) was kept in the dark for 24 hours at 25^0C after which it was transferred to a watertight 125-ml extraction bottle (s_f), 50 ml of 0.5 K_2SO_4 was added to the bottles (s_f and s_0) with the stopper tightly in place. Extraction bottles with soil samples were shaken for 30 minutes, the extract was filtered through No. 42 Whatman filter paper and the filtrate was analysed for dissolved organic C and total N.

From the dissolved organic C, MBC can be calculated using the formula:

$$Microbial\ biomass\ C = (Extracted\ Csf - Extracted\ Cso) * 2.64$$

(Vance et al., 1987).

From total N, MBN can be calculated using the formula:

$$Microbial\ biomass\ N = (Extracted\ Nsf - Extracted\ Nso) * 1.46$$

(Brookes et al., 1985).

Total microbial count/population

One gram of soil was serially diluted from10^{-1} to 10^{-6} dilutions, and the diluted soil samples were spread on sterile plate count agar. The plates were incubated at 37^0C for 24 hours. Colonies were counted and expressed in colony-forming unit/gram ($CFUg^{-1}$). The CFU was calculated using the formula:

$$Colony\ forming\ unit = \frac{number\ of\ colonies}{number\ of\ dilution \times amount\ plated}$$

Grain yield

Rice grain yield was determined at 90% harvest maturity when 90% of the panicles turned golden yellow. In the screen house, grain yield per pot was evaluated, while in the field, grain yield was determined from the net plot and converted to grain yield per hectare.

Statistical analysis

The data collected were subjected to the analysis of variance (ANOVA) fixed model that consisted of water regime and variety in the treatment structure and replicates in the block structure at the 5% probability level. All variables were examined for the violation of ANOVA assumption through the graphical analysis of the residuals prior to analysis. Discrete data were log-transformed before analysis. Significant means were separated using the least significant difference (LSD). The statistical package used was GENSTAT 12th edition (Payne et al., 2009).

Results and Discussion

Physical and chemical properties of the experimental soil

The textural class of the experimental site was loamy sand (Table 1). The soil pH was moderately acidic (5.35). The macronutrient content of the soil was 1.5 g kg^{-1}, 7.79 mg $kg^{-1}$and 0.01cmol kg^{-1} for nitrogen, phosphorus and potassium respectively. The organic carbon content of the soil was 17.0 g kg^{-1} with 10.17 cmol kg^{-1} of ECEC.

Chemical properties of poultry manure

Poultry manure added to the soil as an amendment was also analysed for its chemical properties (Table 2). The pH of the manure was neutral (7.05). Exchangeable calcium was 16.90% while magnesium, sodium and potassium were 1.71%, 0.18% and 0.16% respectively.

Table 1. Pre-planting physical and chemical properties of the soil used for the experiment.

Variable	Value	Method
Sand (%)	84.4	(Bouyoucos, 1962)
Silt (%)	9.8	
Clay (%)	5.80	
Textural class	Loamy sand	USDA textural triangle
pH in H_20 (1:1)	5.35	(McLean, 1982)
Available phosphorus (mg kg^{-1})	7.79	(Bray and Kurtz, 1945), (Murphy and Riley, 1962)
Total nitrogen (g kg^{-1})	1.5	(Jackson,1962)
Organic carbon (g kg^{-1})	17.0	Walkley-Black, modified by Allison (1965)
Exchangeable cation (cmolkg^{-1})		
Ca	8.83	Atomic absorption spectrophotometer
Mg	1.02	Atomic absorption spectrophotometer
K	0.11	Flame photometry
Na	0.16	Flame photometry
Exchangeable acidity (cmolkg^{-1})		
$Al^{3+} + H^+$	0.05	
ECEC	10.17	Summation of exchangeable bases and total acidity

Table 2. Chemical properties of the poultry manure used for the experiment.

Variables	Value
pH in H_2O	7.05
Available phosphorus (%)	1.76
Total nitrogen (g kg^{-1})	4.9
Organic carbon (g kg^{-1})	88.0
Manganese (%)	0.08
Iron (%)	0.71
Copper (%)	0.01
Zinc (%)	0.11
Exchangeable cations (%)	
Ca	16.90
Mg	1.71
K	0.16
Na	0.18

Microbial biomass carbon in the screen house

Moisture regime had a significant ($P< 0.05$) effect on the MBC (Table 3). Lowland rice cultivated in plots with intermittent flooding had significantly higher MBC than those established with continuous flooding at all irrigation cycles except at the third cycle, where water regimes had no significant effect on the MBC. Significant varietal differences ($P< 0.05$) were observed in the MBC throughout the cycles of water regime. NERICA L-19 had significantly higher MBC than Ofada at all cycles of AWD except at the first cycle. At the first cycle of AWD, Ofada rice had significantly higher MBC (309.39ugg^{-1}) than NERICA L-19 (301.22ugg^{-1}). There was a significant (P< 0.05) effect of the interaction of water regime × variety on the MBC in the first cycle of AWD in lowland rice varieties (Figure 1). Lowland rice varieties sown in the plot under AWD had significantly higher MBC in the first cycle than those established under continuous irrigation. The lowland rice variety Ofada had significantly higher MBC than NERICA L-19 under AWD (Figure 1).

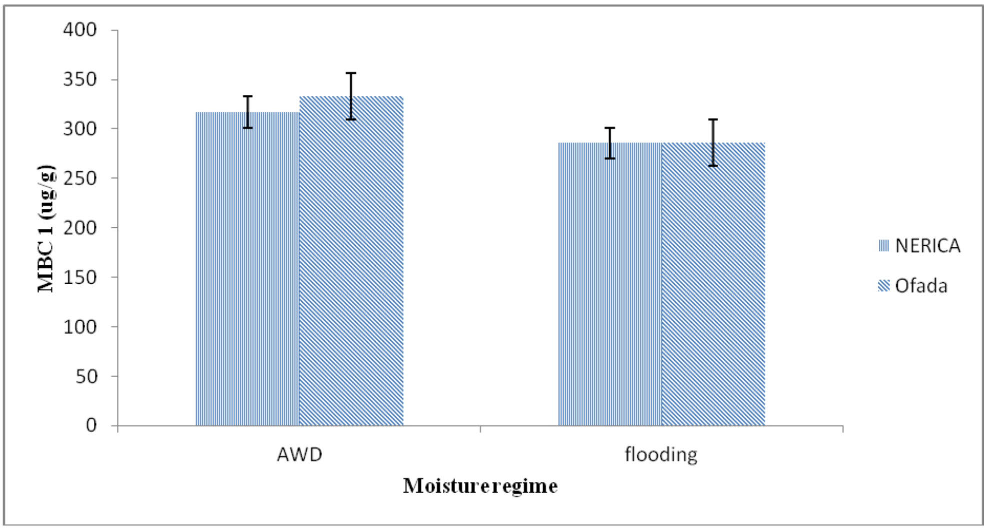

Figure 1. The effect of the interaction of water regime × variety on microbial biomass carbon, cycle 1 in the screen house. MBC 1 – microbial biomass carbon in the first cycle. Vertical bars indicate the standard errors of the mean.

Microbial biomass nitrogen in the screen house

Microbial biomass nitrogen followed a similar response pattern as observed in the MBC in water regimes. In the third cycle of AWD, no significant differences were observed between AWD and continuous flooding on MBN. Significant (P< 0.05) varietal differences were observed in MBN at all cycles except the third cycle of intermittent irrigation. The order of an increase in MBN was NERICA L-19 > Ofada rice in both cycles. There was no significant effect of the interaction of water regime ×variety on the MBN at all cycles except at the first cycle of AWD. All the varieties had significantly higher MBN under AWD than under continuous flooding conditions in the first cycle. NERICA L-19 rice variety established under AWD had significantly higher MBN than Ofada rice established in continuously flooded conditions (Figure 2).

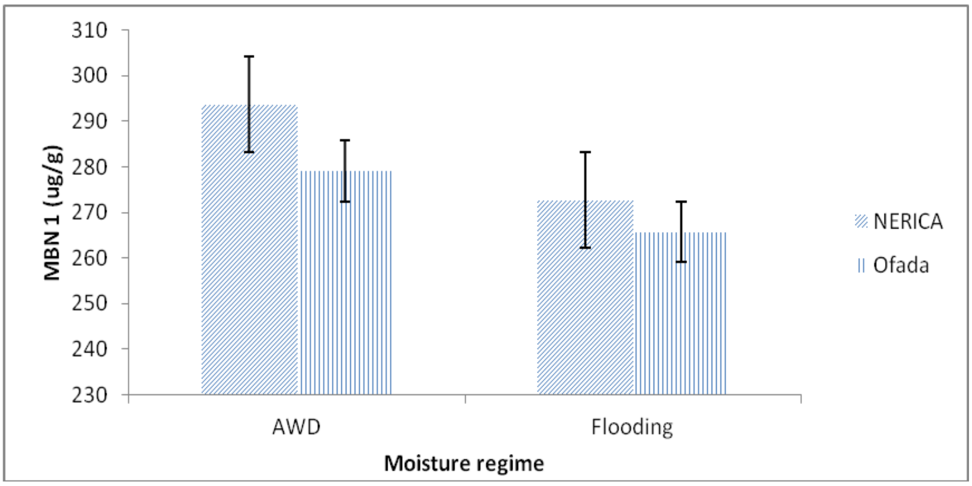

Figure 2. The effect of the interaction of water regime × variety on microbial biomass nitrogen (cycle 1) in the screen house. MBN1 – microbial biomass nitrogen in cycle 1. Vertical bars indicate the standard errors of the mean.

Microbial count in the screen house

There were no significant effects of the irrigation regimes on microbial count (Table 3). Soil microbial count was significantly higher in plots sown with Ofada than with NERICA L-19 rice.

Table 3. The effect of water regime on microbial biomass carbon, nitrogen and microbial count of the soil sown with lowland rice varieties (The screen house experiment).

Treatments	MBC1 (ug g^{-1})	MBC2 (ug g^{-1})	MBC3 (ug g^{-1})	MBN1 (ug g^{-1})	MBN2 (ug g^{-1})	MBN3 (ug g^{-1})	Microbial count (CFU/ml × 10^6)
Moisture regime (MR)							
AWD	324.84	313.3	255.3	286.38	271.5	237.3	40.39
Flooded	285.77	280.5	254.6	269.25	255.3	237.9	38.44
LSD	3.39**	4.59**	NS	3.62**	5.30**	NS	NS
Variety (V)							
NERICA® L-19	301.22	299.2	257.8	283.23	266.5	233.5	37.64
Ofada	309.39	294.6	252.1	272.40	260.3	239.7	41.19
LSD interactions	3.39**	4.59**	4.86*	3.62**	5.30**	NS	2.65*
MR × V	**	NS	NS	**	NS	NS	NS

**Significant at $P<0.01$. *Significant at $p<0.05$. NS – no significant difference. LSD – least significant difference. MBC – microbial biomass carbon, MBN – microbial biomass nitrogen. 1 – cycle one, 2 – cycle two, 3 – cycle three of intermittent irrigation regimes, cfu – colony-forming unit.

Grain yield in the screen house

Water regime had a significant effect on the grain yield. Significantly higher grain yield per plant (6.86 g plant^{-1}) was obtained in plots of lowland rice established with AWD than those under continuous flooding (4.07g plant^{-1}). There was no varietal variation in the grain yield per plant in the screen house (Table 4).

Table 4. The effect of water regime on grain yield of lowland rice varieties in the screen house experiment.

Treatments	Grain yield (g plant^{-1})
Moisture regime (MR)	
AWD	6.86
Flooded	4.07
LSD	1.86**
Variety (V)	
NERICA® L-19	6.09
Ofada	4.84
LSD interactions	NS
MR × V	NS

**Significant at $p<0.01$. *Significant at $p<0.05$. NS – no significant difference. LSD – least significant difference.

Microbial biomass carbon and nitrogen in the field

Water regime had no significant ($P > 0.05$) effect on MBC and MBN in all the irrigation cycles except at the third cycle (Table 5).

Table 5. The effects of moisture regime and variety on microbial biomass carbon, nitrogen and microbial population under field conditions.

Treatments	MBC1 (μg g^{-1})	MBC2 (μg g^{-1})	MBC3 (μg g^{-1})	MBN1 (μg g^{-1})	MBN2 (μg g^{-1})	MBN3 (μg g^{-1})	Microbial count (CFUml^{-1})
Moisture regime (MR)							
AWD	450	453	441.7	208	209	208.5	938
Flooded	520	512	515.7	218	219	219.8	87
LSD (5%)	NS	NS	16.27**	NS	NS	6.90*	NS
Variety (v)							
NERICA® L-19	486	481	474	215	210	208.3	325
Ofada	483	484	483.4	211	218	214.3	700
LSD (5%) Interaction	NS	NS	NS	NS	NS	NS	NS
MR × V	NS	NS	*	NS	NS	NS	NS

**Significant at $p < 0.01$. *Significant at $p < 0.05$. NS – no significant difference. LSD – least significant difference. MBC – microbial biomass carbon, MBN – microbial biomass nitrogen. 1 – cycle one, 2 – cycle two, 3 – cycle three.

Lowland rice established in plots under continuous flooding (515.7µg g^{-1}) had significantly higher MBC than in those plots under AWD (441.7µg g^{-1}) water regime in the third cycle. A similar pattern was observed in MBN in the third irrigation cycle. Soil microbial population was not significantly affected by both irrigation regimes and varietal differences in the field (Table 5).

Grain yield per hectare in the field

Neither of the treatments had any significant effects on the performance of lowland rice in the field. However, the response pattern of the performance of lowland rice to the treatments observed in the screen house was repeated in the field.

Table 6. The effect of moisture regime on the grain yield of lowland rice varieties under field conditions.

Treatments	Grain yield (t ha^{-1})
Moisture regime (MR)	
AWD	6.41
Flooded	4.83
LSD (5%)	NS
Variety (V)	
NERICA	6.78
Ofada	4.47
LSD (5%)	NS
Interaction	
MR × V	NS

**Significant at $P<0.01$. *Significant at $P<0.05$. NS – no significant difference. LSD – least significant difference.

Nutrient release from AWD water regime is dependent on the initial nutrient status in the soil (Chepkwony et al., 2001; Gordon et al., 2008). Nutrient availability below a threshold that would support both the microbial activities and plant growth could result in the competition for nutrients. This justified the application of organic nutrient sources to plots where lowland rice was established. The soil used for both trials indicated that it had adequate nutrients to support the activities of the microbes to release nutrients as indicated in the significant increase in MBC and MBN especially at the earlier stages of AWD than those grown under continuous flooding. Soil microbial biomass has been reported to aid availability of carbon, nitrogen, phosphorus (Turner and Haygarth, 2001) and sulphur (nutrient source). The underlying mechanism responsible for nutrient pulses under this regime was described by Jarvis et al. (2007) and Fierer and Schimel (2002). The observed pulses in nutrients, especially N and C at the early cycles of the imposition of AWD, have suggested that the process of mineralisation is dependent on the frequency of the imposition of AWD. Fierer and Schimel (2002) posited that the reduced nutrient pulses with the increase in the AWD cycles could be linked with the preponderance of microbes with tolerance to osmotic shock and reduced microbial lysis. Roberson and Firestone (1992) proposed that the reduction in C and N mineralisation with increasing frequency of AWD could be a result of the development of a protective layer by microbes. Taken together it could be suggested that the performance of lowland rice cultivars under AWD could be linked with nutrient availability. The pattern of MBN and MBC observed in the screen house was not replicated in the field which could have affected the performance of lowland rice in the field. Belder et al. (2004) suggested that the field variation in the yield under AWD could be attributed to soil hydrological conditions and the timing of its application. However, this position could not be validated in our experiment and requires further studies.

The presence of varietal differences in the microbial population could have an effect on the MBC and MBN. Other studies have reported the influence of crop cultivars and their ages on microbial community structure and activities (Grayston et al., 1998; Hartmann et al., 2009; Knox et al., 2014). This observation was reported to be mediated by the root exudation profile of the crop type (Grayston et al., 1998). It could be inferred that the root exudates from Ofada rice could have favoured an increase in the microbial population in the screen house through the stimulation of their growth and increased activities. However, the metabolic profile of these compounds released by Ofada rice could not be ascertained in this experiment. The increased microbial population in soil established under Ofada rice could have been associated with an increase in MBC at the first cycle of AWD. The MBC could have acted as an energy source to facilitate the activities of the soil microbes. The pattern of MBC observed at the second and third cycles of AWD in NERICA L-19 could have suggested a higher microbial activity in soils due to high concentration of soil C. The presence of high MBN at the first and second cycles of AWD where NERICA L-19 was established could have suggested that the microbial activities leading to the release of N were dependent on the frequency of its imposition for this lowland rice cultivar. A similar varietal variation in MBN was reported by Xu et al. (2015) where wheat was grown as a companion crop with watermelon. Xu et al. (2015) attributed this observed variation in MBN under wheat/watermelon intercropping conditions to the activities of soil enzymes, suppression of soil-borne diseases and changes in the community structure of microbes.

In the screen house, under continuous flooding, both lowland rice cultivars had similar MBC, which could suggest the negative effect of anaerobic conditions on activities of the soil microbes. Tian et al. (2013) posited that in the paddy, anaerobic conditions negatively affect the root morphology and the microbial community structure. Conversely, under aerobic conditions, Mishra and Salokhe (2011) observed an increase in a finer and branched root system. The presence of oxygen could have increased the root activities and the exudation of C. Under anaerobic conditions, this will be suppressed resulting in reduced MBC irrespective of the rice cultivar involved. Lowland Ofada rice could have released root exudates that ensured increased MBC than NERICA L-19 under AWD in its the first cycle. A similar explanation could be adduced to the increased MBN in NERICA L-19 under both water regimes, probably with differential responses of soil microbes to the metabolic profiles of the root exudates.

Conclusion

The improved performance of lowland rice cultivars under AWD in the screen house could be related to significantly higher MBC and MBN, especially at the first two cycles. This could have resulted in increased microbial activities that could have facilitated nutrient pulses for improved lowland rice performance. In the screen house, a significantly higher microbial population in the soil where Ofada rice was established than in the soil where NERICA L-19 was sown could be related to increasing MBC, especially at the first AWD cycle. There is the need to investigate further the metabolic profiles of the rhizodeposition rice cultivars used under this water regime and the timing of their imposition in the future.

References

Allison, L. (1965). Organic carbon. In C.A Black (Ed.), *Methods of soil analysis. Part 2,* (pp. 1307-1378). Madison: American Society of Agronomy.

Belder, P., Bouman, B.A.M., Cabangon, R., Guoan, L., Quilang, E.J.P., Yuanhua, L., & Tuong, T.P. (2004). Effect of water-saving irrigation on rice yield and water use in typical lowland conditions in Asia. *Agricultural Water Management*, *65* (3), 193-210.

Bouyoucos, G. (1962). Hydrometer method improved for making particle size analysis of soil. *Agronomy Journal*, *54*, 464-465.

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

Brookes, P.C., Landman, A., Pruden, G., & Jenkinson, D.S. (1985). Chloroform fumigation and the release of soil nitrogen: a rapid direct extraction method to measure microbial biomass nitrogen in soil. *Soil Biology and Biochemistry*, *17* (6), 837-842.

Chepkwony, C.K., Haynes, R.J., Swift, R.S., & Harrison, R. (2001). Mineralization of soil organic P induced by drying and rewetting as a source of plant-available P in limed and unlimed samples of an acid soil. *Plant and Soil*, *234* (1), 83-90.

Dare, M.O., Soremekun, J.A., Inana, F.O., Adenuga, O.S., & Ajiboye, G.A. (2014). Microbial Biomass Carbon and Nitrogen Under Different Maize Cropping Systems. In *Soil Carbon* (pp. 305-311). Springer.

Fierer, N., & Schimel, J.P. (2002). Effects of drying–rewetting frequency on soil carbon and nitrogen transformations. *Soil Biology and Biochemistry*, *34* (6), 777-787.

Gordon, H., Haygarth, P.M., & Bardgett, R.D. (2008). Drying and rewetting effects on soil microbial community composition and nutrient leaching. *Soil Biology and Biochemistry*, *40* (2), 302-311.

Grayston, S.J., Wang, S., Campbell, C.D., & Edwards, A.C. (1998). Selective influence of plant species on microbial diversity in the rhizosphere. *Soil Biology and Biochemistry*, *30* (3), 369-378.

Hartmann, A., Schmid, M., Van Tuinen, D., & Berg, G. (2009). Plant-driven selection of microbes. *Plant and Soil*, *321* (1-2), 235-257.

Jackson, M. (1962). *Soil chemical analysis*. New Delhi: Prentice Hall of India Pvt, Ltd.

Jarvis, P., Rey, A., Petsikos, C., Wingate, L., Rayment, M., Pereira, J., Banza, J., David, J., Miglietta, F., Borghetti, M., Manca, G., & Valentini, R. (2007). Drying and wetting of Mediterranean soils stimulates decomposition and carbon dioxide emission: the “Birch effect”. *Tree Physiology, 27* (7), 929-940.

Jenkinson, D.S., & Ladd, J.N. (1981). Microbial biomass in soil: measurement and turnover. *Soil Biochemistry*.
Retrieved from http://agris.fao.org/agris-search/search.do?recordID=US19820787384.

Jones, M.P. (1997). *Interspecific hybridization: progress and prospects*. WARDA.

Knox, O.G., Gupta, V.V., & Lardner, R. (2014). Field evaluation of the effects of cotton variety and GM status on rhizosphere microbial diversity and function in Australian soils. *Soil Research*, *52* (2), 203-215.

Loureiro, D.C., De-Polli, H., Ceddia, M.B., & Aquino, A.M.de. (2010). Spatial variability of microbial biomass and organic matter labile pools in a haplic planosol soil. *Bragantia*, *69*, 85-95.

McLean, E.O. (1982). Soil pH and lime requirement. *Methods of Soil Analysis. Part 2. Chemical and Microbiological Properties*, (methods of soil an2), 199-224.

Mishra, A., & Salokhe, V.M. (2011). Rice root growth and physiological responses to SRI water management and implications for crop productivity. *Paddy and Water Environment*, *9* (1), 41-52.

Murphy, J., & Riley, J.P. (1962). A Modified Single Solution Method for Determination of Phosphate in Natural Waters. *Analytica Chimica Acta*, *27*, 31-36.

Payne, R., Murray, D., Harding, S., Baird, D., & Soutar, D. (2009). *Genstat for Windows (12th Edition) Introduction*. Hemel Hempstead: VSN International.

Qu, X.H., & Wang, J.G. (2008). Effect of amendments with different phenolic acids on soil microbial biomass, activity, and community diversity. *Applied Soil Ecology*, *39* (2), 172-179.

Rangel-Vasconcelos, L.G.T., Zarin, D.J., Oliveira, F. de A., Vasconcelos, S.S., Carvalho, C.J.R. de & Santos, M.M. de L.S. (2015). Effect of water availability on soil microbial biomass in secondary forest in eastern Amazonia. *Revista Brasileira de Ciência Do Solo*, *39* (2), 377-384.

Roberson, E.B., & Firestone, M.K. (1992). Relationship between desiccation and exopolysaccharide production in a soil *Pseudomonas* sp. *Applied and Environmental Microbiology*, *58* (4), 1284-1291.

Silva, A.P., Babujia, L.C., Franchini, J.C., Souza, R.A., & Hungria, M. (2010). Microbial biomass under various soil-and crop-management systems in short-and long-term experiments in Brazil. *Field Crops Research*, *119* (1), 20-26.

Tian, J., Dippold, M., Pausch, J., Blagodatskaya, E., Fan, M., Li, X., & Kuzyakov, Y. (2013). Microbial response to rhizodeposition depending on water regimes in paddy soils. *Soil Biology and Biochemistry*, *65*, 195-203.

Turner, B.L., & Haygarth, P.M. (2001). Biogeochemistry: phosphorus solubilization in rewetted soils. *Nature*, *411* (6835), 258-258.

Uphoff, N., & Randriamiharisoa, R. (2002). Reducing water use in irrigated rice production with the Madagascar System of Rice Intensification (SRI). In Bouman, B.A., Hengsdijk, H., Hardy, B., Bindraban, P.S., Thuong, T.P., and Ladha, J.K. (Eds.), *Water-Wise Rice Production* (pp. 71-87).

Proceedings of the International Workshop on Waterwise rice Production, Los Banos, Philippines.

Van der Hoek, W., Sakthivadivel, R., Renshaw, M., Silver, J.B., Birley, M.H., & Konradsen, F. (2001). Alternate wet/dry irrigation in rice cultivation: a practical way to save water and control malaria and Japanese encephalitis? (Vol. 47). IWMI.

Vance, E.D., Brookes, P.C., & Jenkinson, D.S. (1987). An extraction method for measuring soil microbial biomass C. *Soil Biology and Biochemistry*, *19* (6), 703-707.

Xu, W., Wang, Z., & Wu, F. (2015). The effect of D123 wheat as a companion crop on soil enzyme activities, microbial biomass and microbial communities in the rhizosphere of watermelon. *Frontiers in Microbiology*, *6*.
Retrieved from https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4555026/.

Yang, J., & Zhang, J. (2010). Crop management techniques to enhance harvest index in rice. *Journal of Experimental Botany*, *61* (12), 3177-3189.

Received: July 4, 2018
Accepted: July 22, 2019

PROMENE MIKROBIJALNE BIOMASE I PRINOSA ZRNA VARIJETETA PIRINČA KAO ODGOVOR NA NAIZMENIČNI VLAŽNI I SUVI VODNI REŽIM U UNUTRAŠNJOJ DOLINI PRELAZNOG POJASA SAVANE

Adeniyi A. Soretire[1*], Olalekan S. Sakariyawo[2], Oyinkansola S. Yewande[1], John K. Adesodun[1], Aderonke K. Akintokun[3], Paul A.S. Soremi[2] i Sunday G. Aderibigbe[2]

[1]Odsek za nauku o zemljištu i upravljanje zemljištem, Poljoprivredni federalni univerzitet, Abeokuta (FUNAAB), Abeokuta, Država Ogun, Nigerija
[2]Odsek za fiziologiju biljaka i proizvodnju useva, FUNAAB, Abeokuta, Država Ogun, Nigerija
[3]Odsek za mikrobiologiju, FUNAAB, Abeokuta, Država Ogun, Nigerija

R e z i m e

U ovom istraživanju testirana je hipoteza da bi naizmenični vlažni i suvi (engl. *alternate wet and dry – AWD*) vodni režim mogao povećati ugljenik u mikrobnoj biomasi (engl. *soil microbial biomass carbon – MBC*), azot u mikrobnoj biomasi (engl. *microbial biomass nitrogen – MBN*) i ukupan broj mikroorganizama u zemljištu. Varijacije u vrednostima MBC, MBN i prinosu zrna mogu biti posledica razlika u varijantama u prelaznom pojasu savane. Ogledi (u sudovima i na polju) sprovedeni su na Poljoprivrednom federalnom univerzitetu, u Abeokuti (geografska širina 7° 12' do 7° 20' N i geografska dužina 3° 20' do 3° 28' E), u Nigeriji u 2015. godini. Kod oba ogleda, tretmani su se sastojali od vodnih režima (neprekidno plavljenje [kontrola] i režim AWD uveden kod varijeteta pirinča plavljenih područja [NERICA® L-19] i varijeteta Ofada [lokalni kontrolni varijetet]) u fazi vegetativnog rasta u toku tri ciklusa. Dizajn kod oba ogleda podrazumevao je potpuno randomizirani odnosno randomiziran potpuni blok dizajn za ogled u sudovima i poljski ogled, u tri ponavljanja. U ogledu u sudovima, vrednosti MBC i MBN bile su značajno više kod režima AWD nego kod neprekidno plavljenog zemljišta, naročito na početku ciklusa režima AWD. Ovo je možda bilo uzrok da hranljive materije održe poboljšani učinak pirinča plavljenih područja pri režimu AWD. Suprotan obrazac je uočen na polju u trećem ciklusu. Varijetet pirinča Ofada imao je značajno viši broj mikroorganizama i MBC (1. ciklus) nego NERICA L-19. Ipak, suprotan obrazac je uočen kod MBC (2. i 3. ciklus) i MBN (1. ciklus). Sastav rizodepozicije i vreme ciklusa bi mogli objasniti uočene razlike među varijetetima u pogledu vrednosti MBC i MBN.

Ključne reči: biomasa, ciklusi, prinos zrna, ravnica, zemljišta.

Primljeno: 4. jula 2018.
Odobreno: 22. jula 2019.

*Autor za kontakt: e-mail: soretireaa@funaab.edu.ng

Journal of Agricultural Sciences
Vol. 64, No. 3, 2019
Pages 255-263
https://doi.org/10.2298/JAS1903255S
UDC: 633.2/.3(497.11)"2015"
Original scientific paper

PROTEIN DEGRADABILITY OF GRASSLAND FORAGE UNDER SIMULATED ROTATIONAL SPRING GRAZING

Bojan D. Stojanović*, Aleksandar S. Simić, Goran A. Grubić, Nenad Ž. Đorđević, Aleksa Đ. Božičković and Vesna M. Davidović

University of Belgrade, Faculty of Agriculture
Nemanjina 6, 11081 Belgrade, Serbia

Abstract: A cutting experiment was conducted to analyze the changes in the crude protein (CP) fraction content and in the estimated ruminal protein degradability of forage, obtained in conditions of simulated rotational spring grazing on permanent grassland. The field trial was conducted on permanent pasture during 2015 and included three cuttings as a simulated rotational spring grazing. For determination of protein degradability of pasture forage, the fractionation of the CP according to Cornell Net Carbohydrate and Protein System (CNCPS v6.5) and the *Streptomyces griseus* protease assay were used. Relative to CP, no significant differences were found among cuts for ammonia N content (A1 fraction) and for protein fraction C which is completely unavailable to the animals. Values for soluble true protein (A2 fraction) and cell wall-associated protein, which is acid detergent soluble (B2), were significantly increased ($p<0.05$) while a significant reduction ($p<0.05$) of the moderately degradable protein (B1) content was determined during the growing season. The lower rumen degradable protein (RDP) content of grassland herbage was obtained in the second cut which was significant ($p<0.05$) according to the CNCPS procedure. Obtained high solubility and degradability of CP in pasture require adequate content of readily available carbohydrates in rations for grazing ruminants to provide efficient utilization of consumed protein.

Key words: ruminants, pasture, protein, fractions, *in vitro* degradability.

Introduction

Currently, models used to balance rations for ruminants emphasize the need to consider ruminal protein degradability. The pasture, which is the main ingredient of ruminant rations, may supply a significant portion of the total crude protein (CP) content of the diet. Hence, there has been an interest in protein degradability of pasture. Excessive protein degradation in the rumen may be the most limiting

*Corresponding author: e-mail: arcturas@agrif.bg.ac.rs

factor of pasture usage (Stojanović et al., 2014). As a consequence of the high rumen degradability of grassland forage protein, a great part of the N may be lost by excretion in the urine (Merchen and Bourquin, 1994). There is interest in identifying factors that influence the rate and extent of ruminal degradation of forage proteins (Broderick, 1995).

The pasture is characterized by a very high content of rumen degradable protein (RDP). Increased rumen undegradable protein (RUP) concentration is highly ranked for improving the nutritive value of forage (Tremblay et al., 2002). An optimal ratio of rumen degradable protein to RUP is ranked as the second criteria to improve the nutritive value of forages for dairy cattle (Smith et al., 1997). Protein degradation of grassland forages is highly variable and depends on botanical composition, plant maturity and growing period (Rayburn, 1991).

The determination of protein degradability of grassland forages and the changes which may occur during the growing season are important for defining the grazing strategies, to increase the protein use efficiency, and to decrease the N losses (Stojanović et al., 2016).

The fractionation of feed protein and estimation of protein degradability according to the Cornell Net Carbohydrate and Protein System (Sniffen et al., 1992) are well accepted for the characterization of protein quality in ruminant nutrition. One of the generally accepted *in vitro* methods for protein degradability analysis is the *Streptomyces griseus* protease assay (48 h of incubation) (Krishnamoorthy et al., 1983). However, additional work is needed to characterize the grassland herbage crude protein.

The objective of this study was to determine the extent of variation in the CP fraction content and the protein degradability of forage from the simulated rotational spring grazing on permanent grassland.

Material and Methods

The trial was conducted on the natural pasture during the spring of 2015 and included three cuttings as simulated rotational grazing. The study site was located in the western region of Serbia, near Šabac (44°40′ N, 19°39′ E). The experimental design, grassland management and sampling method were described elsewhere (Stojanović et al., 2018). The field trial was established on the pasture which had been exploited permanently for dairy cattle grazing, by the method of an RCB design of plots (5 × 2 m) in 5 replications. There were three cuts (1 May, 24 May and 19 June) in the part of the vegetation season, before the summer drought period. In the 1st, 2nd and 3rd cuts, the botanical composition was as described in Stojanović et al. (2018).

Herbage samples were analyzed in the Laboratory for the Animal Nutrition at the Faculty of Agriculture, University of Belgrade. Chemical analysis was performed according to the procedure of AOAC (2002). Separating of CP into five fractions (A1, A2, B1, B2 and C) based on characteristics of degradability was conducted according to the Cornell Net Carbohydrate and Protein System – CNCPS v6.5 (Higgs et al., 2015) using standardizations of Licitra et al. (1996). Within determined fractions, A1 represented ammonia (as CP equivalents), A2 – soluble true protein (soluble protein minus A1), B1 was buffer insoluble protein minus neutral detergent insoluble protein (NDIP), B2 – NDIP minus acid detergent insoluble protein (ADIP), and ADIP – the C fraction. Calculated rumen degradable protein was estimated from fractions A1, A2, B1 and B2, using digestion rate constants of 200%/h, 27.3%/h, 15%/h and 5%/h (Van Amburgh et al., 2015), with an assumed passage rate (Kp) of 5%/h (Sniffen et al., 1992).

An *in vitro* enzymatic procedure for simulated rumen protein degradation was conducted using *Streptomyces griseus* protease (type XIV, Sigma Chemical Co., Catalog No. P5147) and contained 4.0 U/mg, according to the protocol described by Coblentz et al. (1999). Triplicate forage samples containing 15 mg of nitrogen were incubated for 48 h in a borate-phosphate buffer solution with added protease (a final enzyme concentration of 0.066 U of activity/ml and a ratio of 0.22 U/mg N). The fixed ratio of units of enzyme/N was reached by considering the content of CP in analyzed forages. To calculate enzyme protein degradability (EPD), the equation EPD (%) = (1.0 - (N in residue (mg)/N in sample (mg))) × 100 was used.

An ANOVA procedure using the STATISTICA v.6 (StatSoft, 2003) was conducted to assess the effects of different cuttings on the CP fraction content and the ruminal protein degradability of herbage from permanent grassland during the spring growth. Differences among treatment means were tested for significance using the LSD test. The statistical significance was determined at $p<0.05$. The linear regression was applied to compare RDP estimates of the protease assay, with the values based on CP fractionation as the dependent variable, and described relationships using the coefficient of determination (R^2).

Results and Discussion

Fresh forages contained a high proportion of soluble CP (A1+A2 fractions, from 40.15 to 50.85%) and a relatively low proportion of moderately degradable protein (B1 fraction) for all harvests across the spring growth. Relative to CP, no significant differences were found between cuts during the analyzed spring grazing period for ammonia N content (A1 fraction) and for protein C fraction which is completely unavailable to the animals, whereas the values of A2, B1 and B2 fractions significantly differed (Table 1).

Considering the previously determined changes in the share of grasses (35, 22 and 15%), legumes (39, 43 and 37%) and forbs (26, 35 and 48%) across the cuttings (the 1st, 2nd and 3rd cuts, respectively) (Stojanović et al., 2018), obtained results are in accordance with the findings of Elizalde et al. (1999), where the non-protein N content of forages was not affected by forage species (grass and legumes) and sampling dates.

Table 1. The crude protein fractions of forage (%) according to the Cornell Net Carbohydrate and Protein System.

Cuts	CP, % DM	Fractions				
		A1	A2	B1	B2	C
1.	15.30±1.20	3.29±0.47	36.86±1.70[a]	41.48±2.32[a]	11.26±0.33[a]	7.12±1.42
2.	13.72±1.66	3.25±0.73	41.34±1.68[b]	33.15±0.67[b]	13.71±0.51[b]	8.55±0.32
3.	14.55±1.38	3.63±0.55	47.22±0.66[c]	29.22±0.62[c]	12.17±0.22[c]	7.76±0.64

± standard deviation; [a,b,c] means in the same column with different superscripts differ ($p<0.05$) significantly; CP – crude protein; A1, A2, B1, B2, C – crude protein fractions according to the Cornell Net Carbohydrate and Protein System.

Values for soluble true protein (A2 fraction) and for cell wall-associated protein (B2) that is soluble in acid detergent were significantly increased ($p<0.05$) while a significant reduction ($p<0.05$) of a moderately degradable protein (B1) content was determined with advancing of the vegetation season. The A2 protein fraction was higher by 12.2 and 28.1% and the B2 fraction by 21.8 and 8.1% in the herbage obtained from the second and third harvests relative to the first one, whereas the B1 fraction content was reduced by 20.1 and 29.6%. A displayed trend may be explained by a noted significant increase of neutral detergent fiber – NDF (39.09, 48.61 and 43.61% DM) and acid detergent fiber – ADF (25.54, 31.22 and 28.61% DM) content in analyzed forage during the spring grazing period (Stojanović et al., 2018). The CP fraction content was also influenced by a marked increase of the percentage of forbs that was noted together with the reduced share of grass species, while the percentages of legume species were similar or slightly increased during the spring grazing period (Stojanović et al., 2018). Rayburn (1991) has reported that protein solubility is greater in mixed mostly legume and legume forage than in grass and mixed mostly grass forage, whereby solubility decreases by 0.25 units/unit NDF. According to Solati et al. (2017), insoluble CP soluble in neutral detergent (fraction B1) was the largest fraction in legume and grass herbage, whereas a significant decline in this fraction was observed in white clover and alfalfa across the spring growth. Obtained values for the B1 fraction are more approximate to those of Sniffen et al. (1992) for grass pasture, and are lower relative to Elizalde et al. (1999) for legume and grass herbage, where this fraction was the largest CP fraction.

The determined B2 fraction (including N in the NDF but soluble in acid detergent) content corresponded with the earlier reported values by Abdalla et al. (1988) for grazed mixed pastures (13.0% CP) and by Sniffen et al. (1992) for grass pastures during the spring (10.0% CP). Unavailable or bound proteins, which are insoluble in acid detergent (C fraction), are slightly above the upper values for legume and grass (4.6 and 6.6% of CP) forage according to Cherney et al. (1997), probably due to a high share of forbs in the pasture.

Table 2. The herbage crude protein degradability (%).

Method of estimation	Cuts		
	1.	2.	3.
CNCPS procedure	71.10±0.98[a]	69.83±0.45[b]	71.45±0.49[a]
S. griseus procedure	65.78±3.32	62.83±2.14	64.60±2.85

± standard deviation; [a,b,c] means in the same row with different superscripts differ ($p<0.05$) significantly.

Observed results indicate the high ruminal degradability of the CP in fresh forage. Ruminal degradable protein (RDP) values for the examined forages obtained in conditions of simulated rotational spring grazing on permanent grassland are shown in Table 2. According to the CNCPS procedure, the determined protein degradability was significantly influenced ($p<0.05$) by the growing period with the lowest RDP content in the herbage obtained from the second cut. The concentration of rumen degradable protein (% CP) was lower by 1.79 and 2.27% for the herbage from the second harvest relative to the first and the third ones. A lower protein degradability value is likely a result of the increased concentration of B2 and C protein fractions due to higher fiber content (NDF and ADF) in the second cut. Observed results are in accordance with the research of Rayburn (1991), where it was found that the protein degradability decreased by 0.088 units/unit NDF. With the advancing of the spring season, there were no especially large differences in herbage RDP content between cuts, despite the displayed trend of a significant increase of the soluble true protein concentration (% CP) and decreasing the B1 fraction that is more slowly degraded in the rumen. This is likely due to increasing the cell wall-associated protein fractions (B2+C) that are characterized by limited ruminal degradability or are completely undegradable (Higgs et al., 2015). Our findings are in the range reported by Cone et al. (2004) for rumen undegradable protein in different grass samples after 3 weeks of the regrowth period (23.1–37.4 or 34.9% CP) and by Grabber (2009) for RUP in herbage of different legume species (25.6–33.2% CP).

Estimated RDP values of herbage of different cuts using the *S. griseus* procedure did not differ significantly (probably due to a higher variation between individual replications), but a reduced level of ruminally degraded protein (% CP) was found also in forage obtained from the second harvest (4.48 and 2.74%, compared to the first and third harvests, respectively).

Values for RDP from the protease assay compared to CP fractionation were lower by 7.5–9.0% for different harvests. The relationships between the rumen degradable protein obtained with a *Streptomyces griseus* protease incubation and with the Cornell protein fractionation procedure are shown in Table 3.

Table 3. A linear regression of rumen degradable protein (% CP) estimated by enzymatic degradation (x) and by crude protein fractionation (y).

Equation	*a*	*b*	R^2	SE
Parameters	54.07	0.26	0.60	0.64

a, b – linear regression parameters; R^2 – coefficient of determination; SE – standard error.

The determined values for the ruminal protein degradation of grassland forage obtained from different cuttings according to the CNCPS fractionation and *S. griseus* protease procedure were highly related. The lower estimates of RDP by the *in vitro* enzyme assay (*S. griseus*) relative to values from CNCPS fractionation are supported by the results of Grabber (2009a) for red clover forages, where estimates were also highly related. Coblentz et al. (1999) obtained somewhat lower values for RDP based on protease treatment, compared to those determined by the *in situ* procedure, for alfalfa and grass hay.

Conclusion

The estimations of ruminal protein degradability and protein escape are necessary for an adequate diet formulation. The protein degradability of the analyzed forage from the simulated rotational spring grazing on permanent grassland was generally high, with lower values for the herbage obtained from the second cut. A dominant protein fraction in the herbage of the first harvest was the moderately degradable protein (B1), whereas in the second and third harvests that was the soluble true protein (A2). Estimates of RDP by the *in vitro* enzyme assay were somewhat lower relative to the CNCPS protein fractionation procedure. The determined high solubility and degradability of CP in the pasture indicate that rations for grazing ruminants should have an optimal content of readily fermentable carbohydrates to provide efficient utilization of consumed N.

Acknowledgements

This research was financially supported by the Ministry of Education, Science and Technological Development, Republic of Serbia, through the Project for Technological Development TR-31086: Optimization of technological procedures and zootechnical resources on farms to improve the sustainability of milk production.

References

Abdalla, H.O., Fox, D.G., & Seaney, R.R. (1988). Variation in protein and fiber fractions in pasture during the grazing season. *Journal of Animal Science, 66*, 2663-2667.

AOAC International. (2002). Official Methods of Analysis. 17th ed. *AOAC International*, Arlington, VA.

Broderick, G.A. (1995). Desirable characteristics of forage legumes for improving protein utilization in ruminants. *Journal of Animal Science, 73* (9), 2760-2773.

Cherney, D.J.R., Cherney, J.H., & Davidson, A.H. (1997). Characterization of legume and grass residues following in vitro and in sacco ruminal digestion. *Proceedings of the International Grassland Congress, 17,* 23-24.

Coblentz, W.K., Abdelgadir, I.E.O., Cochran, R.C., Fritz, J.O., Fick, W.H., Olson, K.C., & Turner, J.E. (1999). Degradability of Forage Proteins by In Situ and In Vitro Enzymatic Methods. *Journal of Dairy Science, 82*, 343-354.

Cone, J.W., van Gelder, A.H., Mathijssen-Kamman, A.A., & Hindle, V.A. (2004). Rumen escape protein in grass and grass silage determined with a nylon bag and an enzymatic technique. *Animal Feed Science and Technology, 111*, 1-9.

Elizalde, J.C., Merchen, N.R., & Faulkner, D.B. (1999). Fractionation of fiber and crude protein in fresh forages during the spring growth. *Journal of Animal Science*, *77*, 476-484.

Grabber, J.H. (2009). Protein fractions in forage legumes containing protein-binding polyphenols: Freeze-drying vs. conservation as hay or silage. *Animal Feed Science and Technology*, *151*, 324-329.

Grabber, J.H. (2009a). Forage management effects on protein and fiber fractions, protein degradability, and dry matter yield of red clover conserved as silage. *Animal Feed Science and Technology*, *154*, 284-291.

Higgs, R.J., Chase, L.E., Ross, D.A., & Van Amburgh, M.E. (2015). Updating the Cornell Net Carbohydrate and Protein System feed library and analyzing model sensitivity to feed inputs. *Journal of Dairy Science*, *98*, 6340-6360.

Krishnamoorthy, U., Sniffen, C.J., Stern, M.D., & Van Soest, P.J. (1983). Evaluation of a mathematical model of rumen digestion and an in vitro simulation of rumen proteolysis to estimate the rumen-undegraded nitrogen content of feedstuffs. *British Journal of Nutrition, 50*, 555-568.

Licitra, G., Hernandez, T., & Van Soest, P.J. (1996). Standardization of procedures for nitrogen fractionation of ruminant feeds. *Animal Feed Science and Technology*, *57*, 347-358.

Merchen, N.R., & Bourquin, L.D. (1994). Processes of digestion and factors influencing digestion of forage-based diets by ruminants. *In: Fahey, D.C. (Ed.) Forage quality, evaluation, and utilization* (pp. 564-612). ASA, CSSA, SSSA, Madison, WI, USA.

Rayburn, E.B. (1991). Forage quality of intensive rotationally grazed pastures in the Northeast, 1988 to 1990. *Northeastern Dairy Farm Forage Demonstration Project*. Seneca Trail RC&D, Franklinville, NY.

Smith, K.F., Reed, K.F.M., & Foot, J.Z. (1997). An assessment of the relative importance of specific traits for the genetic improvement of nutritive value in dairy pasture. *Grass Forage Science, 52*, 167-175.

Sniffen, C.J., O'Connor, J.D., Van Soest, P.J., Fox, D.G., & Russell, J.B. (1992). A net carbohydrate and protein system for evaluating cattle diets: II. Carbohydrate and protein availability. *Journal of Animal Science*, *70*, 3562-3577.

Solati, Z., Jørgensen, U., Eriksen, J., & Søegaard, K. (2017). Dry matter yield, chemical composition and estimated extractable protein of legume and grass species during the spring growth. *Journal of the Science of Food and Agriculture, 97*, 3958-3966.

Statsoft (2003). *Statistica (data analysis software system)*, version 6. Available in www.statsoft.com.

Stojanović, B., Grubić, G., Đorđević, N., Božičković, A., & Ivetić, A. (2014). Supplementary feeding of grazing dairy cows. *Proceedings of the International Symposium on Animal Science (ISAS 2014)* (pp. 265-271). Belgrade, Serbia.

Stojanović, B., Grubić, G., Đorđević, N., Božičković, A., Davidović, V., & Ivetić, A. (2016). Pasture in animal nutrition. *Proceedings of the International Symposium on Animal Science (ISAS 2016)* (pp. 203-210). Belgrade, Serbia.

Stojanović, B., Simić, A., Grubić, G., Božičković, A., & Krga, I. (2018). Yield and nutritional value of permanent grassland forage under simulated rotational grazing. *Biotechnology in Animal Husbandry, 34* (1), 21-31.

Tremblay, G.F., Bélanger, G., McRae, K.B., & Michaud, R. (2002). Leaf and stem dry matter digestibility and ruminal undegradable proteins of alfalfa cultivars. *Canadian Journal of Plant Science, 82*, 383-393.

Van Amburgh, M.E., Collao-Saenz, E.A., Higgs, R.J., Ross, D.A., Recktenwald, E.B., Raffrenato, E., Chase, L.E., Overton, T.R., Mills, J.K., & Foskolos, A. (2015). The Cornell Net Carbohydrate and Protein System: Updates to the model and evaluation of version 6.5. *Journal of Dairy Science, 98*, 6361-6380.

Received: December 25, 2018
Accepted: August 26, 2019

RAZGRADIVOST PROTEINA ZELENE MASE SA TRAVNJAKA U USLOVIMA PROLEĆNE PREGONSKE ISPAŠE

Bojan D. Stojanović[*], Aleksandar S. Simić, Goran A. Grubić, Nenad Ž. Đorđević, Aleksa Đ. Božičković i Vesna M. Davidović

Univerzitet u Beogradu, Poljoprivredni Fakultet
Nemanjina 6, 11081 Beograd, Srbija

R e z i m e

Istraživanje je obavljeno u cilju utvrđivanja promena u sadržaju frakcija sirovog proteina (SP) i ruminalne razgradivosti proteina zelene mase dobijene košenjem prirodnog travnjaka u uslovima koji su odgovarali rotacijskoj pregonskoj ispaši tokom prolećne sezone. Poljski ogled je izveden na permanentnom pašnjaku tokom proleća 2015. godine i uključivao je tri otkosa koji su odgovarali ciklusima ispaše. Za determinisanje razgradivosti proteina zelene mase, frakcionisanje sirovog proteina je obavljeno prema proceduri *Cornell Net Carbohydrate and Protein System* (CNCPS v6.5), kao i primenom *in vitro* metode korišćenjem *Streptomyces griseus* proteaze. U odnosu na SP, nisu utvrđene značajne razlike između otkosa – ciklusa ispaše u pogledu sadržaja amonijačnog N (frakcija A1), kao i u pogledu sadržaja proteinske frakcije C, koja je potpuno nedostupna životinjama. Sadržaj rastvorljivog pravog proteina (frakcija A2) i proteina vezanog za ćelijski zid, koji je rastvorljiv u kiselom deterdžentu (frakcija B2) se značajno povećavao ($p<0,05$), dok se sadržaj umereno razgradive frakcije proteina (B1) značajno smanjivao ($p<0,05$) tokom prolećne sezone vegetacije. Najmanja vrednost za ruminalnu razgradivost i učešće RDP (protein razgradiv u rumenu) u SP zelene mase sa pašnjaka utvrđena je u drugom otkosu, a ova razlika je bila značajna ($p<0,05$) kada je ruminalna razgradivost proteina determinisana korišćenjem procedure CNCPS. Utvrđeno visoko učešće rastvorljive frakcije SP i visoka ruminalna razgradivost SP zelene mase sa pašnjaka ukazuju na potrebu podrobnijeg balansiranja obroka za preživare na paši u pogledu sadržaja lako razgradivih ugljenih hidrata, a u cilju obezbeđenja efikasnog iskorišćavanja konzumiranog proteina.

Ključne reči: paša, protein, frakcije, *in vitro* ruminalna razgradivost.

Primljeno: 25. decembra 2018.
Odobreno: 26. avgusta 2019.

[*]Autor za kontakt: e-mail: arcturas@agrif.bg.ac.rs

Journal of Agricultural Sciences
Vol. 64, No. 3, 2019
Pages 265-278

https://doi.org/10.2298/JAS1903265D
UDC: 632.51:633.853.52(669)"2016/2017"
632.954(669)"2016/2017"
Original scientific paper

ECONOMICS OF ROW SPACING AND INTEGRATED WEED MANAGEMENT IN SOYBEAN (*GLYCINE MAX* L.)

Olumide S. Daramola[1*], Olusegun R. Adeyemi[1], Joseph A. Adigun[1] and Christopher O. Adejuyigbe[2]

[1]Department of Plant Physiology and Crop Production, Federal University of Agriculture, Abeokuta
[2]Department of Soil Science, Federal University of Agriculture, Abeokuta

Abstract: The high cost of cultivation and weed management are major limiting factors to increasing soybean productivity and net returns. Field experiments were conducted in 2016 and 2017 at the Teaching and Research Farm of the Federal University of Agriculture, Abeokuta to evaluate the economic performance of different row spacings and integrated weed management system in soybean. Three row spacings (50, 75 and 100 cm) as the main plots and six weed control methods and a weedy check as sub-plot treatments were accommodated in a split-plot arrangement of a randomized complete block design with three replications. There was a significant reduction in weed biomass with a reduction in row spacing from 100 cm to 75 cm and 50 cm. Furthermore, the cost of production, grain yield and gross profit increased with a reduction in row spacing from 100 to 75 and 50. When soybean was sown at 50-cm row spacing, the application of Probaben 400EC (metolachlor 20% w/v + prometryn 20% w/v) or Butachlor 60EC (butachlor) at 2.0 kg a.i/ha each followed by supplementary hoe-weeding at 6 weeks after sowing (WAS) resulted in the highest yield of 2301–2484 kg/ha and total revenue of 2129–1972 $/ha. Conversely, three hoe-weedings resulted in the highest yield of 2155–2081 kg/ha and total revenue of 1848–1783 $/ha for crops grown at 75- and 100-cm row spacings. Despite the higher yield and revenue obtained with three hoe-weedings for crops grown at 75- and 100-cm row spacings, the gross profit and benefit-cost ratios obtained were lower than those obtained with herbicide treatments applied alone or followed by supplementary hoe-weeding. In terms of profitability, soybean planted at 50-cm row spacing and treated with Probaben 400EC at 2.0 kg a.i/ha followed by supplementary hoe-weeding gave the highest gross profit of 1479 $/ha. Two or three hoe-weedings in soybean planted at narrow-row (50 cm) spacing did not guarantee the highest yield, but rather increased the cost of weed control. This study suggests that narrow-row spacing (50 cm) and pre-emergence herbicides will help to reduce the number of

[*]Corresponding author: e-mail: olumidedara01@gmail.com

hoe-weedings and consequently the high cost of production required for optimum yield and increase profitability in soybean production.

Key words: economics, row spacing, soybean, integrated weed management, gross profit.

Introduction

The production of soybean is increasing in Sub-Saharan Africa (SSA) due to its growing demand as a cheap source of protein (40%) and oil (20%) for human diet and animal feed and raw material for industry (Joubert and Jooste, 2013). In addition, it improves soil fertility by fixing atmospheric nitrogen for its own use and the benefit of intercropped cereals and subsequent crops in rotation (Ronner et al., 2016). Hence, soybean cultivation promotes economic, social and ecological development in Africa.

Nigeria is the second largest producer of soybean in SSA after South Africa with an average production of 680,000 tones (Khojely et al., 2018). Soybean production presents a great potential to meet the food and protein need and improve the livelihood of millions of smallholder farmers in Nigeria and other parts of SSA. However, weeds are considered a major constraint to soybean production in Nigeria and other soybean producing countries (Sodangi et al., 2006; Vivian et al., 2013). A survey of crop pests in SSA has earlier revealed that weeds are the most deleterious pest in all zones studied (Oerke and Dehne, 2004). About 37% of attainable soybean production is endangered by weed competition worldwide compared to 22% by pathogens, viruses and animal pests (Oerke and Dehne, 2004). Between 77% and 90% reduction in the potential yield of soybean was reported due to weed infestation in different zones in Nigeria (Sodangi et al., 2006; Imoloame, 2014). Ultimately, weed infestation limits economic benefit and reduces farmers' income from soybean production in SSA. Even with advanced technologies and improved varieties, farmers record high losses as a result of weed interference. Economic losses due to weed infestation in soybean vary with the cost of hoe-weeding, chemical or cultural methods of control that must be used (Sodangi et al., 2006). In the United States, for instance, weeds are reported to cause losses of several millions of US dollars yearly (Vivian et al., 2013), while soybean growers in the tropics lose about 1.8 million dollars annually due to weed infestation (Jannink et al., 2000).

Hoe-weeding is the predominant weed control method used in Nigeria. However, this method is very cumbersome and generally expensive because of the high price of labor which takes about 40 to 60% of the total cost of production (Adigun and Lagoke, 2013). In addition to high cost, labor availability is uncertain during the critical period of weed control which results in delayed weeding in a large portion of the planted crops after they have suffered irrevocable damage from weeds (Adigun, 2005). Herbicide use, on the other hand, although efficient, does not provide full-season weed control when used alone, and a single herbicide application may not control the entire weed spectrum (Chauhan et al., 2013). In addition, uncontrolled use of herbicides for weed control results in the increased number of herbicide-resistant weeds, shift in weed spectrum, environmental contamination and impacts on human health (Labrada, 2002). Therefore, farmers are becoming increasingly interested in more comprehensive weed management that would decrease their dependence on herbicides and multiple hoe-weedings as well as reduce the cost of weed control. There has been increased interest recently in the application of cultural approaches in integrated weed management systems (Chauhan and Johnson, 2010; Adigun et al., 2017). Among cultural practices, row spacing and/or seed rate is of immense significance, because it influences crop-weed interactions and crop competitiveness with weeds and therefore will affect weed management and cost of weed control (Knezevic et al., 2013). Soybean grown in narrow rows has been reported to have high competitive ability and quicker canopy cover with subsequence smothering and suppression of weed growth (Cox and Cherney, 2011). Hence, combining these weed control components with the reduced number of hoe-weedings and/or herbicide applications within the context of integrated weed management could help to improve weed control efficiency, reduce the high cost associated with multiple hoe-weeding or herbicide applications and increase soybean yield. Although some studies (Sodangi et al., 2006; Imoloame, 2014; Adigun et al., 2017) have earlier reported increased weed control efficiency and higher yields with integrated weed management, economic consideration, particularly profit is more important to farmers in driving the adoption of agricultural innovation (Pannell et al., 2006). It has also been reported that practices with the best yield may not necessarily translate to the best economic benefit to farmers (Sepat et al., 2017). Hence, this study was conducted to evaluate the economic performance of weed management methods using hoe-weeding, herbicides or their combination in soybean planted at 50-cm, 75-cm and 100-cm row spacings.

Material and Methods

The study was conducted at the Teaching and Research Farm of the Federal University of Agriculture, Abeokuta, Nigeria (7^o 15′ N, 3^o 23′ E 159 m above sea level) during the cropping seasons of 2016 and 2017 in the forest-savanna transition zone of South-West Nigeria. In both years, the experimental site was disc-plowed and harrowed at the two-week interval, pulverized and leveled manually. The site received an average rainfall of 607.1 mm with a mean temperature of 26.1 to 28.3 throughout the period of crop growth in both years of experimentation. The soils of the fields in both years had a sandy loam texture, pH of 7.7 and 7.5; organic matter of 2.5 and 2.1% and nitrogen of 0.25 and 0.21% in 2016 and 2017, respectively.

Gross and net plot sizes were 4.5x3.0 m^2 and 3.0 x 3.0 m^2, respectively. A late maturing (120-day duration) semi-determinate and high yielding soybean cultivar – TGX 1448-2E recommended for South-West Nigeria was planted on July 14^{th} and 12^{th} in 2016 and 2017, respectively. The treatments comprised three inter-row spacings of 50 cm, 75 cm and 100 cm equivalent to 100, 80 and 60 kg/ha seeding rates, respectively, which were the main plot treatments within the split-plot design with three replications. The sub-plot treatments comprised seven weed control methods: pre-emergence application of Probaben 400EC at 2 kg a.i/ha, pre-emergence application of Probaben at 2 kg a.i/ha followed by supplementary hoe-weeding at 6 weeks after sowing (WAS); pre-emergence application of butachlor 60EC at 2.0 kg a.i/ha; pre-emergence application of butachlor 60EC at 2.0 kg a.i/ha followed by supplementary hoe-weeding at 6 WAS; two hoe-weedings at 3 and 6 WAS; three hoe-weedings at 3, 6 and 9 WAS and the weedy check. Herbicides were applied pre-emergence, one day after sowing of soybean with a knapsack sprayer (CP 15, Hozelock-Exel, Cedex, France) in a spraying volume of about 250 l/ha using a deflector nozzle at a pressure of 2.1 kg/cm^2. Weed samples from each treatment were collected from two 0.5 m^2 quadrates per plot and were dried in an oven at 70°C for 72 h to determine the cumulative weed dry matter production at harvest. Soybean grain yield was obtained from the net plot after threshing the plants. The resulting grain weight in kg at 12.5% moisture content was expressed in kg/ha. Data collected were subjected to the analysis of variance (ANOVA) using the procedures of Genstat. Treatment means were compared using the least significant difference test (LSD) at 5% probability level.

Economic analysis of row spacing and weed management methods used was carried out based on gross profit analysis using partial budgeting. Economics of various row spacing, hoe-weeding and chemical weed control methods was calculated by working out expenditure on different aspects of cultivation and gross income under different treatments. The net return and cost-benefit ratio were also calculated to ascertain the viability of the treatments. The prevailing farm gate price for various cultivation operations, the input used and labor engaged due to treatments were used. Data averaged over two years of the study were used to estimate the profitability of row spacing and different weed control methods. The cost of cultivation was calculated based on the cost of land preparation, seeds, planting and weed control and harvesting. The revenue produced from each treatment was obtained by multiplying the yield by the market price.

TR = Quantity × Price (Osipitan et al., 2018).

TR is total revenue per hectare ($/ha), Quantity is total soybean grain yield harvested in kilograms per hectare (kg/ha), Price is the market price of soybean

($/kg). Gross profit for each weed management method and row spacing was calculated by deducting the total cost of cultivation from the return.

GP = TR – TVC (Osipitan et al., 2018).

GP is the gross profit per hectare ($/ha), TVC is the total variable cost of cultivation ($/ha). The benefit-cost ratio for each treatment was calculated by dividing gross profit by the total cost of cultivation:

Benefit-cost ratio = GP/TVC.

GP and TVC were as defined above (Osipitan et al., 2018).

Results and Discussion

The results of this study (data averaged over two years) showed a substantial increase in the cost of production (from $461.2 to $637.7 ha^{-1}), grain yield (from 1512 to 1937 kg ha^{-1}) and gross profit ($835 to $1023 ha^{-1}) with a reduction in row spacing from 100 cm to 75 cm and 50 cm. However, weed biomass was reduced significantly with a reduction in row spacing (Table 1). The labor costs for land preparation was the same for the three row spacings in both years, thus differences in the cost of production were largely due to variations in the cost of seed, labor required for planting, as well as the cost of hoe-weeding and harvesting which varied between the three row spacings. Planting soybean at 50-cm row spacing required 20 to 40 kg more seed at a cost of $18 to $36/ha than at 75-cm and 100-cm row spacings. Similarly, 75-cm row spacing required 20 kg more seed at $18/ha than 100-cm row spacing. The cost of planting at 50-cm row spacing was $43 to $65/ha higher than at 75-cm and 100-cm row spacings. Similarly, the cost of planting at 75-cm row spacing was $22/ha higher than at 100-cm row spacing. The higher cost of planting at 50-cm row spacing was associated with the higher seed rate and the number of rows required for 50-cm row spacing, which is relatively more labor demanding. The same reason could also be adduced for the higher labor cost required for harvesting soybean planted at 50-cm row spacing. In addition, 50-cm row spacing required more labor for weeding at a cost of $11ha^{-1} than 75-cm and 100-cm row spacings (Table 1). This is associated with a lodging which occurred at 50-cm row spacing, making manual weeding relatively more labor demanding. The increased cost of cultivation associated with reduced row spacing in this study is similar to the observation of Osipitan et al. (2018) in cowpea.

On the other hand, however, a reduction in row spacing from 100 cm to 75 and 50 cm resulted in an increased population of soybean plants per hectare with a subsequent increase in grain yield, total revenue and gross benefit. An increase in grain yield with a reduction in row spacing could also be attributed to better weed suppression and reduced weed competition for resources, occasioned by early canopy closure at narrow compared to wide-row spacing. These results are in agreement with that of Bhagirath et al. (2016) where mungbean spaced at 25 and 50 cm suppressed weed growth and had higher grain yield than those spaced at 75-cm wide-row spacing. In maize, similar results of more effective weed suppression by reduced row spacing were obtained by Simić et al. (2012). Furthermore, the revenue from narrow-row spacing was higher than from wide-row spacing. The market price used for the budget estimation for the three row spacings was the same, thus, differences in revenue were largely due to variations in yield levels of each row spacing. The high yield level of crops planted at 50-cm row spacing was a major factor that accounts for their relatively high harvesting labor compared to crops planted at 75-cm and 100-cm row spacings.

Table 1. The economic analysis of row spacing and weed management methods for soybean cultivation (data averaged for two trials).

Treatments	Seed and seed treatment	Land preparation	Planting	Weed control	Harvesting/ threshing	Total	Weed biomass (kg/ha)	Yield (kg/ha)	Total revenue	Gross profit	Benefit-cost ratio
Row spacing											
50 cm	91.4	77.1	128.6	211.9	128.6	637.7	2061.9	1937.4	1660.2	1023.0	1.7
75 cm	73.1	77.1	85.7	200.6	85.7	522.3	3319.7	1718.6	1472.3	950.3	1.9
100 cm	54.9	77.1	64.3	200.6	64.3	461.2	4222.3	1512.3	1296	835.3	1.9
Lsd (5%)							129.5	56.5			
Weed control methods											
Probaben at 2.0 kg a.i/ha	73.1	77.1	92.9	46.4	92.9	382.4	3275.2	1728.1	1481.1	1099.2	2.9
Probaben at 2.0 kg a.i/ha fb shw	73.1	77.1	92.9	220.0	92.9	556.0	2218.4	2098.4	1798.0	1242.3	2.2
Butachlor at 2.0 kg a.i/ha	73.1	77.1	92.9	55.7	92.9	391.7	3106.6	1756.3	1505.1	1113.3	2.8
Butachlor at 2.0 kg a.i/ha fb shw	73.1	77.1	92.9	230.0	92.9	566.0	2239.5	2043.5	1751.1	1185.4	2.1
2 hoe-weedings at 6 and 9 WAS	73.1	77.1	92.9	351.4	92.9	687.4	3126.3	1780.5	1526.0	839.6	1.2
3 hoe-weedings at 3, 6 and 9 WAS	73.1	77.1	92.9	527.1	92.9	863.1	2615.3	2061.3	1766.6	903.0	1.0
Weedy check	73.1	77.1	92.9	0.0	92.9	336.0	5820.2	589.0	505.1	169.2	0.5
Lsd (5%)							197.7	120.6			

a.i – active ingredient, shw – supplementary hoe-weeding, WAS – weeks after sowing.

All the weed management methods incurred higher costs of cultivation than the weedy check as a result of the cost of weed control (Table 1). Of all the weed control methods, three hoe-weeding treatments incurred the highest total cost ($863) as a result of the accumulated cost of hoe-weeding which is usually expensive (Table 1). On the other hand, weedy plots where weeds were not controlled throughout the crop life cycle had the lowest total variable cost (Table 1). This was consistent across the three row spacings of 50 cm, 75 cm and 100 cm used in this study (Table 2). This finding has confirmed other reports that the cost of weed control takes the bulk of total production cost in many field crops (Adigun and Lagoke; Chikoye, 2007).

Irrespective of the row spacing used, pre-emergence application of Probaben 400EC or butachlor 60EC each alone at 2.0 kg a.i ha^{-1} or followed by supplementary hoe-weeding at 6 WAS resulted in a lower cost of cultivation than two and three hoe-weedings (Table 2). The relatively lower cost incurred by herbicide treatments compared to hoe-weeding may be attributed to a reduction in labor requirement for herbicide application compared with the labor required for hoe-weeding. Comparisons of the economics of different weed control technologies have earlier indicated that the overall reduction in production costs associated with herbicides is caused by a massive reduction in the labor required for weeding from 39.2 to 1.3 person-days per hectare (Overfield et al., 2001). The use of herbicides to remove weeds required only 2 hours of labor per hectare, whereas the optimal amount of hand-weeding required per hectare is estimated to be 400 hours (Gouse et al., 2006). The result of this study has corroborated the findings of Patil et al. (2014) that manual weeding is very expensive, strenuous and causes a lot of drudgery.

All the weed control methods resulted in higher soybean grain yield than the weedy check across the 50-, 75- and 100-cm row spaced plots (Table 2). This result is in agreement with the earlier report of Sodangi et al. (2006) that allowing weeds to compete with soybean substantially reduced yield. The results are also akin to those reported by Patil et al. (2014) and many others who reported an increased yield of soybean due to various weed control treatments owing to the increased availability of nutrient, light and space. When the crops were planted at 50-cm row spacing, pre-emergence application of herbicides (Probaben 400EC or butachlor 60EC) at 2.0 kg a.i/ha each followed by supplementary hoe-weeding at 6 WAS resulted in the highest yield (2301 to 2484 kg/ ha) and total revenue ($1972 to $2129/ha). However, when the crops were planted at 75- and 100-cm row spacings, three hoe-weeding treatments resulted in the highest yield (2081 to 2155 kg/ha) and total revenue ($1783 to $2081/ha). This showed that application of these herbicides followed by single hoe-weeding was only adequate to give optimum yield and revenue in narrow- (50 cm) but not in intermediate- (75 cm) and wide-row (100 cm) soybean, probably because soybean planted in wide-row spacing had higher late-season weed infestation as a result of poor canopy closure and more space available for weed growth, and hence required a longer period of weed control than soybean planted in narrow rows. These results have corroborated the report of Culpepper (2006) that wide-row spacing requires multiple hoe-weedings to achieve a reasonable level of weed control and good yield. On the other hand, however, for the narrow-row spacing of 50 cm, increasing the number of hoe-weedings to two or three times did not guarantee the highest yield, total revenue or cost-benefit ratio, but rather increased the cost of weed control (Table 2). Higher grain yield obtained with pre-emergence herbicide followed by supplementary hoe-weeding at 50-cm row spacing could be attributed to early weed control by the pre-emergence herbicide, early canopy closure and removal of late-emerging weeds by the supplementary hoe-weeding, all of which helped to sustain a weed-free condition throughout the crop life cycle. These results are similar to the findings of Peer et al. (2013) where pendimethalin integrated with hoe-weeding recorded a superior yield of soybean than hoe-weeding treatments. Also, a number of researches like Veeramani et al. (2001) and Osipitan et al. (2013) held similar views and reported higher yield with integrated weed management.

Despite the higher yield and revenue obtained with three hoe-weedings than herbicide treatments applied alone or supplemented by hoe-weeding in plots planted at 75- and 100-cm row spacings, the gross profit and benefit-cost ratio obtained were lower than those obtained with herbicide treatments applied alone or supplemented by hoe-weeding. This shows that the gain in yield and revenue from three hoe-weeded plots was nullified by the higher total cost of production as a result of accumulated labor which is usually expensive. Hence, the reduced benefit-cost ratio was obtained with three hoe-weedings. In all the three row spacings, pre-emergence application of herbicides (Probaben 400EC or butachlor 60EC each at 2.0 kg a.i/ha) consistently resulted in the highest cost-benefit ratio, and when supplemented by hoe-weeding at 6 WAS, the highest yield and gross profit were consistently obtained (Table 2). This study has shown that pre-emergence herbicides followed by supplementary hoe-weeding produced greater yield at less cost than the typical practice of hoe-weeding. Our findings of the cost-effectiveness of herbicides for weed management in soybean are in line with previous studies, in which researchers found that weed control with appropriate herbicides provided higher net benefits than manual hoe weeding (Khaliq et al., 2002; Suria et al., 2011). When the crops were planted at 50-cm or 75-cm row spacings, two hoe-weedings resulted in higher cost-benefit ratio than three hoe-weedings, however, with 100-cm row spacing, three hoe-weedings gave higher cost-benefit ratio than two hoe-weedings (Table 2). This further confirms that the benefit of the reduced number of hoe-weedings increases with a reduction in row spacing as a result of complementary weed control provided by the shading effect of crop canopy on weed at narrow- compared to wide-row spacing (Bhagirath et al., 2016).

Table 2. The breakdown of the economic analysis of weed management methods for soybean cultivation as affected by row spacing (data averaged for two trials).

Row spacing	Weed control methods	Seed and seed treatment	Land preparation	Planting	Weed control	Harvesting/ threshing	Total	Yield (kg/ha)	Total revenue	Gross profit	Benefit-cost ratio
50 cm	Probaben at 2.0 kg a.i/ha	91.4	77.1	128.6	46.4	128.6	472.1	1922.0	1647.4	1175.6	2.5
	Probaben at 2.0 kg a.i/ha fb shw	91.4	77.1	128.6	224.3	128.6	650.0	2484.2	2129.1	1479.3	2.3
	Butachlor at 2.0 kg a.i/ha	91.4	77.1	128.6	55.7	128.6	481.4	1981.3	1698.0	1217.5	2.5
	Butachlor at 2.0 kg a.i/ha fb shw	91.4	77.1	128.6	235.7	128.6	661.4	2301.3	1972.3	1311.6	2.0
	2 hoe-weedings at 6 and 9 WAS	91.4	77.1	128.6	368.6	128.6	794.3	1943.4	1665.4	871.0	1.1
	3 hoe-weedings at 3, 6 and 9 WAS	91.4	77.1	128.6	552.9	128.6	978.6	1947.8	1668.9	690.0	0.7
	Weedy check	91.4	77.1	128.6	0.0	128.6	425.7	980.0	840.0	414.3	1.0
75 cm	Probaben at 2.0 kg a.i/ha	73.1	77.1	85.7	46.4	85.7	368.1	1749.2	1499.1	1131.3	3.1
	Probaben at 2.0 kg a.i/ha fb shw	73.1	77.1	85.7	217.9	85.7	539.6	1999.3	1713.4	1174.4	2.2
	Butachlor at 2.0 kg a.i/ha	73.1	77.1	85.7	55.7	85.7	377.4	1792.4	1536.0	1159.4	3.1
	Butachlor at 2.0 kg a.i/ha fb shw	73.1	77.1	85.7	227.1	85.7	548.9	2013.2	1725.4	1177.5	2.1
	2 hoe-weedings at 6 and 9 WAS	73.1	77.1	85.7	342.9	85.7	664.6	1816.1	1556.6	892.0	1.3
	3 hoe-weedings at 3, 6 and 9 WAS	73.1	77.1	85.7	514.3	85.7	836.0	2155.4	1847.1	1011.1	1.2
	Weedy check	73.1	77.1	85.7	0.0	85.7	321.7	500.0	428.6	107.0	0.3
100 cm	Probaben at 2.0 kg a.i/ha	54.9	77.1	64.3	46.4	64.3	307.0	1513.3	1296.9	990.0	3.2
	Probaben at 2.0 kg a.i/ha fb shw	54.9	77.1	64.3	217.9	64.3	478.4	1810.4	1551.4	1073.0	2.2
	Butachlor at 2.0 kg a.i/ha	54.9	77.1	64.3	55.7	64.3	316.3	1495.2	1281.4	965.3	3.1
	Butachlor at 2.0 kg a.i/ha fb shw	54.9	77.1	64.3	227.1	64.3	487.7	1815.5	1555.7	1068.4	2.2
	2 hoe-weedings at 6 and 9 WAS	54.9	77.1	64.3	342.9	64.3	603.4	1582.4	1356.0	753.5	1.2
	3 hoe-weedings at 3, 6 and 9 WAS	54.9	77.1	64.3	514.3	64.3	774.9	2081.4	1783.7	1009.0	1.3
	Weedy check	54.9	77.1	64.3	0.0	64.3	260.6	288.6	246.9	-14.0	-0.1
	Lsd (5%)							149.0			

a.i – active ingredient, shw – supplementary hoe-weeding, WAS – weeks after sowing.

In terms of overall profitability, soybean planted at 50-cm row spacing and treated with the pre-emergence application of Probaben 400EC at 2.0 kg a.i ha^{-1} followed by supplementary hoe-weeding at 6 WAS gave the highest gross profit of $1479/ha. This was followed closely by soybean planted at 50-cm row spacing and treated with the pre-emergence application of butachlor 60EC at 2.0 kg a.i ha^{-1} followed by supplementary hoe-weeding at 6 WAS with a gross profit of $1311/ha. Due to severe weed pressure, planting soybean at 100-cm row spacing was not profitable without weeding. The economic analysis revealed that, when weeds were not controlled at 100-cm row spacing, a loss of $14/ha was incurred and the cost-benefit ratio was negative (- 0.1). On the other hand, however, no loss was incurred with the use of 50-cm and 75-cm row spacings, even in weedy plots, although it was more profitable to control weeds than allowing weeds on plots at these row spacings. Controlling weed resulted in 66–257 and 733–1000% higher profit than when the crops were left weedy in 50-cm and 75-cm rows, respectively. These results have corroborated earlier reports of Osipitan et al. (2018) that narrow-row spacing reduced economic losses caused by weed infestation and had the potential to increase per capita income as a result of increased yield.

Conclusion

The total variable cost of soybean cultivation was substantially influenced by row spacing and cost of weed control. Narrow-row spacing (50 cm) reduced weed biomass and increased the cost of production and grain yield with subsequent higher gross profit than intermediate- (75 cm) and wide-row (100 cm) spacing. Irrespective of the row spacing, two and three hoe-weedings resulted in higher cost of weed control than pre-emergence herbicide treatments applied alone or supplemented by hoe-weeding. Three hoe-weedings gave the highest yield and gross profit when the crops were planted at 100-cm row spacing. However, an increase in the number of hoe-weedings to two or three times at 50-cm and 75-cm row spaced plots did not guarantee maximum yield and gross profit, but rather increased the cost of weed control, particularly under narrow-row spacing (50 cm). When the crops were planted in narrow rows (50 cm), the highest net benefit could be achieved by using pre-emergence Probaben 400EC or butachlor 60EC each applied alone at 2.0 kg a.i ha^{-1}, and when supplemented by hoe-weeding at 6 WAS, the highest yield and gross profit were consistently obtained. Our study suggests that the use of pre-emergence herbicides supplemented by one hoe-weeding for weed management could help to reduce dependence on multiple hoe-weedings, reduce weed growth, and optimize yield as well as increase profitability and benefit-cost ratio especially under narrow-row spacing in soybean cultivation.

References

Adigun, J.A., & Lagoke, S.T.O. (2003). Weed control in transplanted rain and irrigated tomatoes in the Nigerian savanna. *Nigerian Journal of Weed Science*, *16*, 23-29.

Adigun, J.A. (2005). Critical period of weed interference in rainfed and irrigated tomatoes in the Nigerian savanna. *Agricultura tropica et subtropica*, *38* (2), 73-79.

Adigun, J.A., Adeyemi, O.R., Daramola, O.S., Odueme, P.U., & Fadeyi, O.J. (2017). Growth and yield performance of groundnut (*Arachis hypogeae* L.) as affected by row- spacing and weed control methods in the Nigerian forest–savannah transition zone. *Nigerian Journal of Ecology*, *16* (1), 22-35.

Bhagirath, S.C., Singarayer, K.F., Connor, J.F., & Rodolfo, G.C. (2016). Implications of narrow crop row spacing in managing weeds in mungbean (*Vigna radiata). Crop protection*, *30*, 1-4

Chauhan, B.S., & Johnson, D.E. (2010). Implications of narrow crop row spacing and delayed *Echinochloa colona* and *Echinochloa crus-galli* emergence for weed growth and crop yield loss in aerobic rice. *Field Crops Research*, *117*, 177-182.

Chauhan, B.S., & Opeña, J. (2013). Implications of plant geometry and weed control options in designing a low-seeding seed-drill for dry seeded rice systems. *Field Crops Research*, *144*, 225-231.

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

Cox, W.J., & Cherney, J.A. (2011). Growth and Yield Response of Soybean to Row Spacing and Seeding Rate. *Agronomy Journal*, *103*, 123-128.

Culpepper, A.S. (2006). Glyphosate-induced weed shifts. *Weed Technology*, *20*, 277-281.

Gouse, M., Jenifer, P., & Colin, T. (2006). Output and Labour Effects of GM Maize and Minimum Tillage in a Communal Area of Kwazulu-Natal. *Journal of Development Perspectives*, *2* (2), 71-86.

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.

Jannink, J.I., Orf, J.H., Jordan, N.R., & Shaw, R.G. (2000). Index selection for weed suppressive ability in soybean. *Crop Science*, *40* (4), 1087-1094.

Joubert, J.C.N., & Jooste, A.A.A. (2013). Comparative analysis of the different regions of South Africa soybean industry, Proceedings of the World Soybean Research Conference IX (pp. 77-83). Durban, South Africa.

Khaliq, A., Matloob, A., Ahmed, N., Rasul, F., & Awan, I.U. (2012). Late POST emergence chemical weed control in direct seeded fine rice. *Journal of Animal and Plant Science*, *22*, 1101-1106.

Khojely, D.M., Seifeldin, E.I., Enoch, S., & Tianfu, H. (2018). History, current status, and progress of soybean production and research in sub-Saharan Africa. *The Crop Journal*, *6* (3), 226-235.

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. (2002). 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.

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

Osipitan, O.A., Yahaya, I., & Adigun, J.A. (2018). Economics of Weed Management Methods as Influenced by Row-Spacing in Cowpea. *Journal of Agricultural Science*, *10* (2), 1916-9760.

Overfield, D., Murithi, M.F., Muthamia, J.N., Ouma, J.O., Birungi, K.F., Maina, J.M., Kibata, G.N., Musembi, F.J., Nyanyu, G., Kamidi, M., Mose, L.O., Odendo, M., Ndungu, J., Kamau, G., Kikafunda, J., & Terry, P.T. (2001). Analysis of the constraints to adoption of herbicides by smallholder maize growers in Kenya and Uganda. *Proceedings of The BCPC Conference Weeds* (pp. 907-912). Lagos, Nigeria.

Pannell, D.J., Marshall, G.R., Barr, N., Curtis, A., Vanclay, F., & Wilkinson, R. (2006). Understanding and promoting adoption of conservation practices by rural landholders. *Australian Journal of Experimental Agriculture, 46* (11), 1407-1424.

Patil, B.C., Padanad, L.A., Yashvantkumar, K.Y., Soumya, S., & Ravi, M. (2014). Efficacy and economics of integrated weed management in vegetable cowpea (*Vigna unguiculata* (L.) Walp). *Agriculture Update*, *9* (1), 124-127.

Peer, F.A., Badrul lone, B.A., Qayoom, S., Ahmed, L., Khanday, B., & Singh, G. (2013). Effect of weed control methods on yield and yield attributes of Soyabean. *African Journal of Agricultural Research, 8*, 6135-6141.

Ronner, E., Franke, A.C., Vanlauwe, B., Diande, M., Edeh, E., Ukem, B., Bala, A., Van, J., Heerwaarden, K.E., & Giller, K.E. (2016). Understanding variability in soybean yield and response to P-fertilizer and rhizobium inoculants on farmers' field in northern Nigeria. *Field Crops Research, 186*, 133-145.

Sepat, S., Thierfelder, C., Sharma, A.R., Pavuluri, K., Kumar, D., Iquebal, M.A., & Verma, A. (2017). Effects of weed control strategy on weed dynamics, soybean productivity and profitability under conservation agriculture. *Field Crops Research*, *210*, 61-70.

Simić, M., Dolijanović, Ž., Maletić, R., Stefanović, L., & Filipović, M. (2012). Weed suppression and maize productivity by different arrangement patterns. *Plant, Soil and Environment, 58* (3), 148-153.

Sodangi, I.A., Gworgwor, N.A., & Joshua, S.D. (2006). Effects of weed interference and inter-row spacing on productivity of soyabean (*Glycine Max* (L) Merril) in Maiduguri, Nigeria. *Nigerian Journal of Weed Science, 19*, 33-40.

Suria, A.S., Juraimi, M.J., Rahman, A.S, Man, M.M., & Selamat, A.B. (2011). Efficacy and economics of different herbicides in aerobic rice system. *African Journal of Biotechnology*, *10*, 8007-8022.

Veeramani, A., Palchamy, A., Ramasamy, S., & Rangaraju, G. (2001). Integrated Weed Management in Soybean (*Glycine max* (L.) Merril) under various plant densities. *Madras Agricultural Journal, 88* (7-9), 451-456.

Vivian, R.A., Pablo, A.K., Vargas, L.C.C., Ferreira, F., & Mariana, G. (2013). Weed Management in Soybean-Issues and Practices. In: *Soybean-Pest Resistance* (pp. 50-84). Intech open.

Received: March 28, 2019
Accepted: July 23, 2019

EKONOMSKI EFEKTI MEĐUREDNOG RASTOJANJA I INTEGRALNOG SISTEMA SUZBIJANJA KOROVA U SOJI (*GLYCINE MAX* L.)

Olumide S. Daramola[1*], Olusegun R. Adeyemi[1], Joseph A. Adigun[1] i Christopher O. Adejuyigbe[2]

[1]Odsek za fiziologiju biljaka i proizvodnju useva, Poljoprivredni federalni univerzitet, Abeokuta
[2]Odsek za nauku o zemljištu, Poljoprivredni federalni univerzitet, Abeokuta

R e z i m e

Visoki troškovi uzgajanja i suzbijanja korova predstavljaju glavne ograničavajuće faktore za povećanje produktivnosti soje i neto prihoda. Poljski ogledi su sprovedeni 2016. i 2017. godine na Nastavno-istraživačkom dobru Poljoprivrednog federalnog univerziteta u Abeokuti da bi se ispitali ekonomski efekti različitih međurednih rastojanja i integralnog sistema suzbijanja korova u proizvodnji soje. Eksperiment je postavljen po potpuno slučajnom blok sistemu u tri ponavljanja, sa tri glavna tretmana koji predstavljaju različita međuredna rastojanja (50, 75 and 100 cm). Ovi tretmani su podeljeni na 7 podtretmana koji uključuju šest metoda suzbijanja korova i zakorovljenu kontrolu. Smanjenje međurednog rastojanja sa 100 cm na 75 cm, odnosno 50 cm dovelo je do značajnog smanjenja biomase korova. Osim toga, troškovi proizvodnje, prinos zrna i bruto dobit su povećani sa smanjenjem međurednog rastojanja sa 100 cm na 75 cm, odnosno 50 cm. Kada je soja posejana na međuredno rastojanje od 50 cm, primena 2 kg a.s./ha herbicida Probaben 400EC (metolahlor 20% w/v + prometrin 20% w/v) ili Butahlor 60 EC (butahlor) uz okopavanje 6 nedelja posle setve obezbedila je najveći prinos od 2301–2484 kg/ha i ukupni prihod od 2129–1972 $/ha. Suprotno tome, tri okopavanja su obezbedila najviši prinos od 2155–2081 kg/ha i ukupni prihod od 1848–1783 $/ha za useve gajene na međurednim rastojanjima od 75 i 100 cm. Uprkos većem prinosu i prihodu dobijenim sa tri okopavanja za tretmane sa međurednim rastojanjima od 75 i 100 cm, bruto dobit i odnos prihoda i troškova bili su niži nego za tretmane u kojima je primenjen samo herbicid ili je primena herbicida kombinovana sa okopavanjem. Kada je profitabilnost u pitanju, najveća bruto dobit od 1479 $/ha je postignuta kada je soja zasejana na međurednom rastojanju od 50 cm i tretirana sa 2 kg a.s./ha herbicida Probaben 400EC u kombinaciji sa okopavanjem. Dva ili tri okopavanja soje posejane na uskom (50 cm) međurednom rastojanju nisu garantovala najveći prinos, ali su prilično povećala troškove suzbijanja korova. Ovim istraživanjem se sugeriše da će se uskim međurednim rastojanjem (50 cm) i primenom herbicida pre nicanja smanjiti

[*]Autor za kontakt: e-mail: olumidedara01@gmail.com

broj okopavanja, pa time i visoki troškovi proizvodnje koji su neophodni za optimalni prinos, kao i da će se povećati profitabilnost proizvodnje soje.

Ključne reči: ekonomika, međuredno rastojanje, soja, integralni sistem suzbijanja korova, bruto dobit.

Primljeno: 28. marta 2019.
Odobreno: 23. jula 2019.

Journal of Agricultural Sciences
Vol. 64, No. 3, 2019
Pages 279-291

https://doi.org/10.2298/JAS1903279B
UDC: 637.4(669)
636.52/.57(669)
Original scientific paper

COMPARATIVE INVESTMENT ANALYSIS OF SMALL-SCALE BROILER AND LAYER ENTERPRISES IN OSUN STATE, NIGERIA

Isiaka O. Baruwa and Ololade A. Fabode*

Department of Agricultural Economics,
Obafemi Awolowo University, Ile-Ife, Nigeria

Abstract: The study investigated the investment patterns, costs and return structures of the layer and broiler production in Osun State, Nigeria. It also compared their net present value in the study area to determine their investment returns. A multistage sampling technique was employed in selecting respondents for the study. Primary data were collected from 180 broiler and layer farms, comprising 90 broiler farms and 90 layer farms from six local governments in Osun State using a structured questionnaire. The data were analysed using descriptive statistics, budgetary techniques and investment tools. The investment pattern indicated that a larger amount of money was invested in capital assets for small-scale layers (₦651,274.5) compared to broilers (₦448,068.6). Personal saving was the major source of funding among the small-scale layer enterprises compared to that of broiler enterprises. In addition, the survival of re-investment in small-scale layers depends largely on funds from family members while the small-scale broiler enterprise depends on retained earnings. The budgetary analysis showed that the gross margin of the farmers was ₦166,321.8 and ₦1,150,470.8 for broiler and layer enterprises, respectively. Investment analysis revealed that the layer enterprise had a higher positive net present value (NPV) and the internal rate of return (IRR) value of ₦1,523,692.6 and 64.9 per cent, respectively. In contrast, the broiler enterprise had lower positive NPV and IRR values of ₦961,173.3 and 63.0 per cent, respectively. The study concluded that the small-scale layer enterprise was found to be more economically profitable compared to the small-scale broiler enterprise with higher NPV and IRR values and a shorter discounted payback period in Osun State.

Key words: broilers, layers, NPV, IRR, discounted payback period.

*Corresponding author: e-mail: fabodeololade@gmail.com

Introduction

In developing nations, most poultry farmers embark on small-scale poultry enterprises due to difficulty in obtaining sufficient inputs. Thus, they are found in the rural area where production inputs are difficult to obtain and the marketing outlet is not well organised (Adeyemo and Onikoyi, 2012). Therefore, these are farms with fewer than 1,000 birds. Medium-scale poultry enterprises have between 1,000 and 5,000 birds. Farms that produce more than 5,000 birds are large-scale (Busari and Okanlawon, 2015). Mostly, small-scale farmers engage in the production of broilers and layers with the primary aim of generating income (Okonkwo, 2016). Moreover, the production costs per unit of broiler production are relatively lower compared to other types of poultry (layers) and returns on investment are high. Therefore, a small amount of start-up capital is needed by farmers for a broiler poultry farm. It has a short production cycle (payback period). As such, capital cannot be held down over a long period (Van Veenhuizen and Danso, 2007). Poultry production of broilers assures fast returns within weeks, whereas it is months in the case of layers (Anang et al., 2013). Furthermore, small-scale broiler production can produce meat within eight weeks while small-scale layer farms play an important role in the supply of eggs in addition to poultry meat, thereby contributing to national protein supply (Kabir and Haque, 2010).

According to Okonkwo (2016), most small-scale broilers reach slaughter weight at between 5 and 7 weeks of age, although some layers reach slaughter weight at approximately 14 weeks of age while layers start dropping eggs between 22 and 24 weeks. However, they are constrained by the rising cost of inputs, particularly of feed and medication (Ahmad and Kiresur, 2016). Broiler production has the advantage of the fast growth rate, cheaper, higher feed conversion efficiency when compared to other livestock enterprises such as layer production.

Furthermore, an investment for income, risk and resale value should be evaluated with the ultimate goal of measuring how the given investment is a good fit for a portfolio (James, 2013). Cost and benefit analysis is the essence of investment analysis of the production of layers and broilers. This becomes the basis of the whole decision-making process under resource constraints, which are put into alternative uses (Mwansa, 2013). Having the limited reversibility of investment projects, it is significant to consider many business opportunities and all associated risks before making a final investment decision (Mwansa, 2013). Investment appraisal is the starting point to determine the worthiness of a prospective project. The economic profitability of each enterprise determines the attractiveness of the enterprise. The more economically profitable a project is, the more attractive it is for investment and vice versa (Mwansa, 2013).

Despite the nutritional value of poultry meat and egg, the production in the country is very insufficient, as reflected by the wide interval between supply and demand of the products (Ohajinya et al., 2013). Local demand for poultry products in Nigeria is about 1.5 million tonnes. The supply capacity is between 700,000 and 1 million tonnes, but the poultry production capacity of farms must increase rapidly to meet the increasing demand. To achieve this, the current production level must be improved. In developing countries, most poultry farmers start small-scale poultry enterprises due to the difficulty of obtaining sufficient input.

Many studies (Adepoju, 2008; Olasunkanmi 2008; Taru et al., 2010; Ike and Ugwumba, 2011; Mahama et al., 2013; Olufemi and Adeolu; 2013; Ohajianya et al., 2013; Anang et al., 2013; Tanko and Aji, 2014) were done separately on layer and broiler production enterprises with a greater focus on egg production. However, all these studies failed to compare the investment pattern and net worth of these two categories of poultry production. Thus, the aim of this study is to provide answers to the following research questions: What are the investment patterns of small-scale broiler and layer production? What is the cost and benefit structure of the small-scale layer and broiler production? Is investment in small-scale broiler or layer production economically viable? How comparable is their economic profitability? The specific objectives are to investigate the investment pattern of small-scale broiler and layer production, estimate costs and returns structures of layer and broiler production, and compare the net value of small-scale broiler and layer production.

Material and Methods

The study was conducted in Osun State. Osun State is located in the geopolitical zone of southwestern Nigeria. The state is bordered by Ogun State to the south, Oyo State to the west, Kwara State to the north and Ondo State to the east. It lies between longitude 040 00'E and 050 05'E and latitude 050 58'N and 080 07'N (Omodele and Okere, 2014). There are two separate climate seasons. The rainy season is between March and October, and the dry season between November and early March. The state is a typical rainforest with an average annual rainfall ranging from 880 mm to 2,600 mm and the temperature varies between 25 and 27.5^{o}C, and it is also characterised by forest vegetation (BBC Weather Center, 2008). The majority of the population in the state is agricultural farmers. The production of livestock such as goats, sheep, pigs, rabbits and poultry (chicken) is popular in the area (Adepoju, 2008). The state covers an area of 14,875 square kilometres; of which 9,251 square kilometres are bounded by other territories such as Kwara, Ondo, Oyo, Ogun and Ekiti States. It has 30 local government areas. The state of Osun is large and its population is estimated at approximately 3,423,535 people (Deji, 2012). It has six cities. These include Ede, Ife, Ilesha, Ikirun, Iwo and Oshogbo.

The target population was small-scale broiler and layer producers in Osun State. A multistage sampling technique was employed in selecting respondents for the study. The first stage involved random selection of two agricultural zones (Osogbo and Ife-Ijesha zones) out of the three agricultural zones (Osogbo, Iwo and Ife-Ijesha zones) in Osun State in order to obtain a good geographical spread of the areas. In the second stage, three local government areas were randomly selected from each of the two agricultural zones (Ife-Central, Ife-North, Ilesa-West, Osogbo, Odo-Otin and Obokun LGAs). The third stage involved purposive selection of three communities from each LGA (giving a total of 18 communities) based on a high concentration of poultry producers through the registered poultry farmers' association in the zones. The fourth stage involved the selection of ten poultry farmers from each community using a simple random sampling technique (giving a total of 180 respondents). Respondents were stratified into 90 broiler producers and 90 layer producers. The primary data were collected using a pre-tested and validated questionnaire. The variables observed were: the farm capital outlays of the respondents, and quantities and prices of inputs and outputs in the area during the 2017/2018 production season. The descriptive statistics, budgetary technique, and investment tools were used to analyse data collected.

The budgetary technique was used to estimate the costs and returns on the small-scale broiler and layer production. The different types of inputs used and their cost implications were analysed using the enterprise budget analysis. The cost was divided into variable costs and fixed costs. The variable costs included the cost of labour, day-old chicks, medication, transport, feeding, utility and general management of birds. Fixed costs included depreciation on fixed assets (e.g. building, battery cages, water trough, etc.); this was charged using the straight-line method. The enterprise budget equations are as follows:

Gross margin (GM),

$$\text{GM} = \sum p_i q_i - \sum r_i x_i, \quad (1)$$

where

$p_i =$ the average price of eggs per crates, broilers and layers sold (₦),

$q_i =$ the average quantity of sold eggs in a tray, broilers and layers sold per production cycle,

$r_i =$ the average price of variable inputs (₦),

$x_i =$ the average quantity of variable inputs used (kg).

Subsequently, the net return was obtained from gross margin:

$$\text{NR} = \text{GM-TFC}, \quad (2)$$

where NR = Net returns; TFC = Total fixed cost.

In accordance with Ekunwe and Soniregun (2007), the following economic comparisons were used to measure the economic performance of the farms: the rate of return on investment (ROI); operating expense ratio (OER); profit margin (PM); and benefit-cost ratio (BCR).

The rate of return on investment (ROI) shows the amount gained on every naira (₦) invested. It is measured as:

$$\text{ROI} = \frac{NFI}{TC} \times 100, \tag{3}$$

where:

NFI is net farm income, and

TC is the total cost.

$$\text{Operating expense ratio} = \frac{Total\,variable\,cost}{Gross\,revenue} \tag{4}$$

$$\text{Profit margin} = \frac{NFI\ (₦)}{Total\,revenue\ (₦)} \times 100 \tag{5}$$

$$\text{Benefit-cost ratio (BCR)} = \frac{Total\,revenue}{Total\,cost} \tag{6}$$

The following assumptions were made for the layer enterprise:

1) The foundation stocks were day-old chicks.
2) The mortality rate was 10 per cent.
3) The production period was 12 months and the production cycle was 18 months.
4) Layers started to lay eggs at 6-month-old and continued to lay eggs until 18 months. The total laying period was 12 months.

The layer enterprise had two sources of revenue: namely, eggs laid and culled hens for meat.

The following assumptions were made for the broiler enterprise:

1) The foundation stocks were day-old chicks.
2) The mortality rate was 10 per cent.
3) The production period was 6 months and the production cycle was 18 months.

Adopting the analytical technique of Mwansa (2013), investment tools such as net present value (NPV) and internal rate of return (IRR) and discounted payback period were used to analyse and compare the net present value of the small-scale broiler and layer production.

The net present value:

$$NPV = \frac{CF_1}{(1+i)^1} + \frac{CF_2}{(1+i)^2} + \frac{CF_3}{(1+i)^3} + \dots + \frac{CF_n}{(1+i)^n} - C_0 \tag{7}$$

where,

CF_n – Cash flow at period n (from n number of sales of broilers, eggs and culled hens)

C_0 – Initial cost of investment (costs of land, building, battery cages, drinkers, and feeders)

i – Discount rate.

Internal Rate of return

Discount rate offered for investing by creditors to farmers was used. The IRR will make NPV equals zero.

$$NPV = \frac{CF_1}{(1+i)^1} + \frac{CF_2}{(1+i)^2} + \frac{CF_3}{(1+i)^3} + ... + \frac{CF_n}{(1+i)^n} - C_0 = 0 \quad (8)$$

Results and Discussion

Investment patterns of small-scale broiler and layer enterprises

The investment patterns in small-scale broiler and layer enterprises are shown in Tables 1, 2 and 3. These indicate the various commitments of funds to these enterprises at present and in anticipation of some positive rates of return in the future. The investment patterns encompassed: capital inputs, the distribution of initial sources of funds and sources of finance for subsequent investment. A larger amount of money was invested for capital assets in small-scale enterprises for layers compared to broiler enterprises. This shows that personal savings were predominantly used to fund the small-scale layer enterprise compared to that of broilers (Table 2). To infer, the survival of re-investment in small-scale layers depended largely on funds from family members while small-scale broilers depended largely on retained earnings (Table 3). The small-scale broiler and layer enterprises were reflections of submission by Pawariya and Jheeba (2015) who showed that layer farms needed higher investment and the profitability was greater compared to broiler farms.

Percentage distribution of enterprises by investment patterns

Table 1. Enterprises by costs of capital assets.

Assets	Layer costs (₦)	Percentage	Broiler costs (₦)	Percentage
Land	204,182.07	31.35	200,000.00	44.64
Housing	319,738.50	49.09	232,501.70	51.89
Battery cages	101,718.70	15.62	-	-
Crates	9,817.31	1.51	-	-
Feeders	8,887.67	1.36	8,887.77	1.98
Drinkers	6,930.26	1.06	6,829.22	1.52
Total	651,274.51	100.00	448,068.69	100.00

Source: Field survey, 2018.

Table 2. Enterprises by the source of initial capital.

The initial source of funds	Layers		Broilers	
	Frequency	Percentage	Frequency	Percentage
Own resources	34.00	40.00	15.00	18.75
Family loan	28.00	32.95	46.00	57.50
Community loan	6.00	7.05	7.00	8.75
Money lender	6.00	7.05	5.00	6.25
Commercial banks	11.00	12.95	7.00	8.75
Total	85.00	100.00	80.00	100.00

Table 3. Enterprises by the source of reinvestment.

Source of reinvestment	Layers		Broilers	
	Frequency	Percentage	Frequency	Percentage
Retained earnings	29.00	34.12	45.00	57.69
Debt	7.00	8.24	3.00	3.85
Family	49.00	57.64	30.00	38.46
Total	85.00	100.00	80.00	100.00

Source: Field survey, 2018.

Relative costs and returns (₦) to broiler and layer enterprises

The results of costs, returns and profitability of broiler and layer enterprises are presented in Table 4. It was found that an average poultry farmer invested about ₦332,699.3 and ₦1,082,060.7 as total costs of production for broiler and layer enterprises respectively. These included stocking, feeding, labour, medication, transport and utility and other costs. The stocking cost for small-scale broilers was 12.8 per cent while the cost for layers was 4.1 per cent as the percentage of the total costs. The feeding costs for the two categories of enterprises constituted the largest share of the total costs for broiler farms (46.3%) and layer farms (60.3%). These results support the findings of Oladeebo and Ojo (2012) and Busari and Okanlawon (2015) that feed cost is the major important cost item associated with broiler and layer production probably due to an increase in the cost of maize, groundnut cake, soybean meal and the scarcity of wheat offal (Busari and Okanlawon, 2015). This was followed by the cost of labour for broilers (15.1%) and layers (11.3%). Costs of medication for broiler farms (1.5%) and layer farms accounted for (1.7%) as percentages of the total costs. Costs of transportation for broiler and layer enterprises were 1.5% and 2.1%, respectively. The utility and other costs as percentages of total costs were 2.7% and 3.8% for broiler and layer enterprises, respectively.

Table 4. Costs and returns (₦) to broiler and layer enterprises (for one production cycle).

s/n	Items	Layer enterprise	Cost as % of TC	Broiler enterprise	Cost as % of TC
1	Foundation stock size	337 day-old chicks		304 day-old chicks	
a	Total revenue	2,050,997.00		432,000.00	
2	Variable cost				
i	Stocking	43,820.00	4.05	42,518.00	12.78
ii	Feeding	652,114.09	60.27	153,982.02	46.28
iii	Labour	121,954.80	11.27	50,138.92	15.07
iv	Medication	18,800.20	1.74	5,002.13	1.50
v	Transport	23,094.17	2.13	5,003.03	1.50
vi	Utility and other costs	40,742.93	3.77	9,034.05	2.72
b	Total variable cost	900,526.19	83.22	265,678.15	79.86
c	Gross margin	1,150,470.81		166,321.85	
3	Fixed costs				
i	Depreciation on cages	43,717.38	4.04	-	-
ii	Depreciation on building	91,733.60	8.48	51,045.60	15.34
iii	Depreciation on feeders/ drinkers	40,164.40	3.71	10,056.40	3.02
iv	Depreciation on other fixed inputs	5,919.10	0.55	5,919.10	1.78
d	Total fixed costs	181,534.48	16.78	67,021.10	6.19
e	Total costs	1,082,060.67		332,699.25	
f	Net farm income	968,936.33		99,300.75	
g	Rate of return on investment (₦)= f/e		0.90		0.30
h	Operating expense ratio (%) = b/a		44.00		61.00
i	Benefit-cost ratio = a/e		1.90		1.30
j	Profit margin % = f/a		47.24		22.99

Source: Field survey, 2018.

Table 4 indicates that the total revenues of ₦432,000 and ₦2,050,997 were earned by average small-scale broiler and layer farmers, respectively. The analysis further showed that the net farm incomes received by average small-scale broiler and layer farmers were ₦99,300.75 and ₦968,936.33, respectively. All the profitability ratios confirmed that the small-scale layer enterprise was more profitable compared to the broiler enterprise (Table 4). The profit margin percentage of the layer enterprise was higher (47.2%) compared to 22.9 per cent of the broiler enterprise. This is in agreement with Bamiro (2008) who asserted that the egg production enterprise recorded a higher gross margin while the broiler production enterprise recorded a lower gross margin. Similarly, based on the submission by Memon et al. (2015), it was asserted that higher profit was observed in poultry egg farming in Quetta with a higher benefit-cost ratio compared to the broiler enterprise. The reason for the discrepancy in foundation stock sizes of the two enterprises is that layer farmers purchase more day-old chicks than broiler farmers in the study area.

Relative investment analysis for small-scale broiler and layer enterprises

Tables 5 and 6 present the results for the layer enterprise with a positive NPV of ₦1,523,692.6 and IRR of 64.9 per cent while the broiler enterprise showed a positive NPV of ₦961,173.3 with IRR of 63.0 per cent. The positive NPVs are indications that both enterprises were economically profitable for investment, but the layer enterprise was more economically viable with a higher NPV value and positive IRR compared to the broiler enterprise, hence, more attractive for investment. Similarly, the discounted payback period was estimated to reveal the number of years it took the small-scale poultry producers to pay back their initial investments. The result of the discounted payback period showed that the layer enterprise paid back its initial investment in one year, three months and one week while the broiler enterprise was able to pay back after two years and two weeks (Table 7). The layer enterprise was more attractive for investment than the broiler enterprise as it provided more naira in return on each naira that was invested (Tables 5 and 6). The broiler enterprise had the quickest income generation period and provided income at a specific short time interval, unlike the layer enterprise. Broilers took eight weeks to complete one production cycle and required just two weeks for cleaning and sanitation between successive cycles.

Table 5. The net present value and internal rate of return for the small-scale layer enterprise (with one production cycle).

Year	0 (₦)	1 (₦)	2 (₦)	3 (₦)	4 (₦)	5 (₦)	6 (₦)	7 (₦)
Cash inflows	-	892,498.50	1,158,498.50	998,498.50	1,162,698.50	967,538.82	1,168,426.30	1,062,432.15
Cash outflows	-	600,350.79	550,321.54	606,566.89	538,992.13	600,300.42	520,121.53	500,190.42
Net cash inflows	-	292,147.71	608,176.96	391,931.61	623,706.37	367,238.40	648,304.77	562,241.73
Initial investtment	(651,274.51)							
Discounted net cash flows	(651,274.51)	259,686.85	480,534.88	275,266.09	389,376.82	203,791.22	319,789.41	246,521.85
NPV	1,523,692.62							
IRR	64.96%							

Discount rate: 12.5%. Source: Field survey, 2018.

Table 6. The net present value and internal rate of return for the small-scale broiler enterprise (two production cycles).

Year	0 (₦)	1 (₦)	2 (₦)	3 (₦)	4 (₦)	5 (₦)	6 (₦)	7 (₦)
Cash inflows	-	864,000.00	870,000.00	895,036.00	885,456.00	899,342.00	909,000.00	936,000.00
Cash outflows	-	601,356.30	608,870.46	541,587.14	542,937.52	560,429.86	577,291.74	580,915.12
Net cash inflows	-	262,643.70	261,129.54	353,448.86	342,518.48	338,912.14	331,708.26	355,084.88
Initial investment	(448,068.69)							
Discounted net cash flows	(448,068.69)	233,461.07	206,324.57	248,238.43	213,832.61	188,072.16	163,621.79	155,691.36
NPV	961,173.30							
IRR	63.03%							

Discount rate: 12.5%. Source: Field survey, 2018.

Table 7. The relative discounted payback period for small-scale broiler and layer enterprises.

	Discounted cash flows			Discounted payback period		Post payback cash inflow
Enterprises	0 (₦)	1 (₦)	2 (₦)	3 (₦)	4 (₦)	(₦)
Layers	(651,274.51)	259,686.85	480,534.88	-	1 year, 3 months, 1 week	88,947.22
Broilers	(448,068.69)	233,461.07	206,324.57	248,238.43	2 years, 2 weeks	239,955.38

Discount rate: 12.5%. Source: Field survey, 2018.

In contrast, layers took a minimum of 24 weeks before stable income began and the layer enterprise provided steady and continuous cash inflows that lasted for 34 to 70 weeks in one production cycle. Cash inflows were obtained from two production cycles of broiler production (Table 6). On the other hand, layer enterprise provided cash inflows from two streams: eggs and sales of spent hens. It was evident that layer production commanded high cash inflow in the second year compared to the first year. This could be attributed to the fact that the layer enterprise generated the revenue from egg production in the first period, while the revenue in the second period comprised eggs and culled hen sales (Table 5). Since the layer enterprise is more attractive in terms of economic profitability than the broiler enterprise in Osun State, this could be seen as a possible explanation as to why small-scale producers prefer investing in layers than in broilers. Farmers only engage in small-scale broiler enterprises because of the quick cash inflow, lower initial investment, cash outlay and lower feed cost per production cycle. However, a daily income is preferred from layer to broiler enterprise when the hens are due for laying eggs. These findings contradict Mwansa (2013) who claimed that the small-scale broiler enterprise was found to be more attractive for investment than the small-scale layer enterprise as indicated by the results of the NPVs and IRRs. This was the scenario in Zambia, which contradicted the results obtained from Nigeria. However, both countries were built on different economic frameworks such as interest rate, inflation rate, openness, marketing of poultry products and exchange rate.

Conclusion

In general terms, the study has indicated that there are greater potentials for improvement in small-scale broiler and layer enterprises in the study area. It was concluded that small-scale layer enterprises require higher start-up capital investment as well as running capital compared to the small-scale broiler enterprises. Moreover, in terms of returns, layer enterprises promise high percentages of returns with a reasonable return on investment compared to broiler enterprises. However, the production of broilers at the small-scale level tends to exhibit higher short-run return compared to layer production. Furthermore, net present worth for small-scale broiler enterprises was lesser than for small-scale layer enterprises. The total cost involved in layer production was relatively higher compared to broiler production, although in the long run layers yield higher returns than broilers. The cost of feeding was the major component of variable costs for both broilers and layers. The cost of feeding constituted more than the average of total production cost for the layer enterprise and about the average for the broiler enterprise. Given all these, the small-scale layer enterprise is more economically profitable compared to the small-scale broiler enterprise in terms of NPV, IRR and discounted payback period.

References

Adepoju, A.A. (2008). Technical Efficiency of Egg Production in Osun State. *International Journal of Agricultural Economics and rural development, 1* (1), 7-14.

Adeyemo, A.A., & Onikoyi, M.P. (2012). Prospects and Challenges of Large Scale Commercial Poultry Production in Nigeria. *Agricultural Journal*, *7* (6), 388-393.

Ahmad, I.M., & Kiresur, V.R. (2016). Demand and Supply of Livestock Products in India and Nigeria: The Task of Food Security. *International Journal of Innovative Research and Development*, *5* (6), 102-142.

Anang, B.T., Yeboah, C., & Agbolosu, A.A. (2013). Profitability of Broiler and Layer Production in the Brong Ahafo Region of Ghana. *ARPN Journal of Agric. Biological Science, 8* (5), 423-430.

Bamiro, O.M. (2008). Economic Performance of Commercial Poultry Farms in Oyo State Nigeria. *International Journal of Poultry Science*, *7* (11), 1117-1121.

BBC (2008). British Broadcasting Corporation Weather Centre, Britain, Europe.

Busari, A.O., & Okanlawon, I.N. (2015). Economic Appraisal of Small and Medium Scale Poultry Egg Production in Ife and Ilesha Metropolis, Osun State, Nigeria. *Turkish Journal of Agriculture - Food Science and Technology*, *3* (7), 562-565.

Deji, S.A. (2012). Awareness of Pesticide Residues in Locally Available Food and Condiments among Food Sellers: A case study of Osun State, Nigeria. *Journal of Public Health in Africa, 3* (2), 26.

Ekunwe, P.A., & Soniregun, O.O. (2007). Profitability and Constraints of Medium Scale Battery Cage System of Poultry Egg Production in Edo State, Nigeria. *International Journal of Poultry Science*, *6* (2), 118-121.

Ike, P.C., & Ugwumba, C.O.A. (2011). Profitability of Small Scale Broiler Production in Onitsha North local government area of Anambra State, Nigeria. *International Journal of Poultry Science*, *10* (2), 106-109.

James, W. (2013). Investment Analysis in WikiCFO Houston, TX 77005. Retrived from https://strategiccfo.com/investment-analysis/.

Kabir, F., & Haque, T. (2010). Study on the Production Performance of Isa-Brown strain at Krishibid firm LTD. Trishal Mymensingh. *Bangladesh Research Publication Journal, 3* (3), 1039-1044.

Mahama, E.A., Andah, E.K., Amegashie, D.P.K., & Mensah-Bonsu, A. (2013). Break Even Analysis of Broiler Production in the Accra-Tema and Kumasi Areas. *European Scientific Journal, ESJ*, *9* (21), 320-350.

Memon, I.N., Noonari, S., Asif, M., Shah, S.T., Peerzado, M.B., Panhwar, G.M., & Jamro, A.S. (2015). Economic Analysis of Poultry Egg Production in Quetta District Balochistan. *Journal of Fisheries and Livestock Production*, *3* (3), 215-220.

Mwansa, S. (2013). *Comparative Investment Analysis for Small Scale Broiler and Layer Enterprises in Zambia.* M.Sc dissertation, Kansas State University.

Ohajinya, D.O., Mgbada, J.U., Onu, P.N., Enyia, C.O., Henri-Ukoha, A., Ben-Chendo, N.G., & Godson-Ibeji, C.C. (2013). Technical and Economic Efficiencies in Poultry Production in Imo State, Nigeria, *American Journal of Experimental Agriculture*, *3* (4), 927-938.

Okonkwo, E.N. (2016). *Entry-Level Skills Needed in Poultry Production by Senior Secondary School Final Year Students of Agricultural Science in Aguata, Agricultural Zones of Anambra State* Doctoral dissertation. University of Nigeria, Nsukka.

Oladeebo, J.O., & Ojo, S.O. (2012). Economic Appraisal of Small and Medium Scale Performance in Poultry Egg Production in Ogun State, Nigeria. *African Journal of Agriculture, 7* (37), 170-174.

Olasunkanmi, M.B. (2008). Economic Performance of Commercial Poultry Farms in Oyo State Nigeria. *International Journal of Poultry Science, 7* (11), 1117-1120.

Olufemi, A.Y., & Adeolu, B.A. (2013). Economic Analysis of Factors Affecting the Profitability of Broiler Processing in South western Nigeria. *Learning Publics Journal of Agriculture and Environmental Studies*, *3* (2), 1-19.

Omodele, T., & Okere, I.A. (2014). GIS Application in Poultry Production: Identification of Layers as the major Commercial Product of the Poultry Sector in Nigeria. *Livestock Research for Rural Development*, *26* (7), 1-7.

Pawariya, V., & Jheeba, S.S. (2015). Economic Analysis of Costs-Return, Income and Employment in Poultry Enterprise in Jaipur District of Rajasthan State. *International Journal of Agricultural Science and Research* (*Ijasr*), *5* (1), 203-215.

Tanko, L., & AJi, D.A. (2014). Comparative Analysis of Economic Efficiency of Broiler and Egg Production Enterprises in Niger State, Nigeria. *Proceedings of the Nigeria Association of Agricultural Economics held at the Federal University of Technology* (pp. 170-180). Akure, *Nigeria.*

Taru, V.B., Nkwi, G.E, Medugu, A.I., & Reuben, J. (2010). Economics of Broiler Production in Meme Division of Cameroon. *Agricultural Science journal*, *1* (2), 83-87.

Van Veenhuizen, R., & Danso, G. (2007). *Profitability and Sustainability of Urban and Periurban Agriculture 19*. Food and Agriculture Org. International Water Management Institute (IWMI), Ghana.

Received: November 18, 2018
Accepted: July 29, 2019

UPOREDNA INVESTICIONA ANALIZA ZA MALE PROIZVOĐAČE BROJLERA I JAJA U DRŽAVI OSUN, NIGERIJA

Isiaka O. Baruwa i Ololade A. Fabode*

Odsek za agroekonomiju, Univerzitet Obafemi Awolowo, Ile-Ife, Nigerija

R e z i m e

Ovom studijom se istražuju struktura ulaganja, troškovi i struktura primanja kod proizvodnje jaja i brojlera u Državi Osun u Nigeriji. Upoređuje se takođe njihova neto sadašnja vrednost u ispitivanoj oblasti, kako bi se utvrdili efekti investiranja. Za odabir ispitanika za istraživanje korišćena je tehnika višefaznog uzorkovanja. Primarni podaci su prikupljeni sa 180 farmi za proizvodnju brojlera i jaja, obuhvatalući 90 farmi brojlera i 90 farmi za proizvodnju jaja iz šest lokalnih samouprava u Državi Osun korišćenjem strukturiranog upitnika. Podaci su analizirani korišćenjem deskriptivne statistike, metoda kalkulacija i metoda za ocenu investicija. Obračun ulaganja je pokazao da je veća količina novca uložena u osnovna sredstva kod malih proizvođača jaja (₦651.274,5) nego kod proizvođača brojlera (₦448.068,6). Lična štednja je bila glavni izvor finansiranja kod malih proizvođača jaja u poređenju sa proizvođačima brojlera. Pored toga, mogućnost reinvestiranja kod proizvođača jaja uglavnom zavisi od sredstava članova porodice, dok kod proizvodnje brojlera zavisi od akumulacije. Kalkulacije po varijabilnim troškovima su pokazale da je bruto marža poljoprivrednika ₦166.321,8 odnosno ₦1.150.470,8 za proizvodnju brojlera odnosno jaja. Investiciona analiza je pokazala da proizvodnja jaja ima višu pozitivnu neto sadašnju vrednost (engl. *net present value – NPV*) i vrednost interne stope rentabilnosti (engl. *internal rate of return – IRR*) od ₦1.523.692,6 odnosno 64,9%. Nasuprot tome, proizvodnja brojlera imala je niže pozitivne vrednosti *NPV* i *IRR* od ₦961.173,3 odnosno 63,0%. Istraživanjem se zaključuje da je proizvodnja jaja kod malih proizvođača ekonomski isplativija u poređenju sa proizvodnjom brojlera sa višim vrednostima *NPV* i *IRR* i kraćim dinamičkim rokom povraćaja u Državi Osun.

Ključne reči: brojleri, nosilje, *NPV*, *IRR*, dinamički rok povraćaja.

Primljeno: 18. novembra 2018.
Odobreno: 29. jula 2019.

*Autor za kontakt: e-mail: fabodeololade@gmail.com

Journal of Agricultural Sciences
Vol. 64, No. 3, 2019
Pages 293-302

https://doi.org/10.2298/JAS1903293T
UDC: 631.11:657(497.11)
Original scientific paper

UTICAJ VELIČINE PREDUZEĆA NA PROFITABILNOST POLJOPRIVREDNIH PREDUZEĆA U REPUBLICI SRBIJI

Stevan M. Tomašević[1*], Zoran D. Jović[2] i Sanja M. Vlaović Begović[1]

[1]Visoka poslovna škola strukovnih studija,
Vladimira Perića Valtera 4, 21000 Novi Sad, Srbija
[2]Univerzitet Singidunum, Danijelova 32, 11000 Beograd, Srbija

Sažetak: Veličina preduzeća je jedna od najbitnih determinanti profitabilnosti preduzeća. Pojedini domaći i brojni inostrani autori su pokušali da ukažu na uticaj koji veličina preduzeća ima na profitabilnost. Rezultati tih istraživanja su bili kontradiktorni, naime, neka istraživanja su pokazala da su veća preduzeća profitabilnija, neka da su manja preduzeća profitabilnija, a postoje i ona istraživanja koja su ukazala da veličina preduzeća nema uticaja na profitabilnost. Upravo ovi oprečni zaključci naveli su autore ovog rada da istraže uticaj veličine preduzeća na profitabilnost. U ovom istraživanju korišćeni su podaci iz redovnih finansijskih izveštaja za 121 poljoprivredno preduzeće za period od 2014. do 2017. godine. Kao mera profitabilnosti poljoprivrednih preduzeća korišćena je stopa prinosa na imovinu (engl. *return on assets – ROA),* dok je podatak o veličini svakog pojedinačnog preduzeća preuzet iz zvaničnih izveštaja ovih preduzeća shodno klasifikaciji prema Aktu o razvrstavanju preduzeća. Rezultati istraživanja su pokazali da su veća preduzeća profitabilnija u poređenju sa malim i srednjim preduzećima, ali da ta razlika u uspešnosti nije statistički značajna. Opšti je zaključak da veličina preduzeća nema statistički značajan uticaj na profitabilnost uzorkovanih poljoprivrednih preduzeća.

Ključne reči: poljoprivredna preduzeća, profitabilnost, stopa prinosa na imovinu, veličina preduzeća, Kruskal-Volisov test.

Uvod

Poljoprivredna preduzeća imaju veliki razvojni potencijal u domenu poljoprivredne proizvodnje zahvaljujući brojnim prirodnim pogodnostima. Poljoprivreda se može okvalifikovati kao specifičan sektor koji predstavlja važnu kariku u ostvarivanju strateške vizije razvoja privrede Srbije (Petrović-Ranđelović i Marjanović, 2010). Zajedno sa prehrambenom industrijom, poljoprivredni sektor, u strategiji privrednog razvoja Republike Srbije predstavlja stateški potencijal srpske

[*]Autor za kontakt: e-mail: stevan.tomasevic@vps.ns.ac.rs

privrede (Stošić i Domazet, 2014). Prema podacima Republičkog zavoda za statistiku poljoprivreda je učestvovala u bruto domaćem proizvodu u 2017. godini sa 7,3%.

S druge strane, primarnu poljoprivrednu proizvodnju i poslovanje poljoprivrednih preduzeća u Republici Srbiji odlikuju brojne specifičnosti koje se ogledaju u sezonskim aktivnostima, visokim proizvodnim troškovima, sporom obrtu kapitala i vezivanju sredstava na duži vremenski rok (Vuković et al., 2018). Takođe, finansiranje proizvodnje sopstvenim kapitalom otežava proces proizvodnje pošto se roba neće odmah realizovati po završetku procesa proizvodnje, čime se produžava vreme vezivanja finansijskih sredstava (Jakšić et al., 2011). Navedene specifičnosti poljoprivrede i problemi sa kojima se suočavaju poljoprivredna preduzeća mogu da imaju značajan uticaj na njihove poslovne performanse.

Utvrđivanje profitabilnosti kao opšte mere uspešnosti poslovanja preduzeća predstavlja jedan od najvažnijih zadataka kako vlasnika malih preduzeća, tako i menadžera velikih preduzeća. Profitabilnost predstavlja osnovni pokazatelj performansi koji meri uspešnost poslovanja preduzeća i doprinosi njegovoj boljoj reputaciji. Takođe, profitabilnost kao pokazatelj se koristi u cilju upoređivanja preduzeća iste ili slične delatnosti, ali i konkurentnosti celokupne privrede jedne zemlje, kao i u cilju preduzimanja određenih akcija radi poboljšanja poslovnih rezultata.

Da bi se pravilno procenila profitabilnost poslovanja nekog preduzeća, od posebne je važnosti izabrati adekvatne pokazatelje profitabilnosti. Najveći broj radova domaćih i inostranih autora se bazira na računovodstvenim pokazateljima profitabilnosti (stopa prinosa na imovinu – engl. *return on assets – ROA* i stopa prinosa na kapital – engl. *return on equity – ROE*), što je autore ovog rada podstaklo da primene upravo ove pokazatelje.

Takođe, mnogi istraživači su pokušali da identifikuju razloge zbog kojih su neka preduzeća profitabilnija u odnosu na neka druga. U tom pogledu treba imati u vidu kako faktore internog karaktera (mikroekonomske) tako i faktore eksternog karaktera (makroekonomske), ali i faktore koji su specifični za određenu privrednu granu. U ovom radu posebna pažnja će biti posvećena veličini preduzeća kao faktoru profitabilnosti posmatranih preduzeća, što ujedno predstavlja i predmet ovog istraživanja.

Vlasnici kapitala i menadžeri očekuju da njihovo preduzeće raste i postaje sve veće i značajnije u grani u kojoj posluje. Smatra se da veća preduzeća ostvaruju brojne prednosti u odnosu na mala preduzeća. Neke od tih prednosti se odnose na ekonomiju obima i veću pregovaračku moć. Na osnovu ove pretpostavke, može se zaključiti da su veća preduzeća profitabilnija u odnosu na manja (Knežević, 2015).

Pregledom dosadašnjih rezultata istraživanja možemo zaključiti da postoje različiti rezultati istraživanja u pogledu veze između veličine preduzeća i profitabilnosti. Neka od tih istraživanja pokazuju negativan uticaj, neka otkrivaju pozitivan uticaj, dok su neke studije istraživanja pokazale da uopšte ne postoji veza između veličine preduzeća i profitabilnosti.

Pozitivna i statistički značajna razlika između preduzeća prema veličini ukazuje da veća preduzeća ostvaruju veći profit, odnosno da su profitabilnija u poređenju sa manjim preduzećima. Denčić-Mihajlov je pokušala da istraži kako srednja i velika preduzeća koja se nalaze na Beogradskoj berzi upravljaju svojom profitabilnošću u periodu krize, odnosno od 2008. do 2011. godine. Zaključak do kog je došla je da veća i likvidnija preduzeća ostvaruju veću profitabilnost (Denčić-Mihajlov, 2014). Ozgulbas et al. su istraživali efekat koji veličina preduzeća ima na poslovne rezultate preduzeća. U svom istraživanju su obuhvatili 697 malih i srednjih preduzeća sa Istambulske berze u periodu od 2000. do 2005. godine i zaključili da veća preduzeća ostvaruju bolje poslovne rezultate od manjih preduzeća (Ozgulbas et al., 2006). Slično istraživanje sproveli su Isik i saradnici na primeru 112 proizvodnih preduzeća, koja su se kotirala na Istambulskoj berzi tokom perioda od 2005. do 2013. godine. Autori su zaključili da postoji statistički značajna pozitivna veza između veličine i profitabilnosti posmatranih preduzeća, odnosno da velika preduzeća imaju značajne prednosti u ovom pogledu u odnosu na manja preduzeća (Isik et al., 2017).

Goddard i saradnici su u svom radu pokušali da odrede determinante profitabilnosti proizvodnih i uslužnih preduzeća iz Belgije, Francuske, Italije i Velike Britanije za period od 1993. do 2001. godine. Ovi autori su utvrdili postojanje negativne i statistički značajne veze između profitabilnosti i veličine preduzeća. Zaključak do kojeg su došli odnosi se na činjenicu da preduzeća koja rastu, uglavnom imaju manju profitabilnost, ali da povećanje tržišnog udela utiče na veću profitabilnost preduzeća (Goddard, 2005). U istraživanju koje je sproveo Banchuenvijit analizirani su faktori koji utiču na uspešnost poslovanja preduzeća koja posluju u Vijetnamu. Rezultati ovog istraživanja ukazali su na negativnu vezu između veličine preduzeća merene ukupnom imovinom i profitabilnosti (Banchuenvijit, 2012).

Pored navedenih postoje i brojna istraživanja kojima se potvrdilo da ne postoji veza između veličine preduzeća i profitabilnosti odnosno da ta veza nije statistički značajna. Jonsson je analizirao odnos između veličine preduzeća i profitabilnosti na osnovu uzorka od 250 preduzeća na Islandu u periodu od 5 godina. Istraživanje je pokazalo da ne postoji statistički značajna veza između veličine i profitabilnosti preduzeća, bez obzira na pokazatelje kojima se mere profitabilnost ili veličina preduzeća (Jonsson, 2007). Takođe, istraživanje koje su sproveli Niresh i Velnampi na primeru 15 proizvodnih preduzeća koja su se kotirala na Kolombskoj berzi, ukazuje da veličina preduzeća merena logaritmom ukupne imovine i logaritmom ukupne prodaje nema značajan uticaj na profitabilnosti navedenih preduzeća u Šri Lanki (Niresh i Velnampy, 2014).

Materijal i metode

Prema saznanjima autora, u Republici Srbiji nisu rađena istraživanja vezana za uticaj veličine preduzeća na profitabilnost poljoprivrednih preduzeća odnosno utvrđivanje postojanja razlika između malih, srednjih i velikih poljoprivrednih preduzeća u pogledu profitabilnosti. Upravo zbog toga, ovaj rad ima za cilj da prikaže metodologiju utvrđivanja profitabilnosti putem stope prinosa na imovinu (ROA), te da se na osnovu ovog pokazatelja izvrši izračunavanje profitabilnosti. Dalje, autori teže da na bazi dobijenih rezultata utvrde da li postoje značajne razlike u profitabilnosti između malih, srednjih i velikih poljoprivrednih preduzeća i da li su te razlike statistički značajne.

Baza podataka na osnovu koje je izvršeno izračunavanje profitabilnosti odnosno stope prinosa na imovinu (ROA) čini 121 poljoprivredno preduzeće iz Republike Srbije (Sektor A: Poljoprivredna, šumarstvo i ribarstvo; Oblast 01 – Poljoprivredna proizvodnja), od kojih su 75 preduzeća organizovana kao društva sa ograničenom odgovornošću, 33 kao akcionarska društva i 13 preduzeća pripadaju zemljoradničkim zadrugama. Pri tome, od ukupnog broja pomenutih preduzeća 35 preduzeća pripada grupi malih preduzeća, 77 preduzeća pripada grupi srednjih preduzeća, a 9 pripada grupi velikih preduzeća.

Podaci korišćeni u ovom radu obezbeđeni su elektronskim prikupljanjem podataka o poslovanju poljoprivrednih preduzeća u Republici Srbiji. U procesu prikupljanja podataka autori su koristili redovne finansijske izveštaje preduzeća koje publikuje Agencija za privredne registre. U istraživanju su korišćeni godišnji Bilansi stanja i Bilansi uspeha za 121 poljoprivredno preduzeće za 2017, 2016. i 2015. godinu. Zahvaljujući zvaničnim šemama Bilansa stanja i Bilansa uspeha koje sadrže podatke i za tekuću i za prethodnu godinu, podaci o poslovanju preduzeća u 2014. godini preuzeti su iz finansijskih izveštaja za 2015. godinu.

Prilikom utvrđivanja profitabilnosti preduzeća korišćena je stopa prinosa na imovinu kao jedan od najznačajnijih i najčešće korišćenih pokazatelja. Profitabilnost imovine govori koliko je profita preduzeće sposobno da stvori na jedan dinar uložene imovine (Palepu et al., 2007) odnosno meri sposobnost preduzeća da koristi svoju imovinu za stvaranje profita (Gibson, 2011). Drugim rečima, ovaj racio pokazuje koliko profita preduzeće ostvaruje na svaki dinar angažovanih poslovnih sredstava. Stopa prinosa na imovinu (ROA) se izračunava na sledeći način:

$$\text{ROA} = \frac{\text{Neto dobitak ili neto gubitak}}{\text{Poslovna imovina}} \quad (1)$$

Podatak o veličini svakog pojedinačnog preduzeća preuzet je sa sajta Agencije za privredne registre, koja klasifikaciju preduzeća prema veličini vrši shodno Aktu o razvrstavanju preduzeća. Razvrstavanje preduzeća prema veličini vrši se u skladu sa kriterijumima i graničnim vrednostima iz člana 6. Zakona o računovodstvu. Privredna društva, zadruge, ustanove koje obavljaju delatnost radi sticanja dobiti, druga pravna lica i ogranci stranih pravnih lica se razvrstavaju na mikro, mala, srednja i velika preduzeća, u zavisnosti od prosečnog broja zaposlenih, poslovnog prihoda i prosečne vrednosti poslovne imovine.

U radu je primenjena neparametarska tehnika, odnosno Kruskal-Volisov test, kako bi se utvrdilo ne/postojanje statistički značajne razlike između profitabilnosti malih, srednjih i velikih poljoprivrednih preduzeća. Ova tehnika je primenjena jer dobijeni rezultati stope prinosa na imovinu ne zadovoljavaju pretpostavke na kojima se baziraju parametarske tehnike (npr. jednofaktorska analiza varijanse). Pri tom, deskriptivna statistička analiza i pomenuti test sprovedeni su primenom statističkog softvera SPSS 19.0.

Rezultati i diskusija

Specifičnosti primarne poljoprivredne proizvodnje i problemi navedeni u uvodnom delu rada sa kojima se suočavaju poljoprivredna preduzeća, kao i neadekvatne mere agrarne politike i nepovoljni i ograničeni kreditni uslovi za finansiranje poljoprivrede, mogu u značajnoj meri da utiču na uspešnost tj. profitabilnost koju će ostvariti posmatrana preduzeća.

Rezultati deskriptivne statistike (tabela 1) pokazuju da najveću stopu prinosa na imovinu imaju velika poljoprivredna preduzeća u poređenju sa malim i srednjim poljoprivrednim preduzećima. Naime, prosečna stopa prinosa na imovinu je kod velikih preduzeća u posmatranom periodu iznosila 3,706%, što je neznatno viša stopa od stope prinosa na imovinu koju su ostvarila mala preduzeća (3,518%) i srednja preduzeća (3,482%).

Pored uočenih razlika u kretanju stope prinosa na imovinu između poljoprivrednih preduzeća u posmatranom periodu, izuzetno je bitno ukazati na to da se zapaža variranje tj. odstupanje pojedinačnih vrednosti stope prinosa na imovinu od prosečne vrednosti ove stope (mereno standardnom devijacijom). Prema ovoj apsolutnoj meri varijacije, najveće odstupanje pojedinačnih vrednosti posmatranih poljoprivrednih preduzeća od prosečne vrednosti stope prinosa na imovinu javlja se kod velikih preduzeća (SD=6,249) u poređenju sa malim (SD=5,315) i srednjim preduzećima (SD=4,696).

Iako su ekstremne vrednosti stope prinosa na imovinu isključene pre sprovođenja statističkih analiza, nameće se potreba da se prilikom poređenja prosečne stope prinosa na imovinu (ROA) protumače i vrednosti 5% tzv. „očišćene aritmetičke sredine" (engl. *trimmed mean*). Na ovaj način se zanemaruje 5% donjih i gornjih slučajeva odnosno uticaj koji najniže i najviše vrednosti mogu da imaju na vrednosti prosečne stope prinosa na imovinu kod pojedinih poljoprivrednih preduzeća.

Ukoliko se pogledaju vrednosti „očišćene aritmetičke sredine” može se zaključiti da postoje razlike u odnosu na prethodno tumačenje. Naime, prema ovom pokazatelju najveću prosečnu stopu prinosa na imovinu imaju mala preduzeća (3,653%) u poređenju sa velikim (3,479%) i srednjim poljoprivrednim preduzećima (3,465%).

Tabela 1. Deskriptivna statistika.
Table 1. Descriptive statistics.

		Veličina preduzeća/ *Enterprise size*	Statistika/ *Statistics*	Standardna reška/ *Standard error*
Stopa prinosa na imovinu/*Return on assets*	1 malo	Aritmetička sredina	3,518209	,4508606
		„Očišćena aritmetička sredina”	3,653867	
		Medijana	2,617000	
		Varijansa	28,255	
		Standardna devijacija	5,3155682	
		Minimalna vrednost	-14,3468	
		Maksimalna vrednost	16,5100	
		Simetričnost	-,315	,206
		Spljoštenost	1,561	,408
	2 srednje	Aritmetička sredina	3,482641	,2711330
		„Očišćena aritmetička sredina”	3,465017	
		Medijana	2,985350	
		Varijansa	22,054	
		Standardna devijacija	4,6961610	
		Minimalna vrednost	-13,5997	
		Maksimalna vrednost	20,2706	
		Simetričnost	,095	,141
		Spljoštenost	2,405	,281
	3 veliko	Aritmetička sredina	3,706208	1,0415693
		„Očišćena aritmetička sredina”	3,479356	
		Medijana	2,883450	
		Varijansa	39,055	
		Standardna devijacija	6,2494159	
		Minimalna vrednost	-8,0453	
		Maksimalna vrednost	21,8391	
		Simetričnost	,636	,393
		Spljoštenost	1,193	,768

Izvor: Prikaz autora na osnovu SPSS.

Dakle, na osnovu tabele 1 može se uočiti da postoje mala odstupanja u prosečnoj stopi prinosa na imovinu između poljoprivrednih preduzeća prema njihovoj veličini. Postavlja se pitanje da li je razlika koja postoji između prosečnih stopa prinosa na imovinu malih, srednjih i velikih preduzeća statistički značajna.

Tabela 2. Test normalnosti raspodele.
Table 2. Tests of normality.

		Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Veličina/ *Size*	Statistika/ *Statistics*	Broj stepeni slobode/*df*	Signifikantnost/ *Significance*	Statistika/ *Statistics*	Broj stepeni slobode/*df*	Signifikantnost/ *Significance*
Stopa prinosa na imovinu/ *Return on assets*	1 malo	,167	139	,000	,939	139	,000
	2 srednje	,133	300	,000	,948	300	,000
	3 veliko	,108	36	,200*	,963	36	,259

Izvor: Prikaz autora na osnovu SPSS.

S obzirom na to da je test normalnosti raspodele prosečne stope prinosa na imovinu poljoprivrednih preduzeća pokazao da se hipoteza o normalnosti raspodele kod malih i srednjih preduzeća ne može prihvatiti (tabela 2, Kolmogorov-Smirnov, Sig<0,05), za sagledavanje postojanja statistički značajne razlike u nivou stope prinosa na imovinu između malih, srednjih i velikih poljoprivrednih preduzeća korišćen je Kruskal-Volisov test.

Tabela 3. Kruskal-Volis test.
Table 3. The Kruskal-Wallis test.

	Stopa prinosa na imovinu/*Return on assets*
Chi-Square	,136
Df	2
Asymp. Sig.	,934

Izvor: Prikaz autora na osnovu SPSS.

Rezultat Kruskal-Volisovog testa (tabela 3) pokazuje da razlika koja postoji između srednjih vrednosti stope prinosa na imovinu malih, srednjih i velikih poljoprivrednih preduzeća u posmatranom periodu nije statistički značajna (χ^2=0,136, Sig=0,934). Dakle, možemo zaključiti da su razlike u stopi prinosa na imovinu slučajne i da su medijane sve tri grupe preduzeća u posmatranom periodu jednake.

Zaključak

Pošto poljoprivreda u Srbiji, zahvaljujući brojnim pogodnostima kao što su geografski položaj, prirodna bogatstva i povoljni klimatski uslovi, ima veliki razvojni potencijal i mogućnost da postane osnova razvoja ekonomije naše zemlje, očekivalo bi se da preduzeća koja pripadaju ovoj grani privrede ostvaruju visoke stope profitabilnosti. Međutim, ostvarivanje visokih stopa profitabilnosti treba da bude cilj svakog preduzeća, bez obzira na njegovu veličinu, granu kojoj pripada, vlasništvo, zaduženost i ostale faktore koji utiču direktno ili indirektno na ostvarenje ovog cilja.

Upravo zbog navedenog značaja profitabilnosti, u ovom radu je izvršeno utvrđivanje profitabilnosti za 121 preduzeće koje pripada poljoprivrednom sektoru za period od 2014. do 2017. godine i uticaj koji veličina preduzeća može da ima na profitabilnost ovih preduzeća. Pri tome, neophodni podaci o veličini preduzeća su preuzeti na bazi utvrđene metodologije definisane Zakonom o računovodstvu i reviziji o načinu razvrstavanja preduzeća u Republici Srbiji. S druge strane, za utvrđivanje profitabilnosti upotrebljen je najčešće korišćen pokazatelj odnosno stopa prinosa na imovinu (ROA).

Istraživanjem se došlo do opšteg zaključka da postoji razlika u profitabilnosti između pojedinih poljoprivrednih preduzeća shodno njihovoj veličini. Najveću prosečnu stopu prinosa na imovinu (ROA) imala su velika preduzeća u poređenju sa malim i srednjim preduzećima. Takođe, istraživanje je pokazalo da i pored razlike koja postoji u profitabilnosti, ta razlika nije statistički značajna, te da su razlike u stopi prinosa na imovinu slučajne. Drugim rečima, veličina preduzeća nema statistički značajan uticaj na profitabilnost uzorkovanih preduzeća, što je u skladu sa istraživanjem koje je Jonsson sproveo 2007. godine na primeru islandskih preduzeća, i Niresh i Thirunavukkaras 2014. godine na primeru proizvodnih preduzeća iz Šri Lanke.

Navedeni zaključci se odnose samo na ovu delatnost i ne mogu se uzeti kao osnov za izvođenje istih zaključaka kada su u pitanju ostale delatnosti. Na ovom počiva i težnja da autori ovog rada u budućem periodu urade slično istraživanje kada su u pitanju i ostale delatnosti u Republici Srbiji, na osnovu čega će se moći izvesti zaključak o položaju poljoprivrede u poređenju sa ostalim delatnostima.

Literatura

Agencija za privredne registre Republike Srbije. Pretraga evidencije obveznika finansijskih izveštaja. Preuzeto sa http://www.apr.gov.rs/.

Banchuenvijit, W. (2012). *Determinants of firm performance of Vietnam listed companies.* Academic and Business Research Institute.

Gibson, C.H. (2011). *Financial Statement Analysis,* 12th edition. Canada: South-Western, Cengage Learning.

Goddard, J., Tavakoli, M., & Wilson, J.O.S. (2005). Determinants of profitability in European manufacturing and service: evidence from dynamic panel model. *Applied Financial Economics, 15* (18), 1269-1282.

Denčić-Mihajlov, K. (2014). Profitability during the financial crisis - evidence from the regulated capital market in Serbia. *South-Eastern Europe Journal of Economics, 12* (1), 7-33.

Isik, O., Unal, E.A., & Unal, Y. (2017). The effect of firm size on profitability: evidence from turkish manufacturing sector. *Journal of Business Economics and Finance, 6* (4), 301-308.

Jakšić, D., Vuković, B., & Mijić, K. (2011). Analiza finansijskog položaja poljoprivrednih preduzeća u Republici Srbiji. *Ekonomika poljoprivrede, 58* (1), 78-90.

Jonsson, B. (2007). Does the size matter? The relationship between size and profitability of Icelandic firms. *Bifröst Journal of Social Science, 1*, 43-55.

Knežević, A. (2015). *Primena panel modela u identifikovanju faktora uspešnosti poslovanja proizvodnih preduzeća* (Doktorska disertacija). Novi Sad: Univerzitet u Novom Sadu - Fakultet tehničkih nauka.

Niresh, J.A., & Velnampy, T. (2014). Firm Size and Profitability: A Study of Listed Manufacturing Firms in Sri Lanka. *International Journal of Business and Management, 9* (4), 57-64.

Ozgulbas, N., Koyuncugil, A.S., & Yilmaz, F. (2006). Identifying the effect of firm size on financial performance of SMEs. *The Business Review, Cambridge, 6* (1), 162-167.

Palepu, K.G., Healy, P.M., Bernard, V.L., & Peek, E. (2007). *Business Analysis and Valuation: IFRS Edition - Test and Cases.* London: Thomson Learning.

Petrović-Ranđelović, M., & Marjanović, B. (2010). The Main Trends and Prospects of the Agricultural Development in Serbia. *Facta Universitatis, Series: Economics and Organization, 7* (4), 373-384.

Republički zavod za statistiku Republike Srbije. Godišnji nacionalni računi. Preuzeto sa http://www.stat.gov.rs/

Stošić, I., & Domazet, I. (2014). Analiza konkurentnosti poslovanja i potencijali rasta privrede Srbije u period svetske krize. *TEME: časopis za društvenu teoriju i praksu, 38* (2), 491-506.

Vuković, B., Pjanić, M., & Kalaš, B. (2018). Analiza likvidnosti poljoprivrednih preduzeća AP Vojvodine. *Anali Ekonomskog fakulteta u Subotici, 54* (39), 205-217.

Zakon o računovodstvu. *Sl. Glasnik RS*, br. 62/2013 i 30/2018.

Primljeno: 8. maja 2019.
Odobreno: 25. jula 2019.

THE IMPACT OF ENTERPRISE SIZE ON THE PROFITABILITY OF AGRICULTURAL ENTERPRISES IN THE REPUBLIC OF SERBIA

Stevan M. Tomašević[1*], Zoran D. Jović[2] and Sanja M. Vlaović Begović[1]

[1]Novi Sad School of Business, Vladimira Perića Valtera 4, 21000 Novi Sad, Serbia
[2]Singidunum University, Danijelova 32, 11000 Belgrade, Serbia

A b s t r a c t

The size of the enterprise is one of the most important determinants of the profitability of the enterprise. Some domestic and numerous foreign authors have tried to point out the impact that the size of the enterprise has on profitability. The results of these surveys have been contradictory, namely, some surveys have shown that larger enterprises are more profitable, some that smaller enterprises are more profitable, and some studies have indicated that the size of the enterprise has no impact on profitability. These contradictory conclusions led the authors of this paper to investigate the impact of enterprise size on profitability. This survey used data from regular financial statements for 121 agricultural enterprises for the period from 2014 to 2017. The rate of return on assets (ROA) was used as a measure of the profitability of agricultural enterprises, while the size of each enterprise was taken from the official statements of these enterprises according to the Company Classification Act. The results of the research have shown that larger enterprises were more profitable compared to small and medium-sized enterprises, but that this difference in performance was not statistically significant. It is a general conclusion that the size of the enterprise does not have a statistically significant impact on the profitability of the sampled agricultural enterprises.

Key words: agricultural enterprises, profitability, return on assets (ROA), enterprise size, the Kruskal-Wallis test.

Received: May 8, 2019
Accepted: July 25, 2019

[*]Corresponding author: e-mail: stevan.tomasevic@vps.ns.ac.rs

Journal of Agricultural Sciences
Vol. 64, No. 3, 2019
Pages 303-317

https://doi.org/10.2298/JAS1903303O
UDC: 633.15-211.2(669)
Original scientific paper

WHAT IMPACT DOES THE ADOPTION OF DROUGHT-TOLERANT MAIZE FOR AFRICA HAVE ON THE YIELD AND POVERTY STATUS OF FARMERS IN THE ARID REGION OF NIGERIA?

Oluwakemi A. Obayelu[1*], Oluwatomi M. Fakolujo[1] and Bola A. Awotide[2]

[1]Department of Agricultural Economics, University of Ibadan, Ibadan
[2]International Institute of Tropical Agriculture (IITA), Ibadan

Abstract: Maize production in Nigeria has not been able to meet the needs of people owing to drought, low productivity and lack of access to improved varieties by the farmers. Increased agricultural yield is a potential means for increasing household income, which tends to lower the poverty status of small-holder farmers. This study assessed the impact of Drought-Tolerant Maize for Africa (DTMA) on the yield and poverty status of farmers in the northwestern region of Nigeria. The study used the dataset from Adoption of DTMA Survey by the International Institute of Tropical Agriculture (IITA), Ibadan, with 293 respondents from northwestern Nigeria (90 adopters and 203 non-adopters of DTMA). Data were analysed using descriptive statistics, binary regression and propensity score matching methods. Results showed that small-holder farmers were more likely to adopt DTMA than bigger farms. Adopters had an increase in DTMA yield of 9,262.77kg/ha while the counterfactual non-adopters had an increase of 3,807.74kg/ha. The adoption of DTMA reduced the probability of being poor by 60 percent for the treatment group while poverty incidence was reduced by 35% among the non-adopters. The general conclusion is that DTMA adoption program improved maize yield and reduced poverty incidence among rural households.

Key words: DTMA, poverty, Sudan savannah, propensity score matching, northwestern Nigeria.

Introduction

Maize is the major staple food and feed in sub-Saharan Africa (Elbehri et al., 2013; Macauley, 2015). However, drought is a major challenge to maize production in northern Nigeria given the increasing evidence of climate change (Ogunlade et al., 2010). Despite the great potential of Nigeria in cereal production, the frequent occurrence of drought (more moisture loss from soil surface and fewer precipitation water supplies to soil) occasioned by erratic rainfall distribution

*Corresponding author: e-mail: jkemmyade@yahoo.co.uk

and/or cessation of rain during the growing season is the greatest hindrance to increased production and productivity (Khand et al., 2017). Drought reduces crop yield (Ray et al., 2018), which discourages farmers. Until recently, low productivity of maize could be attributed to the continuous use of traditional varieties which are characterized by low yield and a long maturing period hence easily susceptible to diseases and drought (Awotide et al., 2012). However, increased agricultural productivity has been identified as a potential means for improving the availability of food for household members as well as increasing income and consequently lowering the poverty status among small-holder farmers (Gordon, 2000; Manda et al., 2015).

The average yield of maize in Nigeria declined from < 1.7metric tonnes/ha in 2016 to 1.5metric tonnes/ha in 2017 below Africa (2.17metric tonnes/ha) and the global averages (5.7 metric tonnes/ha) in 2017 (FAOSTAT). This may be attributed to the fact that maize production is largely rain-fed in Nigeria, characterized by irregular rainfall that tends to result in drought. Furthermore, maize production has not been able to fill the demand and supply gap owing to the level of adoption of improved varieties by the farmers despite the introduction of improved varieties (Elbehri et al., 2013). However, improved maize seeds that will only improve yield without drought resistance may not yield an expected outcome under rain-fed agricultural production, especially in the arid regions. Thus, owing to the increasing demand as a result of population increase, there is a need to increase the production of maize to meet the soaring demand of the growing population through the introduction of improved maize varieties. Hence, the introduction of high-yielding varieties which mature quickly and are less susceptible to diseases will increase maize yield. The Drought Tolerant Maize for Africa (DTMA) which was developed with a unique feature of being drought resistant was funded by the Bill and Melinda Gates Foundation to tackle the menace of low productivity and reduce the poverty level amidst small-holder farmers (Awotide et al., 2016). However, the aim of introducing or convincing the farmers to adopt agricultural technology has not been achieved due to their continuous use of traditional varieties. Adoption of DTMA by farmers is determined by several socioeconomic and demographic factors.

The majority of the poor in Nigeria are living in rural areas and they are mainly farmers (Obayelu and Awoyemi, 2010; NBS, 2015). Increasing technology adoption such as new agricultural practices and high-yielding varieties has the potential to contribute to economic growth and poverty reduction among the poor (Kelsey, 2011). A major way to achieve the objectives of the Sustainable Development Goals of eradicating extreme poverty and hunger is by increasing agricultural productivity through yield-increasing technologies in order to sustain food self-sufficiency (Melesse, 2015). In addition, studies have shown that a high measure of improvement can be attained if farmers are properly informed and aware of improved technologies that are available (Ibrahim et al., 2012). These improvements have attractive attributes such as higher yield, shorter maturing period and low susceptibility to diseases, with increased productivity and enhancement of quality of harvested crops. Increased productivity will over time increase farmers' income from the sales of produce, thereby reducing the level of vulnerability to poverty. It can, therefore, be concluded that the uses of improved varieties are keys in the realization of increased agricultural productivity and in raising the standard of living of the farming population (Adenuga et al., 2014).

This study aims to contribute to the existing literature by providing a new perspective on the impact of drought-tolerant maize varieties on productivity and poverty status of farmers in the northwestern region of Nigeria. The specific objectives were to identify the factors influencing the adoption of DTMA and estimate the impact of adoption on the yield of maize and poverty incidence of farmers in arid northwestern Nigeria.

Material and Methods

The survey of Drought-Tolerant Maize for Africa was conducted in Nigeria from November 2014 to February 2015 by the International Institute of Tropical Agriculture (IITA), Ibadan, Nigeria. For the purpose of this study, data for northwestern Nigeria (NW) was extracted from the whole data set. Zamfara and Kaduna states were the selected states, which represented the northwestern region of the country in the survey. The vegetation cover for the study area is the Sudan savannah, characterized by scattered short trees, shrubs and grasses. The climate is tropical with an annual temperature of 25.2^0C and about 1211mm of precipitation annually. Both states are involved in agriculture as the mainstay of the economy and produce similar crops which include cotton, groundnut, tobacco, maize, beans, guinea corn, millet, rice. These states were purposively selected due to the implementation of the DTMA project there. The data set for northwestern Nigeria comprises 293 respondents (90 adopters and 203 non-adopters of DTMA varieties). The structure of the data collection instrument suggests that key variables for the proposed study were adequately covered.

The logit regression was used to identify factors influencing the adoption of DTMA while the propensity score matching was used to assess the impact of the adoption of DTMA on the poverty status of the households. The main steps involved in the application of statistical matching to impact evaluation were: estimating the propensity score, matching the unit using the propensity score, assessing the quality of the match and estimating the impact and its standard error. The core characteristic of the matching procedure is the establishment of the conditions of a randomised experiment, in order to evaluate a causal effect as in a controlled experiment. To achieve this, we need the conditional independence assumption, which states that technology selection is random and uncorrelated with outcomes (yield and poverty incidence) (Mendola, 2007). To examine the impact of DTMA adoption on the yield and poverty status of the farmers in the study area, kernel propensity score matching was used to check whether there was a statistical difference between the means of the matched variables and the average treatment effect. The propensity score is a probability which is the interval (0, 1) (Table 1). Therefore, the independent variables had an average effect of 32% on the probability of farmers adopting the DTMA indicating that the population had 32% chance of adopting DTMA with respect to the outcome variable (yield and poverty).

Table 1. Summary statistics of the propensity score matching.

Variable	Observation	Mean	Standard deviation	Minimum	Maximum
Propensity score	293	0.3159	0.2378	0.0047	0.9765

Source: Author's computation (2017)

Furthermore, the common support graph gives a clearer picture of the similarities in characteristics between the treatment and control groups (adopters and non-adopters). The common support graph finds the matches from the comparison group so that the measured cofounders can be equally distributed between treatment and control groups. The graph further helps to improve the precision of estimates of treatment effects. The importance of the common support graph is to improve the quality of the match by ensuring that matches are formed only when the distribution of the density of the propensity scores overlaps adopter and non-adopter observations (Heckman et al., 1999). This test further ensures effectiveness as it gives a visual presentation of the density distribution of the treated and control cases indicating the existence of substantial overlap in the density distribution of the estimated propensity scores of the adopters and non-adopters, thereby satisfying the common support condition. Figure 1 shows the distribution of the propensity scores and the region of common support between the adopters (upper portion) and the non-adopters (lower portion). It revealed the bias in the distribution of the propensity scores between the adopters and non-adopters, and clearly suggested the significance of proper matching and the imposition of the common support condition to avoid bad matches. In addition, it is evident from this graph that there was a good match as there were no variables lying outside the 0–1 region. This implies that the respondents (adopters and non-adopters) in this study had unique characteristics making the match overlap without exceeding the range of values.

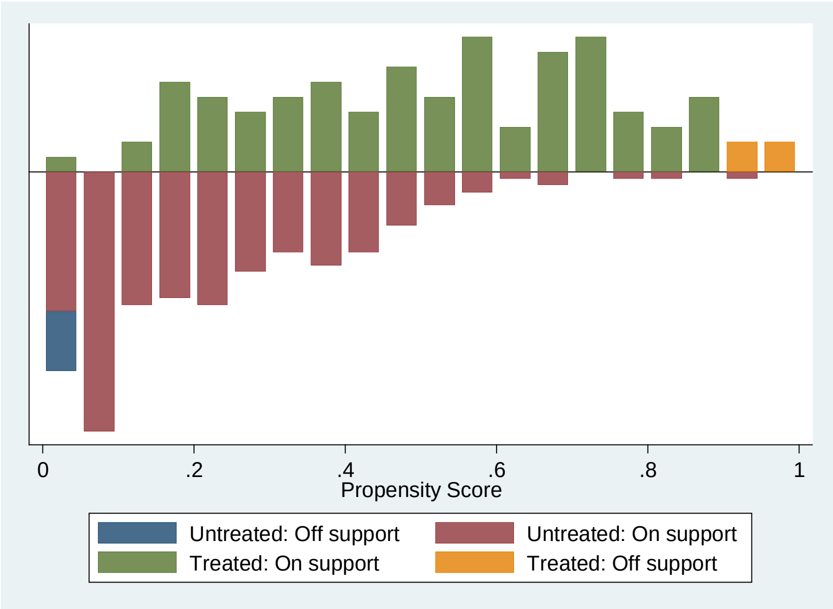

Figure 1. A common support graph for propensity score estimation.

The propensity scores of adopters and non-adopters (treated and untreated) further showed that 96% of the respondents' profiles were matched while 4% of the profiles were dropped (Table 2) suggesting the fitness of the model.

Table 2. The propensity score matching outcome.

Treatment assignment	Off support	On support	Total
Treated	3	87	90
Untreated	10	193	203
Total	13	280	293

Source: Author's computation (2017).

The impact of treatment for a farmer *j*, denoted *δj*, is defined as the difference between the potential outcome in case of the treatment and the potential outcome in the absence of the treatment:

$$\delta j = Y_1 j - Y_0 j \qquad (1)$$

In general, an evaluation seeks to estimate the mean impact of adoption which is obtained by averaging the impact across all the individuals in the population. This parameter is known as an Average Treatment Effect **(**ATE**)**:

$$ATE = E\,(\delta) = E\,(Y_1 - Y_0) \qquad (2)$$

where *E*(.) represents the average (or the *expected value*).

To further measure the impact of adoption on individuals who participated, the Average Treatment Effect on the Treated **(**ATT**)** was employed:

$$ATT = E\,(Y_1 - Y_0 \mid D = 1) \quad (3)$$

Finally, the Average Treatment Effect on the Untreated **(**ATU**)** measures the impact the adoption program would have had on those who did not participate:

$$ATU = E\,(Y_1 - Y_0 \mid D = 0) \quad (4)$$

The ATT which is used to determine the impact on the adopters was employed since we aimed to determine the impact of DTMA adoption on the productivity and poverty status of the farmers and this can be written as:

$$ATT = E\,(Y_1 \mid D = 1) - E\,(Y_0 \mid D = 1) \quad (5)$$

where $E\,(Y_0 \mid D = 1)$ is the average outcome that the treated individuals (adopters) would have obtained in the absence of treatment (adoption) and $E(Y_0 \mid D = 0)$ i.e. the value of the Y_0 for the non-adopters. From this, we can, therefore, calculate Δ as:

$$\Delta = E\,(Y_1 \mid D = 1) - E\,(Y_0 \mid D = 0) \quad (6)$$

The difference between Δ and the ATT is such that the term E (Y0 | D =1) is added and subtracted:

$$\Delta = E\,(Y_1 \mid D = 1) - E\,(Y_0 \mid D = 1) + E\,(Y_0 \mid D = 1) - E\,(Y_0 \mid D = 0) \quad (7)$$

$$\Delta = ATT + E\,(Y_0 \mid D = 1) - E\,(Y_0 \mid D = 0) \quad (8)$$

$$\Delta = ATT + SB \quad (9)$$

The term SB is the selection bias which is the difference between the counterfactual for adopters and the observed outcome for the non-adopters.

The simulation-based sensitivity analysis was done to determine whether an unobserved confounding binary variable could cause the ATT estimate to be zero or not under the assumption that this variable simultaneously affects a treatment assignment and the outcome variable (Nannicini, 2007). However, the sensitivity of the estimated results with respect to a hidden bias would indicate that the results are not robust (Caliendo and Kopeinig, 2008).

The Rosenbaum method of sensitivity analysis relies on the sensitivity parameter gamma (Γ) that measures the degree of departure from the random assignment of the treatment. Two subjects with the same observed characteristics may differ in the odds of receiving the treatment by at most a factor of Γ. In a randomized experiment, the randomization of the treatment ensures that $\Gamma = 1$. In an observational study, if $\Gamma = 2$, and two subjects are identical on the matched covariates, then one might be twice as likely as the other to receive the treatment because they differ in terms of an unobserved covariate (Rosenbaum, 2005).

Changes in the poverty level of DTMA adopters and non-adopters were measured using the Foster, Greer and Thorbecke (1984) classes of the poverty index (FGT) which include the Headcount Index (P_0), Poverty Gap Index (P_1) and Severe Poverty Index (P_2). These three indices can be compressed into one general formula and distinguish themselves with the different weights attributed to the distance between the expenditure of the poor and the poverty line. The P_0 attributes equal weight to all expenditure of the poor, while (P_1) and (P_2) attribute increasingly more weight to the distance of the expenditure of the poor from the poverty line. They are widely used because they are consistent and additively decomposable (Verme, 2003).

$$FGT_\alpha = \frac{1}{M}\sum_{i=1}^{r}\left(\frac{z - y_i}{z}\right)\alpha \tag{10}$$

where:

M = the total number of individuals in reference population;

r = the number of individuals below the poverty line;

z = the poverty line obtained as 2/3 mean per capita annual expenditure;

y_i = the annual per capita expenditure of the household i, and

α = degree of aversion (0, 1, 2).

In this study, we estimated the poverty incidence among adopters and non-adopters of DTMA in the study area (that is, α = 0).

Results and Discussion

There was a significant difference between the household sizes of adopters and non-adopters. This implied that the adopters had more household members than the non-adopters (Table 3). The means of the age and farm size of adopters were not significantly higher than those of non-adopters, while the means of the years of farming experience, years of education and distance to a seed source of non-adopters were not significantly higher than those of adopters.

Table 3. The difference in the means between continuous socio-economic characteristics of adopters and non-adopters.

Variables	Adopters		Non-adopters		t-value
	Mean	S.D.	Mean	S.D.	
Age	44.7	1.264	46.09	0.790	0.059
Household size	9.167	0.563	6.801	0.252	-4.446***
Years of farming experience	25.528	0.1.386	25.877	0.871	0.218
Years of education	8.122	0.644	8.710	0.487	0.680
Field size	5.593	0.460	5.210	0.361	-0.133
Distance (nearness) to a seed source	42.944	4.031	44.859	2.889	0.380

Source: Author's computation (2017). *** represents one percent level of significance.

Determinants of adoption of DTMA

The result of the logit model had a log-likelihood of -140.2772 and a Chi-square value of 71.60, which was significant ($p<0.01$) suggesting that the model has a strong explanatory power capable of jointly influencing the adoption of DTMA (Table 4). Nine variables were found to significantly influence the adoption of the DTMA in the study area. The age is expected to signify experience and sound judgment. A year increase in the age of the farmer increased the probability of adopting DTMA by 0.0319 unit. Thus, older farmers were more likely to adopt DTMA than younger ones and this is consistent with the finding of Etoundi and Dia (2008) and Ademiluyi (2014) on the adoption of improved maize varieties in Cameroon and Nigeria, respectively. Education was positively related to the adoption of DTMA. This suggests that a literate household head recognized the benefits of adoption to influence their productivity level. This is consistent with findings of Ersado et al. (2004) and Sewando et al. (2013), who have reported that educated household heads are more likely to adopt new and improved technologies as compared to the uneducated heads.

Proximity to the source of the DTMA seed increases the log-likelihood of a farmer adopting DTMA. The positive relationship further explains that an additional kilometer to the seed source will increase the probability of adoption by 0.0061 unit. It can be concluded that farmers whose homesteads were closer to the seed source were more likely to adopt DTMA than those whose households were farther away, which is an advantage to those closer to the seed source. This buttressed the findings of Idrisa et al. (2012) that distance to the technology source was positively related to the log-likelihood of adoption and the extent of adoption of improved soybean in Borno State, Nigeria.

Table 4. Determinants of DTMA adoption.

Variables	Coefficient	Standard error	Marginal effect	Standard error
Constant	-4.6443**	0.9188		
Gender	-0.5746	0.4122	-0.2098	0.1616
Age	0.0319***	0.0104	0.0104	0.0034
Education	0.0359***	0.0143	0.0117	0.0047
Marital status	0.1729	0.4145	0.0532	0.1205
Distance to a seed source	0.0189**	0.0084	0.0061	0.0028
Household size	-0.0389*	0.2225	-0.0126	0.0073
Farming experience	-0.0009	0.0098	-0.0003	0.0032
Farm size	-0.0365*	0.0201	-0.0118	0.0065
Access to credit	0.5501*	0.2945	0.1976	0.1136
Land ownership	1.0085***	0.5663	0.2252	0.0701
Member of a farmers' group	0.7410***	0.1892	0.2496	0.0651
Training on improved production practices	0.4380	0.6051	0.1578	0.2349
Awareness and access to seed	1.4680**	0.6549	0.5063	0.2109
Chi^2 = 71.60; Log-likelihood = -140.27717; Chi^2 = 71.60				

Source: Author's computation (2017). *, ** and *** represent 10%, 5% and 1% levels of significance, respectively.

Large household sizes may ensure an adequate supply of family labour for crop production and the adoption of improved agricultural technologies (Melesse, 2015). However, this study found that larger households may not adopt DTMA. Larger households had low per capita expenditure, were poor and could be cash-constrained to purchase improved seed. An additional member in the household decreased the log-likelihood of the adoption of DTMA by 0.0126 unit, which is in line with the finding of Audu et al. (2014) that household size was negatively related to the adoption of improved maize variety in Benue State, Nigeria. However, this is in contrast with the findings of Bamire et al. (2002) that household size was positively related to the adoption of improved technology. A unit increase in the farm size decreased the probability of adopting DTMA by 0.0118 unit. It, therefore, suggested that the majority of the small-holder farmers were more likely to adopt DTMA than bigger farms with irrigation technology. This finding is consistent with Adekoya et al. (2014) and Baruwa et al. (2015).

Access to credit was positively related to the decision of the farmer to adopt DTMA. This is because access to credit is a motivation for the farmer to produce more and corroborates the finding of Baruwa et al. (2015) that access to credit will increase the likelihood of adopting improved maize variety in Osun State, Nigeria. However, it is in contrast with the findings of Beke (2011) that access to credit had a negative significant effect on the adoption and use intensity of improved varieties in Ivory Coast. It can, therefore, be concluded that credit constraint will more likely reduce the likelihood of adoption of improved varieties because the farmers may not have sufficient income to encourage adoption.

Ownership of land increases the probability of a farmer adopting DTMA suggesting that ownership of land gives the farmer a high level of security on the land. Hence, farmers would want to acquire the land to increase maize productivity through adoption of DTMA. This corroborated the findings of Haliu et al. (2005) that land ownership significantly influenced the adoption of agricultural technologies in northern Ethiopia. Similarly, the interaction of the farmer between the time of awareness and access to seed positively influenced the adoption of DTMA. Thus, quick awareness and easy access to seed hastened the decision to adopt DTMA, which is consistent with the finding of Afolami et al. (2015) that a unit increase in access to improved cassava cutting within southwestern villages had a likelihood of increasing farmers' adoption of improved cassava varieties. Furthermore, being a member of a farmers' group positively influenced the decision of a farmer to adopt the DTMA variety. This further emphasized that a farmer in an association had a higher opportunity of adopting DTMA than those who were not members. In addition, membership of a group can provide easy access to farm inputs for the farmers, which is consistent with the findings of Onumadu and Osahon (2014) that membership of a group influenced the adoption of improved rice technologies in south-southern Nigeria.

The observed difference in the household expenditure and yield of adopters and non-adopters

The observed mean difference between adopters and non-adopters is presented in this section. The mean yield of maize and mean per capita household expenditure of adopters were significantly different from and higher than values for non-adopters (Table 5). However, there was no significant difference between the per capita food expenditure of both adopters and non-adopters.

Table 5. The difference in means between adopters and non-adopters.

Variables	Adopters	Non-adopters	Pooled	Difference	t-value
Per capita household expenditure	27762.44	23058.71	24503.54	-4703.73	-5.10***
Total household expenditure	558207.5	156086.1	279604.6	-402121.4	-2.05**
Yield of maize	13195.81	9530.24	10656.18	-3665.58	-1.81*
Per capita food expenditure	4601.99	2687.32	3281.53	-1914.68	-1.23
Per capita non-food expenditure	4144.74	1964.08	2640.83	-2180.67	-5.84***

Source: Author's computation (2017). *, ** and *** represent 10%, 5% and 1% levels of significance respectively.

The impact of the adoption of DTMA on the productivity and poverty status of maize farmers

To examine the impact of DTMA adoption on the yield and poverty status of the farmers in the study area, kernel propensity score matching was used to check whether there was the statistical difference between the means of the matched variables and the average treatment effect. The propensity score was a probability which is an interval (0, 1) (Table 6). The independent variables had an average effect of 32% on the probability of farmers adopting the DTMA, indicating the population had 32% chance of adopting DTMA with respect to the outcome variable (yield and poverty).

The adoption of DTMA had a significant treatment effect on the treated (t-statistic = 2.18), suggesting that there was a significant difference between the matched and the unmatched respondents. Thus, the adoption of DTMA increased the productivity of the adopters. The ATT measured the impact of the program on DTMA adopters and revealed an increase of 9,262.77kg/ha in productivity of adopters. The counterfactual outcome, ATU, measured the impact of adoption on those who did not adopt DTMA and indicated an increase of 3,807.74kg/ha. This implied that non-adopters would have had an increase of 3,807.7kg/ha in their productivity if they had adopted DTMA. The ATE on the entire population in the study area (i.e. picking any farmer at random) which measures the average impact across all respondents was 4,903.66kg/ha (Table 6).

Table 6. The impact of DTMA adoption on yield and poverty.

Variable	Sample	Treated	Control	Difference	t-test
Yield	Unmatched	13070.51	9036.19	4034.32	1.35
	ATT	13070.51	3807.74	9262.77	2.18**
	ATU	9036.19	12109.02	3072.83	
	ATE			4903.66	
Poverty incidence	Unmatched	0.3444	0.4778	-0.1334	-2.13**
	ATT	0.3444	0.9444	-6.0	-2.12**
	ATU	0.4778	0.1182	-0.3596	
	ATE			-0.4334	

Source: Author's computation (2017). *, ** and *** represent 10%, 5% and 1% levels of significance, respectively.

Furthermore, the adoption of DTMA reduced the probability of being poor by 60 percent for the treatment group (ATT) while the ATE implied that if DTMA was adopted, the poverty level of the farmer would reduce by 43 percent. The ATU indicated that the poverty level of the farmers was reduced by 35% among the non-adopters, corroborating the findings of Manale et al. (2010) that the adoption of improved groundnut varieties had a positive impact on the rural household poverty status in Uganda. In addition, there was a 12-fold increase in the difference between the unmatched and the treated (Table 6). These findings gave an evident positive impact of the adoption of DTMA on the poverty status of the farmers.

Table 7. Rosenbaum sensitivity analysis results.

Gamma (Γ)	sig+	sig-	t-hat+	t-hat-	CI+	CI-
1	0.373389	0.373389	494.4	494.4	-2352.7	3006.56
1.2	0.60218	0.182082	-344.5	1195.2	-3540	3962.5
1.4	0.774111	0.79655	-1115	1738.5	-4604.1	4768.44
1.6	0.881679	0.032365	-1603.5	2382.8	-5117.5	5827.78
1.8	0.941545	0.012489	-2281.8	2850.3	-6095.8	-
2	0.97234	0.004643	-2587.1	3414.2	-7338.3	7770.33
2.2	0.987329	0.00168	-3281.8	3716.4	-8314.1	9327.78
2.4	0.994337	0.000595	-3640	4053.6	-8867.9	14916
2.6	0.997518	0.000208	-4140.4	4500	-9666.7	17530.5
2.8	0.998929	0.000071	-4644.4	4802	-10048	18940
3	0.999543	0.000024	-4870.8	5290.3	-10891.8	19845

Source: Author's computation (2017). *Gamma = log odds of the differential assignment due to unobserved factors: sig+ = the upper bound significance level, sig- = the lower bound significance level, t-hat+ = the upper bound Hodges-Lehmann point estimate, t-hat- = the lower bound Hodges-Lehmann point estimate, CI+ = the upper bound confidence interval (a= 0.95), and CI- = the lower bound confidence interval (a= 0.95).

Results showed that for $\Gamma = 1$, the odds ratio of the treatment was the same for any two units matched on the same number of covariates (Table 7). The estimate was highly robust as Hodges-Lehmann point estimates encompassed zero at gamma=1.2. Thus, the DTMA adoption program had a positive treatment effect and estimates were almost free from unobserved covariates, thereby concluding that the overall results were remarkably robust and the analysis supported the robustness of the matching estimates.

Conclusion

The impact of the adoption of DTMA on the yield and poverty status of farmers in the northwestern region of Nigeria was assessed in the study. The adoption of DTMA was positively influenced by age of the farmer, years of education, land ownership, distance (nearness) to a seed source, awareness and access to seed, access to credit and membership of a farmers' group while it was negatively influenced by the farm size and household size. Thus, education and farming experience were found to determine the farmers' decision to adopt the DTMA. Hence, this emphasizes the importance of human capital development by ameliorating the farmers' access to agricultural knowledge, improved skills and gain more experience. Facilitating access to DTMA varieties by farmers would ensure higher maize yield for farmers and consequently reduce the incidence of poverty among them. For sustainable increased maize productivity and poverty reduction among farmers, the Nigerian government should review land-use decree and facilitate agricultural credit scheme to farmers in order to increase the level of land ownership by farmers and investment in large-scale DTMA production that will address the challenges facing agriculture's contribution to food security.

Acknowledgements

Authors are grateful to the International Institute of Tropical Agriculture for providing the data for the study.

References

Ademiluyi, I.O. (2014). Adoption of improved maize varieties among farmers in Bassa Local Government Area of Plateau State, Nigeria. *International Journal of Innovative Agriculture and Biology Research, 2* (4), 26-33.

Adenuga, A.H., Omotesho, O.A., Ojehomon, V.E.T., & Diagne, A. (2014). Determinants of adoption of improved rice varieties in selected Local Government Areas in Nasarawa State, Nigeria. *Ife Journal of Agriculture, 27,* 25-34.

Afolami, C.A., Obayelu, A.E., & Vaughan, I.I. (2015). Welfare impact of adoption of improved cassava varieties by rural households in South Western Nigeria. *Agricultural and Food Economics Journal, 3* (18), 1-17.

Aslam, M., Zamir, M.S.I., Afzal, I., Yaseen, M., Mubeen, M., & Shoaib, A. (2013). Drought stress, its effect on maize production and development of drought tolerance through potassium application. *Certari Agronomice in Moldova, 2* (58), 101-103.

Awotide, B.A., Abdoulaye, T., Alene, A.D., & Manyong, V.M. (2016). Adoption of drought tolerance maize varieties for Africa, productivity, food security and welfare in Nigeria: An ex-post impact assessment. Paper presented at CSAE 2016. Oxford University, United Kingdom.

Awotide, B.A., Diagne, A., & Omonona, B.T. (2012). Impact of improved agricultural technology adoption on sustainable rice productivity and rural farmers' welfare in Nigeria: A Local Average Treatment Effect (LATE) Technique. A paper Prepared for Presentation at the African Economic Conference. Kigali, Rwanda.

Beke, T.E. (2011). Institutional constraints and adoption of improved rice varieties: econometric evidence from Ivory Coast. *Review of Agricultural and Environmental Studies, 92* (2), 117-141.

Caliendo, M., & Kopeinig, S. (2008). Some practical guidance for the implementation of propensity score matching. *Journal of Economic Surveys*, *22* (1), 31-72.

Elbehri, A., Kaminski, J., Koroma, S., Iafrate, M., & Benali, M. (2013). West Africa food systems: An overview of trends and indicators of demand, supply, and competitiveness of staple food value chains, In: A. Elbehri (ed.), *Rebuilding West Africa's Food Potential*, FAO/IFAD.

Ersado, L., Amacher, G.S., & Alwang, J. (2004). Productivity and land enhancing technologies in northern Ethiopia: Health, public investments, and sequential adoption. *American Journal of Agricultural Economics*, *86* (2), 321-331.

Etoundi, S.M.N., & Dia, b. K. (2008). Determinants of the adoption of improved varieties of Maize in Cameroon: case of CMS 8704. *Proceedings of the African Economic Conference on "Globalisation, Institutions and African Economic Development"* (pp. 397-413). Tunis, Tunisia.

Foster, J., Greer, J., & Thorbecke, E. (1984). A class of decomposable poverty measures. *Econometrica, 52*, 761-766.

Gordon, A. (2000). Improving Smallholder access to purchased inputs in sub-Saharan Africa. Policy Series 7. Natural Resources Institute. University of Greenwich, London, UK. Available at: http://r4d.dfid.gov.uk/Output/55006/.

Heckman, J.J., LaLonde, R., & Smith, J., (1999). The Economics and Econometrics of Active Labor Market Programs. In O. Ashenfelter, & D. Card, (Eds.) *Handbook of Labor Economics*, *3,* (pp.1865-2097). Amsterdam: North-Holland.

IITA (2001). *International Institute of Tropical Agriculture,* Ibadan, Oyo State. Annual Report on Maize Production.

Khand, K., Taghvaeian, S., & Ajaz, A. (2017). Drought and Its Impact on Agricultural Water Resources in Oklahoma. Oklahoma Cooperative Extension Service BAE 1533. Retrieved on 26 July 2019 from: http://pods.dasnr.okstate.edu/docushare/dsweb/Get/Document-10705/BAE-1533web.pdf.

Kaine, G. (2004). Consumer behaviour as a theory of innovation adoption in agriculture. *Social Research working paper* 01/04, Social Research group, AgResearch.

Macauly, H. (2015). *Cereal Crops: Rice, Maize, Millet, Sorghum, Wheat.* Presented at Feeding Africa Conference, Darkar, Senegal.

Manda, J., Alene, A.D., Gardebroek, C., Kassie, M., & Tembo, G. (2015). Adoption and impacts of sustainable agricultural practices on maize yields and incomes: Evidence from rural Zambia. *Journal of Agricultural Economics, 66*, 130-153.

Melesse, T.M. (2015). Agricultural Technology adoption and market participation under learning externality: Impact evaluation on small-scale agriculture from rural Ethiopia. The Maastricht School of Management Working Paper No. 2015/06.

Obayelu, O.A., & Awoyemi, T.T. (2010). Spatial dimension of poverty in rural Nigeria. *Journal of Development and Agricultural Economics, 2* (6), 231-244.

Ogunlade, I., Olaoye, G., Tologbonse, D., & Ayinde, O.E. (2010). On-farm evaluation of drought tolerant maize varieties and hybrids in the southern guniea savanna zones of Nigeria. *Proceedings of the 4th Annual Conference of the South African Society for Agricultural Extension* (pp. 1-5). Langebaan, Western Cae, South Africa.

Onumadu, F.N., & Osahon, E.E. (2014). Socio-economic determinants of adoption of improved rice technologies by farmers in Ayamelum Local Government Area of Anambra State, Nigeria. *International Journal of Scientific and Technology* Research, *3* (1), 308-314.

Ray, R.L., Fares, A., & Risch, E. (2018). Effects of Drought on Crop Production and Cropping Areas in Texas. *Agricultural and Environmental Letters* 3, 170037. doi:10.2134/ael2017.11.0037.

Rosenbaum, P.R. (2005). Observational study. In B.S. Everitt & D.C. Howell (Eds.) *Encyclopedia of Statistics in Behavioral Science, 3*. John Wiley and Sons.

Received: February 6, 2019
Accepted: September 12, 2019

KAKAV UTICAJ KORIŠĆENJE KUKURUZA TOLERANTNOG NA SUŠU ZA AFRIKU IMA NA PRINOS I STATUS SIROMAŠTVA POLJOPRIVREDNIKA U SUŠNOM PODRUČJU NIGERIJE?

Oluwakemi A. Obayelu[1*], Oluwatomi M. Fakolujo[1] i Bola A. Awotide[2]

[1]Odsek za agroekonomiju, Univerzitet u Ibadanu, Ibadan
[2]Međunarodni institut za tropsku poljoprivredu, Ibadan

R e z i m e

Proizvodnja kukuruza u Nigeriji nije uspela sa zadovolji potrebe ljudi usled suše, niske produktivnosti i nedostatka pristupa poljoprivrednika poboljšanim varijetetima. Povećani poljoprivredni prinos je moguće sredstvo za povećanje prihoda domaćinstva, s ciljem da se smanji siromaštvo nosilaca malih poljoprivrednih gazdinstava. Ovim istraživanjem se procenjuje uticaj kukuruza tolerantnog na sušu za Afriku (engl. *Drought-Tolerant Maize for Africa – DTMA*) na prinos i na status siromaštva poljoprivrednika u severozapadnom području Nigerije. U istraživanju su korišćeni podaci iz Ankete u vezi sa korišćenjem kukuruza tolerantnog na sušu za Afriku, koju je sproveo Međunarodni institut za tropsku poljoprivredu u Ibadanu, sa 293 ispitanika iz severoistočne Nigerije (90 onih koji su koristili i 203 onih koji nisu koristili *DTMA*). Podaci su analizirani korišćenjem deskriptivne statistike, binarne regresije i metode uparivanja prema srodnosti. Rezultati su pokazali da je verovatnije da će nosioci malih gazdinstava pre usvojiti *DTMA* nego veća gazdinstva. Korisnici su imali povećanje prinosa *DTMA* od 9.262,77 kg/ha dok su oni koji nisu koristili *DTMA* imali povećanje od 3.807,74 kg/ha. Korišćenje *DTMA* smanjilo je verovatnoću siromaštva za 60% za posmatranu grupu, dok je učestalost siromaštva smanjena za 35% među onima koji nisu bili korisnici. Opšti je zaključak da je program korišćenja *DTMA* poboljšao prinos kukuruza i smanjio učestalost siromaštva među poljoprivrednim gazdinstvima.

Ključne reči: *DTMA*, siromaštvo, Sudanska savana, metoda uparivanja prema srodnosti, severozapadna Nigerija.

Primljeno: 6. februara 2019.
Odobreno: 12. septembra 2019.

[*]Autor za kontakt: e-mail: jkemmyade@yahoo.co.uk

INSTRUCTIONS FOR AUTHORS

MANUSCRIPT SUBMISSION

By submitting a manuscript authors warrant that their contribution to the Journal is their original work, that it has not been published before, that it is not under consideration for publication elsewhere, and that its publication has been approved by all co-authors, if any, and tacitly or explicitly by the responsible authorities at the institution where the work was carried out.
Authors are exclusively responsible for the contents of their submissions, the validity of the experimental results and must make sure that they have permission from all involved parties to make the data public.
Authors wishing to include figures or text passages that have already been published elsewhere are required to obtain permission from the copyright holder(s) and to include evidence that such permission has been granted when submitting their papers. Any material received without such evidence will be assumed to originate from the authors.
Authors must make sure that all only contributors who have significantly contributed to the submission are listed as authors and, conversely, that all contributors who have significantly contributed to the submission are listed as authors.
The registration of the authors and the submission of the papers should be done via the following link: http://aseestant.ceon.rs/index.php/jas/user
Manuscripts are to be pre-evaluated at the Editorial Office in order to check whether they meet the basic publishing requirements and quality standards. They are also screened for plagiarism.
Authors will be notified by email upon receiving their submission. Only those contributions which conform to the following instructions can be accepted for peer-review. Otherwise, the manuscripts shall be returned to the authors with observations, comments and annotations.

MANUSCRIPT PREPARATION

Authors must follow the instructions for authors strictly, failing which the manuscripts would be rejected without review.
The manuscript should be written in MS-Word in .doc, .docx, format. Font Times New Roman, font size 12, single spacing, margin 2.5 cm should be used when writing the paper. Page numbering should be avoided.
Original scientific paper - The paper should report the unpublished results of original research. This paper should occupy 6 to 12 pages.
Review article - The article which contains original, detailed and critical review of research problem or area where the author has made a certain contribution, noticed by auto citation (at least 10). This article should occupy 15 to 20 pages.
Preliminary communication - Original research paper of full format, small-scale or preliminary character. It should occupy 2 to 6 pages.

The obligatory parts of each Original scientific paper and Preliminary communication are the following: Title of the paper, Name(s) of author(s), Complete postal address(es) of affiliations, Abstract, Key words, Introduction, Material and Methods, Results and Discussion, Conclusion, Acknowledgements, References and Summary in Serbian (if manuscript is submitted in English and vice versa). The obligatory parts of each Review article are the following: Title of the paper, Name(s) of author(s), Complete postal address(es) of affiliations, Abstract, Key words, Introduction, Analysis-discussion of a certain topic, Conclusion, References and Summary in Serbian (if manuscript is submitted in English and vice versa). If manuscript is written in English British version is preferred.

Title of the paper

The title of the paper should describe the content of the paper as accurately and concisely as possible. Authors are recommended to use words in the title which are suitable for indexing and browsing purposes. The title should be centred and written in capital letters. If the paper has already been announced at certain meeting as an oral presentation, under the same or similar title, the datum should be stated on it at the bottom of the first page, after the data of the corresponding author.

Authors' Names

First name, middle initial(s) and last (family) name of all authors, in the original form, should be provided. The names should be written below the title, in lower-case letters, centred and bolded. If several different affiliations need to be mentioned, using the command "insert footnote", consecutive numerals should be placed as the superscript after the respective author's name. The corresponding author should be designated with an asterisk as the superscript, after the last (family) name, and his/her e-mail address should be given under the line, at the bottom of the first page of the paper.

Authors' Affiliations

The full name and address of the institution where the author is employed should be provided. It should be centred and written immediately after the author's name. If authors belong to different institutions, the numerals should be placed as the superscript before the name of institution to provide information on the institution where each of the stated authors is employed.

Abstract

The abstract is a short informative review of the content of the paper, which should enable the reader to estimate its relevance easily and accurately. It is in the interests of the author that the abstract contains terms used for indexing and browsing purposes. The references should not be given in the abstract. The abstract should include the aim of research, the methods, the results and the conclusion. It should contain between 200 and 250 words and be placed between the name of the authors' affiliations and key words. The title of the abstract should be bolded and indented pressing the tab key. The colon should be used after the title of the abstract, and then the text of the abstract should follow without any indentation.

Key words
Key words are terms or phrases which describe best the content of the article for the needs of indexing and browsing purposes. The number of key words should be 3 to 10. They should appear below the abstract. The title of key words should be bolded and indented by pressing the tab key. The colon should be used after the title, and then the list of key words in lower-case letters should be given with the full stop at the end. Key words should be provided in Serbian and English after abstract on both languages.

Introduction
The introduction should contain all the relevant information on past researches according to the stated problem and what can be achieved by further research. Reviewing the references, the author and the year should be provided, and the mentioned author should be cited in References. The title of the introduction should be centred and bolded, written in lower-case letters, below which using one line spacing, the text of the introduction should follow, justified. Each new paragraph should be indented pressing the tab key. These rules should be applied to all parts of the paper.

Material and Methods
The material and methods should be clearly outlined explaining all applied procedures in the paper. Generally known methods should be presented briefly, and a detailed explanation should be given if there is a deviation from previously published procedures. Papers, which have an experimental character, should provide the way of statistical data processing. This part, as well as the part Results and Discussion, if needed, may comprise certain subparts, too.

Results and Discussion
In the part Results and Discussion data obtained on the basis of observation and conducted experiments should be interpreted. In the comment of the results, references should be quoted at the end of the paper, providing the comparison between the obtained results and previous knowledge of the certain area.

Conclusion
All relevant items achieved in the researched area should be mentioned in the conclusion. Listing of all results with repetition of numbers previously specified in Results and Discussion should be avoided. Conclusion should not contain references.

Acknowledgements
Acknowledgements should contain the title and the number of the project that is the title of the program within which the paper was written, as well as the name of the institution which financed the project or program. It should be placed between the conclusion and references.

References

The References section should contain only papers cited in the main text. The paper cited in the text should contain the last (family) name and the year. If the citation is comprised of one author, it is stated as Jalikop (2010) or (Jalikop, 2010). When the citation is comprised of the two authors it is stated as Sadras and Soar (2009) or (Sadras and Soar, 2009). If more than two authors are cited, after the last (family) name of the first author, the abbreviation "et al." is given, and then the year. This citation is stated as Lehrer et al. (2008) or (Lehrer et al., 2008). If more than one paper are cited simultaneously for a certain problem, they should be listed chronologically. A large number of cited papers out of brackets should be separated by comma (,) and if in brackets, by semicolon (;). If two or more papers of the same author are cited, they must be listed chronologically (1997, 2002, 2006, etc.). If a certain author appears several times for the same year, the letters are added (2005a, b, c, etc.). The citations of personal communication and unpublished papers should be avoided, except that it is an absolute necessity. Such citations should appear in the text only as (Brown, personal communication), and not in the list of References.

The references, cited in the text should be stated in the list of references in the original form, alphabetically, without numbering. If a greater number of publications of the same author is cited, then the papers where the author is the single author should first be cited and then the publications of the same author with one and then with more co-authors. If a considerable number of publications appear in any of the above mentioned categories, they should be listed chronologically (1997, 2002, 2006, etc.), and if a great number of publications is of the same year then the letters are added (2005a, 2005b, 2005c, etc.). References entry should contain: the last (family) name of the author, the first letter of the author's name, the year of publishing in the brackets, the title of the paper, the title of the journal, the volume and the number of pages (the first-the last). When the book is cited, the publisher and place of publishing should be given. The lines of each reference entry should be indented after the first line. APA - Publication Manual of the American Psychological Association citation style is used in this journal.

The examples of listing references are the following:

Periodicals

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.

Tables

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.

The corresponding author will be sent a free copy of the journal after it has been published.

All future associates are asked to prepare the paper according to the given instructions in order to facilitate the work of the Editorial Board. Unless the paper is prepared according to the given instructions it will not be accepted for the prospective publishing.

Editorial Board of the Journal
Journal of Agricultural Sciences

UPUTSTVO AUTORIMA

SLANJE RUKOPISA

Prilikim podnošenja rukopisa autori garantuju da rukopis predstavlja njihov originalan doprinos, da nije već objavljen, da se ne razmatra za objavljivanje kod drugog izdavača ili u okviru neke druge publikacije, da je objavljivanje odobreno od strane svih koautora, ukoliko ih ima, kao i, prećutno ili eksplicitno, od strane nadležnih tela u ustanovi u kojoj je izvršeno istraživanje.

Autori snose svu odgovornost za sadržaj ponesenih rukopisa, kao i validnost eksperimentalnih rezultata, i moraju da pribave dozvolu za objavljivanje podataka od svih strana uključenih u istraživanje.

Autori koji žele da u rad uključe slike ili delove teksta koji su već negde objavljeni dužni su da za to pribave saglasnost nosilaca autorskih prava i da prilikom podnošenja rada dostave dokaze da je takva saglasnost data. Materijal za koji takvi dokazi nisu dostavljeni smatraće se originalnim delom autora.

Autori garantuju, da su kao autori navedena samo ona lica koja su značajno doprinela sadržaju rukopisa, odnosno da su sva lica koja su značajno doprinela sadržaju rukopisa navedena kao autori. Registracija autora i prijava radova se vrši preko linka: http://aseestant.ceon.rs/index.php/jas/user

Pri prijavi rada autori treba da navedu podatke za kontakt (ime i prezime, ustanovu i E-mail adresu) najmanje tri potencijalna recenzenta. Oni treba da budu eksperti iz date oblasti istraživanja koji će obezbediti objektivnu procenu rada. Predloženi recenzenti ne bi trebalo da budu iz iste institucije iz koje su i autori rada.

Nakon prijema, rukopisi prolaze kroz preliminarnu proveru u redakciji kako bi se proverilo da li ispunjavaju osnovne kriterijume i standarde. Pored toga, proverava se da li su rad ili njegovi delovi plagirani.

Autori će o prijemu rukopisa biti obavešteni elektronskom poštom. Samo oni rukopisi koji su u skladu sa datim uputstvima biće poslati na recenziju. U suprotnom, rukopis će, sa primedbama i komentarima, biti vraćen autorima.

UPUTSTVO ZA PRIPREMU RUKOPISA

Autori su dužni da se pridržavaju uputstva za pripremu radova. Rukopisi u kojima ova uputstva nisu poštovana biće odbijeni bez recenzije.

Za obradu teksta treba koristiti program MS-Word. Rukopise treba slati u jednom od sledećih formata .doc, .docx, koristiti font Times New Roman, veličina 12, jednostruki prored, margine 2,5 cm. Strane ne treba numerisati.

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

Pregledni rad – Rad koji sadrži originalan, detaljan i kritički prikaz istraživačkog problema ili područja u kome je autor ostvario određeni doprinos, vidljiv na osnovu autocitata (najmanje 10). Obim ovog rada treba da iznosi od 15 do 20 strana.

Prethodno saopštenje – Originalan naučni rad punog formata, ali manjeg obima ili preliminarnog karaktera (od 2 do 6 strana).
Obavezna poglavlja svakog originalnog naučnog rada i prethodnog saopštenja su sledeća: naslov rada, imena autora, naziv ustanove autora, sažetak, ključne reči, uvod, materijal i metode, rezultati i diskusija, zaključak, zahvalnica, literatura i rezime na srpskom jeziku (ako je rad na engleskom i obrnuto). Pregledni rad mora da sadrži: naslov rada, imena autora, naziv ustanove autora, sažetak, ključne reči, uvod, analizu-diskusiju određene teme, zaključak, literaturu i rezime na srpskom jeziku (ako je rad na engleskom i obrnuto). Ako su radovi na engleskom jeziku, prednost se daje britanskoj varijanti ovog jezika.

Naslov rada
Naslov rada treba što vernije da opiše sadržaj rada i da ima što manje reči. U interesu je autora da se u naslovu koriste reči prikladne za indeksiranje i pretraživanje. Naslov se piše velikim slovima i centrirano. Ako je rad prethodno bio izložen na nekom skupu u vidu usmenog saopštenja, pod istim ili sličnim naslovom, podatak o tome treba navesti pri dnu prve stranice, posle podataka autora za kontakt.

Imena autora
Navodi se puno ime, srednje slovo i prezime svih autora, u originalnom obliku. Imena se pišu ispod naslova, malim slovima, centrirano i boldovano. Ukoliko su autori iz različitih institucija brojčanom oznakom u superskriptu, iza prezimena, označiti ustanovu u kojoj radi svaki autor. Autor za kontakt označava se zvezdicom u superskriptu, iza prezimena, komandom „insert footnote“, a njegova e-mail adresa navodi se ispod crte pri dnu prve stranice članka.

Naziv ustanove autora
Navodi se pun naziv i adresa ustanove u kojoj je autor zaposlen. Ispisuje se neposredno nakon imena autora, centrirano. Ukoliko su autori iz različitih institucija brojčanom oznakom u superskriptu ispred institucije označava se ustanova u kojoj je zaposlen svaki od navedenih autora.

Sažetak
Sažetak je kratak informativni prikaz sadržaja članka koji čitaocu omogućava da brzo i tačno odredi njegovu relevantnost. U interesu je autora da sažetak sadrži termine koji se koriste za indeksiranje i pretraživanje. Sažetak ne sme da sadrži reference. Sastavni delovi sažetka su cilj istraživanja, metode, rezultati i zaključak. Sažetak treba da ima od 200 do 250 reči. Reč „Sažetak“ piše se boldovano i uvlači jednim tabulatorom, nakon čega slede dve tačke, a zatim tekst sažetka.

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.

Literatura

Poglavlje „Literatura“ treba da sadrži samo radove citirane u glavnom tekstu. Rad citiran u tekstu treba da sadrži prezime autora i godinu. Ako citat obuhvata jednog autora on se navodi kao Jalikop (2010) ili (Jalikop, 2010). Kada citat obuhvata dva autora on se navodi kao Sadras i Soar (2009) ili (Sadras i Soar, 2009). Ako se u tekstu citiraju više od dva autora posle prezimena prvog autora navodi se skraćenica „et al.“, a zatim godina. Ovakav citat navodi se kao Lehrer et al. (2008) ili (Lehrer et al., 2008). Ako se za određeni problem istovremeno citira više radova onda se oni hronološki nabrajaju. Odvajanje većeg broja citiranih radova van zagrade vrši se zarezom (,) a u zagradi tačkom i zarezom (;). Ako se citiraju dva ili više rada istog autora oni moraju biti poređani prema hronološkom redu (1997, 2002, 2006, itd.). Ukoliko se određeni autor pojavljuje nekoliko puta u istoj godini, dodaju se slova (2005a, b, c, itd.). Citate ličnih komunikacija i neobjavljenih podataka treba izbegavati, osim ako je to apsolutno neophodno. Takvi citati bi trebali da se pojave samo u tekstu (npr. Brown, lična komunikacija), ali ne i u spisku referenci.

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

Rezime

Rezime na srpskom jeziku (za radove napisane na engleskom jeziku) ili na engleskom jeziku (za radove napisane na srpskom jeziku) navodi se na kraju rada i treba da ima od 200 do 250 reči. Ispred osnovnog teksta rezimea, navodi se naslov rada, puno ime, srednje slovo i prezime svih autora i naziv i adresa ustanove autora. Naslov „Rezime“ piše se razmaknuto i centrirano. Nakon naslova sledi jedan razmak, a zatim tekst rezimea, uvučen jednim tabulatorom. Neposredno nakon teksta rezimea, navode se ključne reči, sa tačkom na kraju. E-mail adresa autora za kontakt navodi se ispod crte, pri dnu stranice.

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.

Nakon objavljivanja rada, autoru za kontakt će biti poslat jedan primerak časopisa.
Mole se svi budući saradnici da rad pripreme prema datom uputstvu, kako bi olakšali rad redakcije časopisa. Ukoliko se rad ne pripremi po navedenom uputstvu neće biti prihvaćen za objavljivanje.

Redakcioni odbor časopisa
JOURNAL OF AGRICULTURAL SCIENCES

CIP - Каталогизација у публикацији
Народна библиотека Србије, Београд

63

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
of Agricultural Sciences (Belgrade. Online) = ISSN 2406-0968
ISSN 1450-8109 = Journal of Agricultural Sciences (Belgrade)
COBISS.SR-ID 169380871