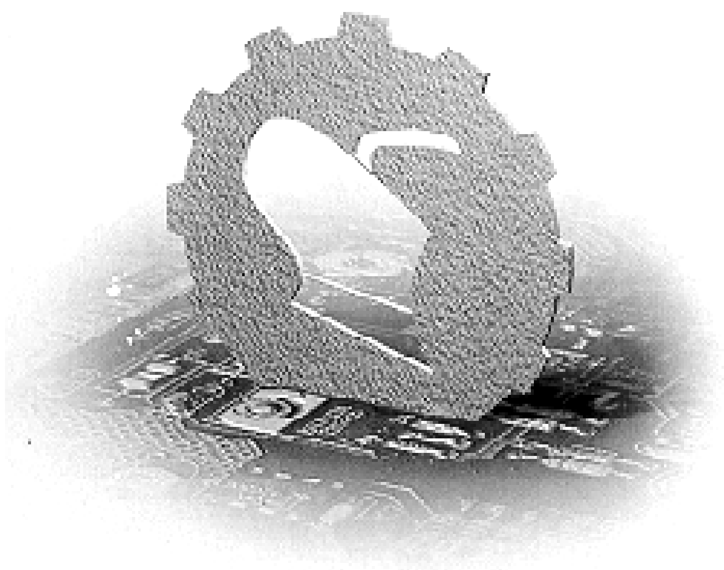
Print ISSN 0554-5587
On line eISSN 2406-1123
UDK 631 (059)

ПОЉОПРИВРЕДНА ТЕХНИКА

AGRICULTURAL ENGINEERING

НАУЧНИ ЧАСОПИС
SCIENTIFIC JOURNAL



УНИВЕРЗИТЕТ У БЕОГРАДУ, ПОЉОПРИВРЕДНИ ФАКУЛТЕТ,
ИНСТИТУТ ЗА ПОЉОПРИВРЕДНУ ТЕХНИКУ
UNIVERSITY OF BELGRADE, FACULTY OF AGRICULTURE,
INSTITUTE OF AGRICULTURAL ENGINEERING

ПОЉОПРИВРЕДНИ ФАКУЛТЕТ УНИВЕРЗИТЕТА У БЕОГРАДУ · ОСНОВАН 1919 ГОД

Година XLVII, Број 2., 2022.
Year XLVII, No.2., 2022.

ПОЉОПРИВРЕДНА ТЕХНИКА

НАУЧНИ ЧАСОПИС

AGRICULTURAL ENGINEERING

SCIENTIFIC JOURNAL

УНИВЕРЗИТЕТ У БЕОГРАДУ, ПОЉОПРИВРЕДНИ ФАКУЛТЕТ,
ИНСТИТУТ ЗА ПОЉОПРИВРЕДНУ ТЕХНИКУ

UNIVERSITY OF BELGRADE, FACULTY OF AGRICULTURE,
INSTITUTE OF AGRICULTURAL ENGINEERING

WEB адреса ***(WEB Address)***
www.jageng.agrif.bg.ac.rs

Техничка припрема *(Technical editor)*
Проф. др Коста Глигоревић, Пољопривредни факултет, 11080 Земун-Београд, Р.Србија

Лектура и коректура: *(Proofreader)*
Проф. др Иван Златановић, Машински факултет , 11120 Београд 35, Р.Србија

Превод: *(Translation)*
Проф. др Иван Златановић (Енглески језик), Машински факултет , 11120 Београд 35, Р.Србија
Проф. др Андреј Стојановић (Руски језик), Пољопривредни факултет, 11080 Земун-Београд, Р.Србија

Штампа *(Printed by)*
Пољопривредни факултет , 11080 Земун-Београд, Р.Србија и Duga motiv, 11030 Београд, Р.Србија
Часопис излази четири пута годишње

Тираж *(Circulation)*
200 примерака
Дистрибуција примерака часописа Пољопривредна техника за заинтересоване је бесплатна .

Радови објављени у часопису индексирани су у базама *(Abstracting and Indexing)*:
AGRIS (International Information System for the Agricultural Science and Technology)
SCIndeks (Serbian Citation Index)
NAAS (National Academy of Agricultural Sciences - India)
ScienceMediaCentre
ArgosBiotech
CiteFactor (International Academic Scientific Journals)
J4F (Journals for Free).
AgroSpace, Faculty of Agriculture, University of Belgrade, Republic of Serbia

Издавање часописа помогло *(Publication supported by)*
Министарство просвете, науке и технолошког развоја Републике Србије
Према одлукама Министра просвете, науке и технолошког развоја: 451-03-684/2020-14
и 451-03-1210/2020-14/2 .

На основу мишљења Министарства за науку и технологију Републике Србије према
решењу бр. 413-00-606/96-01 од 24. 12. 1996. године, научни часопис Пољопривредна техника
је ослобођен плаћања пореза на промет робе на мало.

S A D R Ž A J

C O N T E N T S

Univerzitet u Beogradu
Poljoprivredni fakultet
Institut za poljoprivrednu tehniku
Naučni časopis
POLJOPRIVREDNA TEHNIKA
Godina XLVII
Broj 2, 2022.
Strane: 1 – 10

University of Belgrade
Faculty of Agriculture
Institute of Agricultural Engineering
Scientific Journal
AGRICULTURAL ENGINEERING
Year XLVII
No. 2, 2022.
pp. 1 – 10

UDK: 631.6:631.536

Original Scientific paper
Originalni naučni rad
DOI:10.5937/POLJTEH2202001E

EXPENDING AND CONSERVING ENERGY IN POUNDED YAM FLOUR PRODUCTION

Nseobong Obioha Eberendu*[1], Alex Folami Adisa[2], Adewole Ayobami Aderinlewo [2], Sidikat Ibiyemi Kuye[3], Wahabi Bolanle Asiru[4]

[1]Agricultural Mechanization, Centre of Excellence in Agricultural Development and Sustainable Environment (CEADESE), Federal University of Agriculture, Abeokuta (FUNAAB). Ogun State, Nigeria.
[2]Agricultural Engineering Department, Federal University of Agriculture, Abeokuta (FUNAAB). Ogun State, Nigeria.
[3]Mechanical Engineering Department, Federal University of Agriculture, Abeokuta (FUNAAB). Ogun State, Nigeria.
[4]Project Development and Design, Federal Institute of Industrial Research, Oshodi, Lagos, Nigeria.

Abstract: conducted using two approaches, namely: without process adjustment (Slice thickness ≤ 14 mm, parboiled for 25 minutes, dried at 60 °C) and with process adjustment (Slice thickness ≤ 5 mm, parboiled for 20 minutes, dried at 80 °C). Results revealed eight units of operation for instant pounded Yam flour production. Adjustments in production conditions; thickness of Yam slices, steaming time and drying temperature resulted in less production time with an energy reduction from 86.26 kWh at a cost of ₦2,618.70/day to 28.60 kWh at a cost of ₦ 868.15/day to give 67.00% decrease in energy consumption.

The ANOVA showed that process adjustment had a significant ($p < 0.05$) effect on the amount of energy consumed during the processing of instant pounded Yam flour.
Thermal processes namely; parboiling and drying were the most energy intensive while washing was the least energy intensive unit operation, thus energy assessment aided in cutting down losses while running an efficient instant pounded Yam flour processing operation.

***Key words**: Yam, instant pounded Yam flour, unit operations, energy assessment, energy consumption, process adjustment, energy utilization*

*Coresponding Author. Email: nseberendu@yahoo.co.uk

INTRODUCTION

Nigeria is acknowledged to be the largest producer of Yams in the world, yielding over 35.02 million metric tonnes in 2008 [1]. The protein content of Yam (*Dioscorea* spp.) surpasses that of other root and tubers [2], and Yam is used in the preparation of various traditional recipes in Nigeria, West Africa. Instant Pounded Yam Flour (IPYF) is the flour obtained after Yam tubers have been sliced, sulphited, parboiled, dried and milled. The flour when poured into a known volume of boiling water is mixed to form a dough comparable to that obtained from the customary and manually tasking "mortar and pestle" pounded Yam [3], which is a delicacy in Nigerian socio cultural events. The IPYF is preferred by the working class and the crème de la crème in Nigeria because of its ease and speed of preparation. Generally, the white Yam (*Dioscorea rotundata)* is preferred for the preparation of pounded Yam as can be observed in most eateries and important occasions in Nigeria.

The aim of Yam processing which includes, lessening of postharvest losses of fresh tubers, improvement of the taste of Yam products, and transformation of Yam from fresh solids to flour requires energy intensive operations. [4] reported that the approach used in the reduction of energy consumption is heat recovery, adjusting the operation conditions or to reduce heat loss with insulation. In agriculture, the best energy use is revealed in two ways, i.e. energy savings with no change in productivity or a growth in productivity using the current levels of the source of energy available [5]. Incessant black out coupled with increase in electricity tariff in Nigeria, West Africa are causes of concern for agro-food industries because an increase in energy cost will result in a concurrent increase in operating costs and invariably the cost of resulting products hence the need to save and manage energy effectively.

Studies are available on energy utilization for production of cocoa flour [6], wheat flour [7], instant pounded Yam flour with respect to Yam thickness and shape [8], instant pounded Yam flour by comparing cooking, steam and wet milling methods of preparation [7]. The purpose of this study was to quantify energy consumption from the national grid in processing IPYF at pilot scale in order to provide data for understanding energy expenditure, and also proffer solution to high cost of energy in processing of IPYF by adjusting the operating condition for proper management of energy.

MATERIAL AND METHODS

Investigations were conducted in a pilot plant of a medium sized organization located in southwestern Nigeria. Yam tubers were bought from the local Yam market, cleaned of extraneous material and weighed. The cleaned Yam tubers were manually peeled with stainless steel knives, manually washed with potable water and sliced using a mechanical slicer. The slices were sulphited (0.1 g / litre of water) for 30 minutes, precooked in a steaming machine and dried in a batch dryer. The dried Yam chips were milled, allowed to cool and sealed in low density polythene packs.

All unit operations were timed with a digital timer. Based on energy supplied from the national grid, two approaches for energy assessment of IPYF production were used namely; (a) Without process adjustment (b) With process adjustment.

The energy resources used in the production of IPYF including the number of persons per operation, the power ratings of each machine used and time required for operation were recorded. Data obtained were inputted in available energy equations as described below.

Without process adjustment

Ten kilogram of Yam tubers were peeled, washed and mechanically sliced. The total output of Yam slices (thickness ≤ 14 mm) from the mechanical slicer were sulphited for 30 minutes, cooked for 25 minutes using steam, dried at a temperature of 60 °C [9] to ≤ 14.5 % moisture content wet basis, milled and packaged.

With process adjustment

Ten kilogram of Yam tubers were peeled, washed and mechanically sliced. The Yam slices from the mechanical slicer (thickness ≤ 5 mm) excluding the discolored head region were sulphited for 30 minutes, cooked for 20 minutes using steam, dried at a temperature of 80 °C to ≤ 14.5 % moisture content wet basis, milled and packaged.

Energy consumption of IPYF production line

Using the data collected from the IPYF production line, the energy consumption during production was determined based on an 8-hour working day, according to Equations (1 to 9) by [10] as follows:

$$E_{pl} = (0.075 \times N_{pl} \times t_{pl}) \quad (1)$$
$$E_w = (0.075 \times N_w \times t_w) \quad (2)$$
$$E_s = [(0.075 \times N_s \times t_s) + (\eta \times P_s \times t_s)] \quad (3)$$
$$E_{sul} = (0.075 \times N_{sul} \times t_{sul}) \quad (4)$$
$$E_{pb} = [0.075 \times N_{pb} \times t_{pb}) + (W_{pb} \times C)] \quad (5)$$
$$E_d = [(0.075 \times N_d \times t_d) + (\eta \times P_d \times t_d)] \quad (6)$$
$$E_m = [(0.075 \times N_m \times t_m) + (\eta \times P_m \times t_m)] \quad (7)$$
$$E_{pk} = [(0.075 \times N_{pk} \times t_{pk}) + (\eta \times P_{pk} \times t_{pk})] \quad (8)$$
$$E_T = E_{pl} + E_w + E_s + E_{sul} + E_{pb} + E_d + E_m + E_{pk} \quad (9)$$

Where: E is energy and subscripts (pl, w, s, sul, pb, d, m, and pk) are used to indicate the particular unit operation, for which energy estimate will be carried out, i.e. peeling, washing, slicing, sulphiting, parboiling, drying, milling and packaging respectively.

N is the number of persons involved in a unit operation.
t is the time to complete a unit operation (h).
The average power output a human being in the tropics will sustain for an 8 - 10 hour workday is 0.075 kW [11].
η is 80% being the efficiency for electric motor of the machine [12].

W is the quantity of fuel used (kg).
C is 45.5 MJ/kg (12.64 kW/kg) being heating value of cooking gas (LPG) [13].
P is rated power for a particular unit operation (kW).
E_T is total quantity of energy (kWh).
Conversion factor for electrical energy is 1 kWh = 3.6 MJ [6].
Nigeria electricity tariff is ₦30.36/ kWh [14].

Statistical analysis

The experimental data (total energy consumption) was inputted for Analysis of Variance (ANOVA) using general linear model and means were compared using Tukey test. Statistical analysis ($p \leq 0.05$) was carried out by means of Minitab 17 software at two levels of process adjustment (with process adjustment and without process adjustment) in seven replicates.

RESULTS AND DISCUSSION

Table 1 shows that manual, electrical and thermal energy were involved in the processing of IPYF. Drying and parboiling were estimated to be 5.21 and 80.92 kWh respectively without process adjustment and 4.20 and 24.28 kWh respectively with process adjustment, however washing was 0.004 kWh for both processes.

Table 1. Parameters used for estimation of energy values for IPYF production

S/N	Unit operation	Required parameter	Value
1	Peeling	Manual power (kW)	0.075±0.00
		Time taken (hr)	0.036±0.012
		Number of persons involved	1±0.00
2	Washing	Manual power (kW)	0.075±0.00
		Time taken (hr)	0.005±0.00
		Number of persons involved	1±0.00
3	Slicing	Manual power (kW)	0.075±0.00
		Electrical power (kW)	1.5±0.00
		Time taken (hr)	0.0059±0.001(0.0071±0.002)
		Number of persons involved	1±0.00
4	Sulphiting	Manual power (kW)	0.075±0.00
		Time taken (hr)	0.5±0.00
		Number of persons involved	1±0.00
5	Parboiling	Manual power (kW)	0.075±0.00
		Calorific value of fuel used (MJ/kg)	45.5 (12.64 kWh/kg)
		Quantity of fuel used (kg)	0.41±0.09 (0.33±0.05)
		Time taken (hr)	0.42±0.00 (0.33±0.00)
		Number of persons involved	1±0.00
6	Drying	Manual power (kW)	0.075±0.00

		Cont. Table 1.	
		Electrical power (kW)	4.87±0.00
		Total time taken (hr)	20±0.00 (6±0.00)
		Number of persons involved	2±0.00
7	Milling	Manual power (kW)	0.075±0.00
		Electrical power (kW)	2.2±0.00
		Time taken (hr)	0.034±0.001
		Number of persons involved	1±0.00
8	Packaging	Manual power (kW)	0.075±0.00
		Electrical power (kW)	0.4±0.00
		Time taken (hr)	0.0173±0.00
		Number of persons involved	1±0.00

Note: Bold font indicates with process adjustment where different (Mean ± Std Dev)

The total energy used for IPYF production without process adjustments was estimated to be 86.26 kWh at a cost of ₦2,618.70/day (Tab. 2) at a total operating time of 21 hours attaining dried Yam chips (≤ 14.5% moisture content wet basis) and IPYF (≤ 10% w.b) beyond the operating time of the pilot plant (8 hours).

Table 2. Estimates of energy use pattern for IPYF production without process adjustment

S/N	UNIT OPERATION	POWER INPUT	ENERGY VALUE (kW)	NO. OF PERSONS	TIME TAKEN (hrs.)	60 °C ENERGY (kWh)
1	Peeling	Manual	0.075	1	0.0356	0.0030
2	Washing	Manual	0.075	1	0.0050	0.0004
3	Slicing	Electrical	1.5	1	0.0059	0.0075
4	Sulfiting	Manual	0.075	1	0.5000	0.0375
5	Parboiling	Thermal	12.64	1	0.4200	5.2139
6	Drying	Electrical	4.87	2	20.000	80.9200
7	Milling	Electrical	2.2	1	0.0340	0.0624
8	Packaging	Electrical	0.4	1	0.0173	0.0082
	Total energy consumption (kWh)					86.2551
	Energy costs (₦)/day					2,618.7042

Table 3 reveals that the total energy used for IPYF production with process adjustment was estimated to be 28.60 kWh at a cost of ₦ 868.15/day at a total operating time of 7 hours, attaining dried Yam chips (≤ 14.5% moisture content wet basis) and IPYF (≤ 10% w.b) within the operating time of the pilot plant (8 hours). The ANOVA showed that the effect of process adjustment was significant ($p \leq 0.05$) on energy consumption, also the Tukey test for comparison of means showed that the process used for IPYF preparation are significantly different ($p \leq 0.05$).

Table 3: Estimates of energy use pattern for IPYF production with process adjustment

S/N	UNIT OPERATION	POWER INPUT	ENERGY VALUE (kW)	NO. OF PER-SONS	TIME TAKEN (hrs.)	80 °C ENERGY (kWh)
1	Peeling	Manual	0.075	1	0.0356	0.0030
2	Washing	Manual	0.075	1	0.0050	0.0004
3	Slicing	Electrical	1.5	1	0.0071	0.0091
4	Sulfiting	Manual	0.075	1	0.5000	0.0375
5	Parboiling	Thermal	12.64	1	0.3300	4.1960
6	Drying	Electrical	4.87	2	6.0000	24.2760
7	Milling	Electrical	2.2	1	0.0340	0.0624
8	Packaging	Electrical	0.4	1	0.1730	0.0082
	Total energy consumption (kWh)					28.5952
	Energy costs (₦/day)					**868.1489**

Analysis of Variance

Source	DF	Adj SS	Adj MS	F-Value	P-Value
Process adjustment	1	11672.9	11672.9	13953.45	0.000
Error	12	10.0	0.8		
Total	13	11683.0			

Tukey Pairwise Comparisons

Grouping Information Using the Tukey Method and 95% Confidence

Process adjustment	N	Mean	Grouping
Without process adjustment	7	86.327	A
With process adjustment	7	28.577	B

*Means that do not share a letter are significantly different.

Eight units of operation were involved in the processing of IPYF, manual energy was used in all stages of production for either method of production and the energy intensive operations were identified as drying and parboiling while washing was non energy intensive for both methods used in this study.

Drying consumed more than half of the total energy requirements for both approaches. A similar observation on high energy consumption during drying was reported by [7] for instant pounded Yam flour production. Washing (cleaning) was the least energy intensive operation, this may be due to simplicity of the process as similarly reported by [6] for cocoa flour processing. Total energy consumption for IPYF production without process adjustment exceeded that with process adjustment by 57.66 kWh surpassing it by 67.00%.

The high energy cost for IPYF production without process adjustments may be due to high thickness of Yam slices and low drying temperature resulting in long drying time. Conversely, the low energy cost for IPYF production with process adjustments showed a reduction with thinner Yam slices at higher temperature while attaining shorter drying duration. Observations in this study agrees with report of [15] that thinner pumpkin slices dry faster than thicker slices because the internal moisture had less distance to travel resulting in an increase in drying rate and the reports of [16] for convective drying of apple slices which showed that an increase in air temperature reduces the drying time and increases the drying rate. The ANOVA results show that energy consumption increased without process adjustment and decreased with process adjustment implying that the effect of process adjustment was significant on energy consumption during IPYF processing.

CONCLUSIONS

It was found that eight unit of operations are required for IPYF production. Manual, electrical and thermal energy were the major sources of energy input in the production of IPYF. Total energy consumption without process adjustments exceeded that with process adjustments by 57.66 kWh.

The total energy consumption decreased by 67.00%, with increase in drying temperature and a decrease in thickness of Yam slices resulting in a decrease in total operating time for IPYF production with process adjustment. With the aid of a proper energy audit, the Yam processing industry can profit greatly with process adjustment as this translates to a reduction in energy consumption and inevitably production cost. Other methods of energy savings during IPYF preparation needs to be carried out for further studies as cooking gas prices have more than doubled and energy tariffs have also been increased since the period of this study.

REFERENCES

[1] FAO. 2012. *FAOSTAT.* Available through http://faostat.fao.org. [Accessed 2, 15, 2016].

[2] Nweke, F. I. 2017. West African Yam food technologies: prospects and impediments to change. *African Journal of Food Science and Technology,* 8 (3), pp. 40-49.

[3] Ayodeji, S. P., O. M. Olabanji, and M. K. Adeyeri. 2012. Design of a process plant for the production of poundo Yam. *International Journal of Engineering,* 6 (1), pp. 10-24.

[4] Kemp, I. C. 2012. *Fundamentals of energy analysis of dryers.* Germany: Wiley-VCH.

[5] Jadidi, M. R., M. S. Sabuni, M. Homayounifar, and A. Mohammadi. 2012. Assessment of energy use pattern for tomato production in Iran; A case study from the Marand region. *Research in Agriculture and Engineering,* 58, pp. 50-56.

[6] Ogunsina, B. S., M. A. Adeyemi, T. A. Morankinyo, O. J. Aremu, and A. I. Bamgboye. 2017. Direct energy utilization in the processing of cocoa beans into powder. *Agricultural Engineering International, CIGR journal* 19 (3), pp. 213-218.

[7] Olatoye, K. K., R. Akinoso, A. I. Lawal, and K. A. Babalola. 2014. A comparative study of energy demand on instant pounded Yam flour production methods. *Journal of Energy Technologies and Policy,* 4 (3), pp. 14-18.

[8] Akinoso, R., and K. Olatoye. 2013. Energy utilization and conservation in instant-pounded Yam flour production. *International Food Research Journal,* 20 (2), pp. 575-579.

[9] Mercer, D. G. 2014. *Some key aspects of the drying process.* Canada: University of Guelph, Ontario.

[10] Akinoso, R., A. A. Olapade, and A. A. Akande. 2013. Estimation of energy requirements in cowpea flour production in Nigeria. *Foc. on Modern Food Industry,* 2 (2), pp.86-90.

[11] Odigboh, E. U. 1998. Machines for crop production. Edited by B. A. Stout. *CIGR Hand-Book of Agricultural Engineers* (American Society of Agricultural Engineers).

[12] Sulaiman, M. A., A. O. Oni, and D. A. Fadare. 2012. Energy and exergy analysis of a vegetable oil refinery. *Energy and power engineering,* 4, pp.358-364.

[13] CES. 2011. *Efficiency measurement of biogas, kerosene and LPG stoves.* Lalitpur, Nepal: Centre for Energy Studies, Biogas support programme.

[14] IKEDC. 2019. *Ikeja electric tariff, energy charges N/kWh.* Available through www.nerc.gov.ng. [Accessed 2, 18, 2020].

[15] Onwude, D. I., N. Hashim, R . B. Janius, N. M. Nawi, and K. Abdan. 2016. Evaluation of a suitable thin layer model for drying of pumpkin under forced air convection. *Internation Food Research Journal,* 23 (3), pp.1173 - 1181.

[16] Beigi, M. 2016. Energy efficiency and moisture diffusivity of apple slices during convective drying. *Food Science Technology Campinas,* 36 (1), pp.145 - 150.

APPENDIX 1

Statistical analysis

General Linear Model: Energy consumption (kWh) versus Process adjustment

Method
Factor coding (-1, 0, +1)

Factor Information

Factor	Type	Levels	Values
Process adjustment	Fixed	2	With process adjustment, Without process adjustment

Analysis of Variance

Source	DF	Adj SS	Adj MS	F-Value	P-Value
Process adjust.	1	11672.9	11672.9	13953.45	0.000
Error	12	10.0	0.8		
Total	13	11683.0			

Model Summary

S	R-sq	R-sq(adj)	R-sq(pred)
0.914637	99.91%	99.91%	99.88%

Coefficients

Term	Coef	SE Coef	T-Value	P-Value	VIF
Constant	57.452	0.244	235.03	0.000	

Process adjustment
With process adjustment -28.875 0.244 -118.12 0.000 1.00
Regression Equation

Energy consumption (kWh) = 57.452 - 28.875 Process adjustment_With process adjustment + 28.875 Process adjustment_Without process adjustment

Tukey Pairwise Comparisons

Grouping Information Using the Tukey Method and 95% Confidence

Process adjustment	N	Mean	Grouping
Without process adjustment	7	86.327	A
With process adjustment	7	28.577	B

Means that do not share a letter are significantly different.

Tukey Simultaneous 95% CIs

POTROŠNJA I OČUVANJE ENERGIJE U PROIZVODNJI YAM (*Dioscorea rotundata*) BRAŠNA

Nseobong Obioha Eberendu[1], Alex Folami Adisa[2], Adewole Ayobami Aderinlewo [2], Sidikat Ibiyemi Kuye[3], Wahabi Bolanle Asiru[4]

[1]Agricultural Mechanization, Centre of Excellence in Agricultural Development and Sustainable Environment (CEADESE), Federal University of Agriculture, Abeokuta (FUNAAB). Ogun State, Nigeria.
[2]Agricultural Engineering Department, Federal University of Agriculture, Abeokuta (FUNAAB). Ogun State, Nigeria.
[3]Mechanical Engineering Department, Federal University of Agriculture, Abeokuta (FUNAAB). Ogun State, Nigeria.
[4]Project Development and Design, Federal Institute of Industrial Research, Oshodi, Lagos, Nigeria.

Apstrakt: Istraživanje je provedeno korišćenjem dva pristupa, i to:
bez prilagođavanja procesa (debljina preseka kriški je ≤ 14 mm, prokuvano 25 minuta, sušeno na 60 °C);
sa podešavanjem procesa (debljina preseka kriški je ≤ 5 mm, prokuvano 20 minuta, sušeno na 80 °C).
Rezultati su pokazali osam jedinica (uzoraka) za instant proizvodnju mlevenog Yam brašna.

Prilagođavanja uslova proizvodnje; debljina Yam kriški, vreme prokuvavanja i temperatura sušenja rezultirali su kraćim vremenom proizvodnje sa smanjenjem energije sa 86,26 kWh po ceni 2,618,70 ₦/dan na novu vrednost od 28,60 kWh po ceni 868,15 ₦/dan, što je dovelo do smanjenja potrošnje energije za 67,00%.
Analiza ANOVA pokazuje da prilagođavanje procesa ima značajan ($p < 0,05$) uticaj na količinu energije potrošene tokom prerade instant mlevenog brašna.
Toplotni procesi kao što je prokuvavanje i sušenje su energetski najzahtevniji, dok je pranje uzoraka bilo najmanje energetski intenzivan .
Procena utrošene energije je pomogla u smanjenju gubitaka tokom efikasne operacije prerade instant mlevenog Yam brašna.

Ključne reči: *Yam, instant mleveno yam brašno, jedinica procesa , procena energije, potrošnja energije, prilagođavanje procesa, korišćenje energije*

Prijavljen: *Submitted*:	**08.05.2022.**
Ispravljen: *Revised*:	**10.05.2022.**
Prihvaćen: *Accepted*:	**25.05.2022.**

Univerzitet u Beogradu
Poljoprivredni fakultet
Institut za poljoprivrednu tehniku
Naučni časopis
POLJOPRIVREDNA TEHNIKA
Godina XLVII
Broj 2, 2022.
Strane: 11 – 19

University of Belgrade
Faculty of Agriculture
Institute of Agricultural Engineering
Scientific Journal
AGRICULTURAL ENGINEERING
Year XLVII
No. 2, 2022.
pp. 11 – 19

UDK: 621.9: 621.7

Originalni naučni rad
Original Scientific paper
DOI: 10.5937/PoljTeh2202011G

ANALIZA PRIMENE SISTEMA ZAŠTITE NA STONIM I STUBNIM BUŠILICAMA

Dušan Gavanski*, **Vladimir Blanuša**

Visoka tehnička škola strukovnih studija, Novi Sad, Republika Srbija

Sažetak: Cilj rada je analiza primene sistema zaštite na stonim i stubnim bušilicama. Prikazana je metodologija istraživanja koja se koristila za analizu primene sistema zaštite na bušilicama, i to metodom deskripcije pomoću ček-liste. Istraživanje je sprovedeno na uzorku od 55 bušilica, pri čemu je utvrđeno da je najizraženiji problem nepostojanje zaštitnika oko reznog alata. Prodiskutovani su dobijeni rezultati istraživanja analize primene sistema zaštite na bušilicama i predložena su dalja istraživanja.

Ključne reči: *bušilica, sistem zaštite, metodologija, istraživanje, analiza, ček lista.*

UVOD

Pod pojmom oprema za rad podrazumeva se mašina, uređaj, postrojenje, instalacija i alat koji se koriste u procesu rada [1,2]. Mašina je, prema standardu SRPS EN 12100:2014, sklop međusobno povezanih delova ili komponenata od kojih je barem jedan pokretan uz pomoć pokretača (nije ljudska ili životinjska snaga) i namenjen je za obradu različitih materijala uz pomoć alata. Na radnim mestima u okviru procesa proizvodnje mogu da se koriste raznovrsne mašine, koje su najčešće namenjene obradi i preradi metala, drveta, plastike, gume, papira i tekstila. Mašine alatke obuhvataju razne vrste: strugova, bušilica, rendisaljki, glodalica, testera, brusilica, provlakačica i mašina za izradu navoja i zupčanika. Prema Autoru [4] na mašinama alatkama može se izvršiti izrada i obrada delova različitih oblika i dimenzija i to od najjednostavnijih (vratila, osovine, osovinice i slično) do najsloženijih (lopatice turbina, bregaste ploče i slično). Sve mašine alatke, na osonovu tehnologije koja se na njima koristi pri obradi, mogu se svrstati u sledeće dve velike grupe: klasične mašine alatke i numerički upravlajnnje (NU)-mašine alatke.

*Corresponding Author. Email: gavanski@vtsns.edu.rs

Na mašinama alatkama radnik je prvenstveno ugrožen zbog rasipanja strugotine i zahvatanja delova tela ili odeće od obrtnih elemenata, alata i predmeta obrade. Analizirajući mehaničke opasnosti koje su prisutne u zoni rezanja može se zaključiti da potencijalne posledice – povrede potiču od sledećih izvora, kao što su: predmet obrade, alat, strugotina, obrtni delovi, prašina, tečnost za hlađenje, ulje za podmazivanje i slično, [5], [6].

Bušenje je postupak izrade i obrade otvora i rupa. Pored osnovnih operacija (bušenje, proširivanje, upuštanje i razvrtanje) bušenjem se mogu realizovati i druge obrade otvora i rupa, kao što su: zabušivanje, bušenje dubokih otvora i izrada navoja. Glavno obrtno i pomoćno pravolinijsko kretanje izvodi rezni alat.

U Poljskoj se prema bazi podataka Nacionalne inspekcije rada dogodi 23-28% smrtnih i teških nezgoda pri radu na mašinama, odnosno u periodu od 2005-2010 godine u proseku je svake godine bilo preko 400 nezgoda [7]. Do ovih nezgoda je došlo usled: rada mašina u proizvodnim procesima (50% registrovanih smrtnih i ozbiljnih nezgoda), čišćenja mašina (25% nezgoda) i održavanja i popravki (25% nezgoda),[7].

U sisteme zaštite na stubnim i stonim bušilicama spadaju: zaštitnik oko reznog alata, zaštitnik oko prenosnog mehanizma, pribori za stezanje predmeta obrade i prekidač za hitno zaustavljanje mašine.

U ovom radu se razmatraju klasične stubne i stone bušilice, kao najznačajnije vrste bušilica.

MATERIJAL I METODE RADA

Definisanje problema istraživanja

Problem istraživanja je nedostatak podataka o ispunjenosti mera zaštite kod bušilica, naročito onih koji se odnose na postojanje i ispravnost sistema zaštite: zaštitnik oko reznog alata, zaštitnik oko prenosnog mehanizma, pribor za stezanje predmeta obrade i prekidač za hitno isključivanje mašine.

Cilj istraživanja

Cilj istraživanja je da se u posmatranim preduzećima utvrdi koliko je procentualno učešće stonih i stubnih bušilica kod kojih postoji neusaglašenost u vezi sistema zaštite.

Hipoteza istraživanja

Pretpostavlja se da u preduzećima u kojima je sprovedeno istraživanje procentualno najviše stonih i stubnih bušilica kod kojih ne postoji zaštitnik oko reznog alata.

Metode istraživanja

U postojećim ček-listama u Republici Srbiji uglavnom .su ponuđeni odgovori DA/NE, gde se u nekim pitanjima za opasno stanje daje odgovor DA, a u nekim pitanjima odgovor NE, te je preglednost na nezavidnom nivou.

Predloženo je da se u novoformiranoj ček-listi za analizu sistema zaštite kod bušilica ponude odgovori „opasno“, „nebitno“ i „bezbedno“, kako bi se preglednost podigla na viši nivo. Nakon popunjavanja ček-liste, odgovori tipa „bezbedno“ i „nebitno“ ne zahtevaju preduzimanje korektivnih mera, dok odgovori tipa „opasno“ zahtevaju analizu i predložene mere koje se unose u kolonu „Korektivne mere koje trebe preduzeti“. Na osnovu analize primene sistema zaštite na bušilicama [8], i stručnih nalaza za periodične preglede i provere ispravnosti bušilica postavljena su pitanja u novoformiranoj ček-listi za analizu sistema zaštite na bušilicama. Korišćena je metoda deskripcije, odnosno postupak opisivanja putem davanja komentara na postavljena pitanja [9].

Primer popunjene ček-liste za analizu sistema zaštite na stonim i stubnim bušilicama dat je u tabeli 1.

Tabela 1. Analiza primene sistema zaštite na bušilicama
(OP – opasno, NB – nebitno, NZ – bezbedno)
Table 1. Analysis of the application of the safety system on drilling machines
(D – Dangerous, N/R – Not Relevant, S – Safe)

ANALIZA PRIMENE SISTEMA ZAŠTITE NA BUŠILICAMA ANALYSIS OF THE APPLICATION OF THE SAFETY SYSTEM ON DRILLING MACHINES					**1/46**	02.03.2021.
Ime i sedište poslodavca Name and registered office of the employer		/				
Delatnost (oblast u kojoj privređuje) Activity (business area)		/				
Vrsta opreme za rad Type of work equipment	STUBNA BUŠILICA COLUMN DRILLING MACHINE		Proizvođač Manufactures		/	
Tip / model Type / model	/		Godina proizvodnje The year of production		/	
Redni broj Serial number	Pitanje The question	Komentar Comment	OP D	NB N/T	BZ S	KOREKTIVNE MERE koje treba primeniti CORRECTIVE MEASURES which should be applied
1.	Zaštitnik oko reznog alata Safety guard about the cutting tool	Ne postoji zaštitnik oko reznog alata There is no safety guard about the cutting tool				Ugraditi zaštitnik oko reznog alata sa mikroprekidačem Install a safety guard about the cutting tool with a microswitch

	Наставак Таб.1. Continued Tab.1.					
2.	Zaštitnik oko prenosnog mehanizma Safety guard about the transmission	Postoji zaštitnik oko prenosnog mehanizma There is safety guard about the transmission				
3.	Pribori za stezanje predmeta obrade (stege, mengele, šape) Accessories to clamp the workpiece	U radionici koriste pribore za stezanje predmeta obrade In the workshop, they use accessories to clamp the workpiece				
4.	Prekidač za hitno zaustavljanje mašine (STOP taster) Emergency stop switch (STOP button)	Postoji ispravan prekidač za hitno zaustavljanje mašine There is correct emengency stop switch				

Uzorak istraživanja

Istraživanjem je obuhvaćen uzorak od 55 stonih i stubnih bušilica za koje su prikupljeni podaci o postojanju sistema zaštite, Istraživanje je trajalo dva meseca (mart-april 2021. godine) i sprovedeno je u 29 preduzeća na teritoriji opštine grada Novog Sada. Stubnih bušilica je bilo 49 (87,27%), dok je stonih bušilica bilo 6 (10,9%).

REZULTATI ISTRAŽIVANJA I DISKUSIJA

Rezultati istraživanja koji se odnose na postojanje sistema zaštite na stonim i stubnim bušilicama: zaštitnik oko reznog alata, zaštitnik oko prenosnog mehanizma, pribori za stezanje predmeta obrade i prekidač za hitno zaustavljanje dati su u tabeli 2.

Sistemi zaštite na bušilicama imaju dvojaku ulogu – s jedne strane štite radnika od rasipanja strugotine i odletanja delova, alata ili ključa, a sa druge strane štite od zahvatanja delova tela ili odeće obrtnim delovima mašine, alatom ili predmetom obrade, [8].

Prema tabeli 2 uočava da su najzastupljenije bušilice koje nemaju zaštitnik oko stezne glave i reznog alata, jer nije bio obavezan element zaštite pre nekoliko decenija kada je većina ispitanih bušilica proizvedena. Kod analiziranih bušilica samo 8 je opremljeno zaštitnikom oko reznog alata, odnosno samo kod 14,55% bušilica je ispunjena ova mera zaštite.

Tabela 2. Rezultati analize sistema zaštite na stonim i stubnim bušilicama
Table 2. The result of the analysis of safety systems on drilling machine

SISTEMI ZAŠTITE SAFETY SYSTEMS	ANALIZA SISTEMA ZAŠTITE NA BUŠILICAMA ANALYSIS OF SAFETY SYSTEMS ON DRILLING MACHINES		
	Ukupan broj analiziranih bušilica / odgovora The total number of analyzed drilling machines / answers	Broj negativnih (opasnih) odgovora Number of negative (dangerous) answers	% negativnih odgovora % negative answers
Zaštitnik oko reznog alata Safetyguard about the cutting tool	55	47	85,45
Zaštitnik oko prenosnog mehanizma Safeguard about the transmission	55	3	5,45
Pribori za stezanje predmeta obrade (stege, mengele, šape) Accessories to clamp the workpiece	55	1	1,81
Prekidač za hitno zaustavljanje (STOP taster) Emergency stop switch (STOP button)	55	27	49

Primeri bušilica sa zaštitnikom oko reznog alata dati su na slici 1. Preporučljivo je da se na stonim i stubnim bušilicama u našoj industriji instaliraju zaštitnici oko reznog alata sa mikroprekidačem, kao što je prikazano na slici 1/levo/sredina.

Na slici 1/desno prikazana je stubna bušilica na kojoj je naknadno ugrađen zaštitnik oko reznog alata od pleksiglasa, ali bez mikroprekidača.

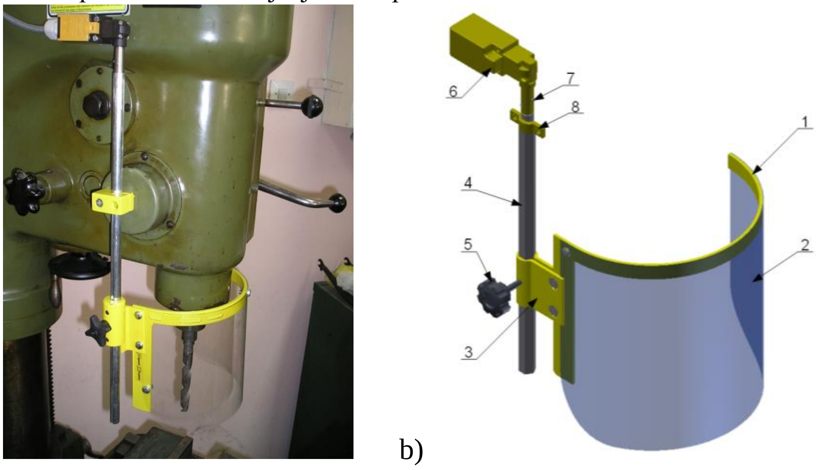
Slika 1. Bušilice opremljene zaštitnikom oko reznog alata (sopstveni izvor)
Figure 1. Drilling machine equipped with safety guard around the cutting tools (Authors source)

Kod analiziranih bušilica utvrđeno da 52 od ukupno 55 (94,55%) ima postavljen zaštitnik oko prenosnog mehanizma. Primeri bušilica koje nisu opremljene zaštitnikom oko prenosnog mehanizma dati su na slici 2.

Slika 2. Bušilice koje nisu opremljene zaštitnikom oko prenosnog mehanizma (sopstveni izvor)
Figure 2. Drilling machines not equipped with a safety guear around the transmission (Authors source)

Najzastupljenije su bušilica kod kojih postoji pribor za stezanje predmeta obrada. Na slici 3 prikazan je izgled montirane zaštite na bušilici čiji je zadatak da onemogući operateru mašine da prilikom rada mašine dođe u kontakt sa reznim alatom – zavojnom burgijom, kao i da spreči nekontrolisano odletanje strugotine nastale prilikom radnog hoda mašine. Princip rada mehanizma je sledeći: u toku rada bušilice zaštita je zatvorena. Ukoliko na primer želimo da zamenimo predmet obrade ili alat, neophodno je zakrenuti zaštitu što bi preko mikroprekidala dovelo do automatskog isključivanja obrtnog kretanja alata bušilice. Detaljan opis mehanizma koji je za Visoku tehničku školu strukovnih studija iz Novog Sada projektovala firma Popović company doo iz Bačkog Jarka 2012. godine biće prikazan dalje u radu. Detaljan izgled mehanizma prikazan je na slici 3. Zaštita se sastoji od vizira (2), koji je preko zavrtnjeva pričvršćen za nosač vizira (1). Vizir sa nosačem je preko kliznog ležišta (3) povezan sa vratilom mehanizma (4).

Klizno ležište (3) je napravljeno sa profilisanim otvorom kroz koji prolazi vratilo (4). Na ovaj način sprečava se mogućnost da operater mašine podešava ugao nosača vizira (2) sa vizirom (1) u odnosu na alat. Vertikalni položaj vizira se podešava preko zavrtnjeva sa plastičnom kapom (5). Vratilo mehanizma (4) na svom kraju ima cilindrični rukavac koji ulazi u rupu obrtnog nastavka mikroprekidača (6). Pričvršćenje vratila i mikroprekidača je izvršeno preko dva zavrtnjeva (7). Mehanizmu je dodat klizni oslonac (8) koji omogućuje da se prilikom zakretanja vratila (4) sila ne prenosi na mikroprekidač već samo na oslonac što produžava vek trajanja mikroprekidača.



a) b)

Slika 3. Detaljan izgled zaštitnika oko reznog alata (burgije) od pleksiglasa sa mikroprekidačem
Figure 3. The appearance the safety guard around the cutting tool (drill) made of plexiglas with a microswitch

Prilikom koncepcijskog rešenja i projektovanja mašina neophodno je prvo tačno utvrditi – definisati opasne zone u kojima potencijalno može doći do mehaničkih povređivanja radnika i na osnovu toga treba projektovati odgovarajuće zaštitnike ili zaštitne uređaje.

ZAKLJUČAK

U radu je data analiza primene sistema zaštite na stonim i stubnim bušilicama, koje su zajedno sa univerzalnim strugovima najzastupljenije mašine alatke u Republici Srbiji.

Analiza primene sistema zaštite na bušilicama je sprovedena na odabranom uzorku od 55 bušilica, pri čemu je utvrđeno da na samo 8 (14,55%) bušilica od ukupnog analiziranog broja ne postoji problem koji se odnosi na nepostojanje sistema zaštite.

Postavljena hipoteza istraživanja je dokazana jer je utvrđeno da od 55 analiziranih bušilica, pribor za stezanje predmeta obrade nema 1 (1,81%), zaštitnik oko prenosnog mehanizma nema 3 (4,45%), prekidač za hitno zaustavljanje (STOP taster) nema 27 (49%) i zaštitnik oko reznog alata nema 47 (85,45%), što predstavlja i najveći problem u primeni propisanih mera bezbednosti i zdravlja na radu i obezbeđivanja korišćenja – upotrebe bezbedne bušilice.

Konstrukciona rešenja starih bušilica ne obezbeđuju dovoljnu zaštitu radnika od mehaničkih opasnostima kojima je izložen u toku rada, već je neophodno projektovati i ugraditi odgovarajuće zaštitnike ili zaštitne uređaje oko reznog alata.

LITERATURA

[1] Zakon o bezbednosti i zdravlju na radu ("Službeni glasnik RS", br. 101/2005, 91/2015 i 113/2017 – dr. zakon).

[2] Pravilnik o preventivnim merama za bezbedan i zdrav rad pri korišćenju opreme za rad ("Službeni glasnik RS", br. 23/2009, 123/2012, 102/2015 i 101/2018)

[3] SRPS EN 12100:2014. Bezbednost mašina – Opšti principi za projektovanje – Ocena rizika i smanjenje rizika

[4] Nedić, B., Lazić, M. 2007. Proizvodne tehnologije, Obrada metala rezanjem, Skripta, Mašinski fakultet u Kragujevcu, Kragujevac.

[5] Drezgić, M., Janković, Ž.1994 Zaštita na mašinama i uređajima. Univerzitet u Nišu, Fakultet zaštite na radu, Niš.

[6] Janković, Ž.1999. Sistemi zaštite na mašinama – koncepcijska analiza, Univerzitet u Nišu, Fakultet zaštite na radu, Niš.

[7] Dźwiarek, M., Latala, A. 2016. Analysis of occupational accidents: prevention through the use of additional technical safety measures for machinery, International journal of occupational safety and ergonomics: JOSE 22(2):1-28, 2015, DOI:10.1080/10803548.2015.1129154. Dostupno:https://www.researchgate.net/publication/286962439_Analysis_of_occupational_accidents_prevention_through_the_use_of_additional_technical_safety_measures_for_machinery (datum pristupa: 06.09.2021.)

[8] Sokola, M., Gavanski, D. 2012. Bezbedan rad na stubnim i stonim bušilicama, 7 . Međunarodno naučno savetovanje Rizik i bezbednosni inženjering, Kopaonik. Zbornik radova, str. 384-389, Visoka tehnička škola strukovnih studija u Novom Sadu, Departman Inženjerstva zaštite životne sredine Fakulteta tehničkih nauka Univerziteta u Novom Sadu, Ministarstvo rada i socijalne politike Republike Srbije..

[9] Gavanski, D. 2020. Analiza stanja točkova viljuškara u eksploataciji. *Poljopruvredna tehnika*. Volumen (XLV/3): pp. 27-37.

ANALYSIS OF THE APPLICATION OF THE SAFETY SYSTEM ON BENCH AND COLUMN DRILLING MACHINES

Dušan Gavanski, Vladimir Blanuša

Higher Education Technical School of Professional Studies,
Novi Sad, Republic of Serbia

Abstract: The aim of this paper is to analyze the application of protection systems on column and bench drilling machines. The research methodology used for the analysis of the application of the safety system on drilling machines is presented, by the method of description using a checklist. The research was conducted on a sample of 55 drilling machines, and it was determined that the most pronounced problem is the lack of safety guard around the cutting tool.

The obtained results of the research of the analysis of the application of the safety system on drilling machines are discussed and further researches are proposed .

Key words: *Drilling machines, safety system, methodology, research, analysis, check list.*

Prijavljen: *Submitted*:	**01.11.2021.**
Ispravljen: *Revised*:	**07.03.2022.**
Prihvaćen: *Accepted*:	**25.05.2022**.

Univerzitet u Beogradu
Poljoprivredni fakultet
Institut za poljoprivrednu tehniku
Naučni časopis
POLJOPRIVREDNA TEHNIKA
Godina XLVII
Broj 2, 2022.
Strane: 20 – 30

University of Belgrade
Faculty of Agriculture
Institute of Agricultural Engineering
Scientific Journal
AGRICULTURAL ENGINEERING
Year XLVII
No. 2, 2022.
pp. 20 – 30

UDK: 631.4:631.51:631.44

Original Scientific paper
Originalni naučni rad
DOI: 10.5937/PoljTeh2202020A

SOIL PROPERTIES AFFECTED BY SOIL AND WATER CONSERVATION STRUCTURES (GABIONS AND MATTRESSES) IN IKOT AKPAN RAVINE, UYO, NIGERIA

Ifechukwude I. Ahuchaogu*[1], Godwin A. Usoh[2], Rose E. Daffi[3], James M. Umana[1]

[1]Department of Agricultural and Food Engineering, University of Uyo, Akwa Ibom State, Nigeria.
[2]Department of Agricultural Engineering, Akwa Ibom State University, Nigeria,
[3]Department of Civil Engineering, University of Jos, Plateau State, Nigeria.

Abstract: Land degradation is a major challenge to agriculture in Nigeria. Soil conservation practices have been put in place to reclaim degraded landscapes. The effectiveness of these measures in improving soil properties have not been really studied in Nigeria, particularly in Uyo, Akwa Ibom State. This research assessed the effect of soil and water conservation structures (Gabions and Mattresses) in Ikot Akpan ravine on selected soil properties. A total of 12 soil samples were collected from the conserved (plots treated with gabions and mattresses) and non-conserved (plots with no treatment). Soil tests to determine soil properties were done. A one-way analysis of variance (ANOVA) statistics using a general linear model at α=0.05 was used to show significant difference exists between the two landscapes.

The results showed that sand (80.84 ± 1.26%, 81.07 ± 1.90%), silt (13.70 ±3.30%, 11.41 ± 2.53%), and pH (6.51 ± 0.26) were positively affected by the conservation structure.

*Corresponding Author. Email: israelahuchaogu@uniuyo.edu.ng

However, bulk density (2.33± 0.27g/cc, 2.38 ± 0.16g/cc) and electrical conductivity (00.12 ± 0.02ds/m) were negatively impacted by the conservation structure. Other soil properties such as clay (7.71 ±2.54%, 7.79 ± 1.02%), available phosphorus (30.12 ±4.55mg/kg, 44.81 ± 9.28mg/kg), total nitrogen (0.05 ±0.01%, 0.05±0.02), moisture content (5.48 ±0.96%, 5.68 ± 0.85%), organic carbon (1.97 ± 0.04%, 1.95 ± 0.11%), effective cation exchange capacity (ECEC) (13.85±4.30 cmol/kg, 15.76 ± 2.06 cmol/kg) and exchangeable bases were not affected by the conservation practice. The conservation structure was very effective in controlling soil erosion and reducing soil loss. Soil conservation practices should be encouraged.

***Key words**: Gabion, Mattresses, Soil properties, Conserved, Non-conserved, ANOVA, Soil Conservation.*

INTRODUCTION

Land degradation is a global challenge and is widely related to agricultural use. It is a serious problem in Nigeria that has greatly affected agricultural productivity and the environment. From [22], it was explained that land degradation is majorly caused by accelerated soil erosion and other underlying causes such as burning of vegetation, forest and woodland destruction, overgrazing by farm animals, low input agriculture, absence of regulations on land use, lack of knowledge about land conservation and absence of social organizational structure conducive to a suitable land use. In a review by [19], land degradation is primarily caused by overexploitation for production of fuel wood, overgrazing, overpopulation, industrial activities and poor agricultural practices. However, it has been proven by [7] that wind and water erosion (key factors), floods, premature rotation of farmland, burning of vegetation, deforestation and even illiteracy of inhabitants have led to land degradation.

Land degradation leads to the susceptibility of people to adverse effects of climate change with its accompanying irregularities by reducing soil organic carbon (SOC) concentration, water holding capacity of the soil, which in turn reduces the level of agricultural productivity as well as local resource assets [14]. Similarly [25], identified decreased production of food, droughts, economical imbalance and the reduction in the quality of life as the consequences of land degradation.

Various soil and water conservation measures (management and mechanical) have been adopted in a bid to solve the problem of land degradation in Nigeria. Some management or agronomical methods include planting of trees and afforestation (example; cashew nut), contour cultivation, mulching, crop rotation, strip cropping, planting of grasses for stabilizing bunds. Mechanical methods include construction of bunds and terraces, gully control and control of stream and river banks [23] as well as gabions and mattresses as found in this research are used to conserve a ravine site.

However, a ravine is defined by [5] as a steep mountain slope which creates abrupt borders in the landscape and can provide a diversity of unique microhabitats for plants and other habitats.

In a research conducted to assess the relationship between ravine erosion and livelihoods, [28] reported a positive relationship between indices of natural resources availability and socioeconomic development.

A number of villages found within the ravines were found to be very poor in development. This further underlines the need to conserve ravine sites to facilitate agriculture and bring about improved living conditions among rural dwellers where agriculture is the major occupation of its dwellers.

Lack of appropriate soil and water conservation measures has led to land degradation. The top soil which contains most of the essential nutrients as well as soil organic matter is most affected which in turn affects agricultural productivity [13, 29]. In a bid to curb the problem of soil erosion and reclaim degraded lands, a lot of soil and water conservation measures have been applied [23]. However, the effectiveness of these measures in improving soil properties has not been really studied in Nigeria, particularly in Akwa Ibom state as has been done in some parts of Africa namely, Ethiopia [14, 13], hence this study. The study aimed at assessing the variability of soil property between the conserved area and non-conserved plot in the study area. This would serve as a guide to improve land management practices in the study area and similar areas in the state and country as well. It would also provide information for people in the study area, the government, Agricultural/Civil Engineers as well as all others who are interested in impact of soil conservation structures on soil properties which might be vital for sustainable agricultural production. A lot of work has been done in soil conservation and more work still needs to be done and for this reason researchers such as [16 and 27] suggested that the government through her appropriate agencies should put a mechanism in place to educate and train farmers more on soil and water conservation measures for sustainable agricultural production.

MATERIAL AND METHODS

The Ikot Akpan Ravine is located in the University of Uyo town campus area in Uyo local government area of Akwa Ibom state (Figure 1). Geographically, it is located between 5°2'38"N to 5°2'59"N latitude and 7°55'28"E to 7°55'43"E longitude of the Greenwich meridian. The mean annual rainfall of the study area is 2509 mm while the lowest and highest mean annual temperatures are 25.1°C and 27.6°C respectively. Although detailed soil description is not available in the study area, 2 major soils are dominant in the area: Red soil covers (Nitosol) and Black soil (Vertisol). The area has a population of over 60,000 inhabitants. Subsistence farming is mostly practiced as the major occupation in the area. Crops dominantly cultivated include: Water leaf (*Talinum triangulare),* fluted pumpkim *(Telifaira occidentalis)* and Maize (*Zea mays).* Others crops cultivated include: yam (*Discorea spp) and* Cassava *(Manihot spp).*

The research represents a field case study. A reconnaissance survey was carried out to identify representative soil sampling plots. Sample sites were selected from the conserved (plots treated with gabions and mattresses, aged 5years and non-conserved (plots with no treatment) sites in the study area. Randomized sampling was used for selection of typical sites to represent large areas in the conserved and non-conserved sites. The sample sites were 4 from each plot category.

The first 10 cm of top soil was removed to exclude the presence of nematodes. Soil samples were collected using a sharp edged and closed, circular auger from 10-30 cm depth pushed manually down the soil profile. The collected samples were packed in plastic bags and well labelled for laboratory analysis.

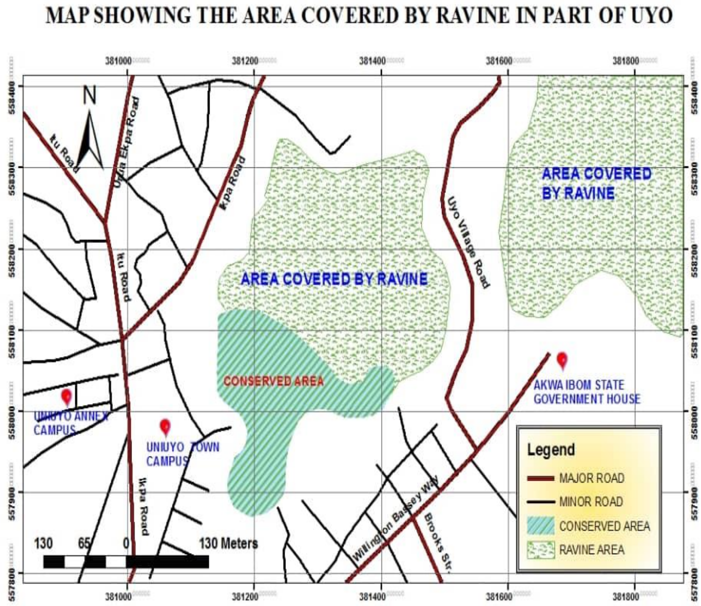


Figure 1. Location map of the study area in Uyo Local Government Area, Nigeria.

The samples were taken to the laboratory for oven drying as soon as they were collected in order to maximize changes in the concentration of extractable nutrients. The samples were air dried by spreading out thinly in a dry, warm and well-ventilated room. When the samples were completely dried, pestles and mortars were used to grind the samples. In addition, 2 mm sieves were used to sieve the samples and later stored for physical and chemical analysis. Moreover, for the determination of bulk density, undisturbed samples were collected using core samplers of height 6 cm and diameter 4 cm.

The soil properties considered in this study are moisture content, bulk density, soil organic carbon, soil organic matter (SOM), total nitrogen, PH, texture, exchangeable bases (Na^{++}, K^{+}, Ca^{++} and Mg^{++}), available phosphorus, electrical conductivity, percentage base saturation and cation exchange capacity [14].

The soil parameters were analyzed at the Department of Soil Science laboratory of the University of Uyo following the procedures in [38].

The different physical and chemical properties of soil samples as dependent variables and landscape category as independent variables were statistically tested. A one-way analysis of variance (ANOVA) statistics using the general linear model (GLM) at alpha value of 5% was used to evaluate whether significant difference exists between the conservation practice and soil properties [33, 34].

RESULTS AND DISCUSSION

Table 1. Physical and chemical properties of soil in the conserved area (site 1)

Sampling Point	Units	Sample I	Sample II	Sample III	Sample IV	Mean ± Std. Dev.
*PSA:						
Sand	(%)	82.04	81.80	79.55	79.98	80.84±1.26
Silt	(%)	11.70	6.70	13.70	13.70	13.70±3.30
Clay	(%)	6.26	11.50	6.75	6.32	7.71 ±2.54
Textural Classes		Loamy sand	Loamy sand	Loamy sand	Loamy sand	
Bulk Density	(g/cm^3)	2.17	2.72	2.12	2.30	2.33± 0.27
Total Porosity	(%)	18.20	10.20	19.20	11.40	14.75±4.61
Moisture Content	(%)	6.73	5.00	4.51	5.68	5.48 ±0.96
Ph		6.14	6.52	6.70	6.68	6.51 ± 0.26
EC	(ds/m)	0.11	0.05	0.17	0.15	0.12 ± 0.05
Organic Carbon	(%)	1.92	2.00	1.99	1.98	1.97 ± 0.04
Total Nitrogen	(%)	0.05	0.04	0.04	0.05	0.05 ±0.01
Available Phosphorus	(mg/kg)	23.50	33.57	32.50	30.90	30.12±4.55
Ex. Bases:						
Calcium	(Cmol/kg)	10.10	11.30	12.10	11.40	11.23±0.83
Magnesium	(Cmol/kg)	2.80	2.30	3.00	8.40	4.13± 2.87
Sodium	(Cmol/kg)	0.07	0.06	0.07	0.05	0.06 ± 0.01
Potassium	(Cmol/kg)	0.12	0.09	0.10	0.11	0.11 ± 0.01
ECEC	(Cmol/Kg)	15.28	15.86	7.46	16.78	13.85±4.30
Bases Sat.	(%)	85.60	86.78	85.99	86.89	86.32 ±0.62

*PSA = Particle Size Analysis, Ex. Bases = Exchangeable Bases and Sat. = Saturation

The soil organic carbon was not significantly different (since p [0.557] > 0.05) in the conserved landscape which shows that the nature of soil conservation did not have any impact on soil organic carbon content. The mean value of the total organic carbon in the conserved landscape was close to that of the non-conserved landscape although remaining higher in the conserved site. Following the rating of [20], the organic carbon content of the study area was low.

In a comparison of total organic carbon determination by walk ley black wet oxidation-titration method and high temperature catalytic combustion oxidation-infrared method, the results indicated that even though the walk ley black methods can be used for a quick estimation of total organic carbon, they have limitations in concentration range [1]. A similar idea was also reported by [6] and was recommended that better organic carbon estimations can be arrived at using the dry combustion method. With low concentration of organic carbon, it is possible that the method of determination is responsible for the underestimation of total organic carbon. Otherwise, low carbon in the study area is due to human disturbance and low cultivation as [32] reported that intensive land use with inadequate cultivation indicating human disturbance could lead to serious reduction in organic carbon contents.

In line with the recommendation of [11], organic carbon depletion resulting from soil nutrient transport should be remediated through the application of fertilizers, residues and organic manures.

Table 2. Physical and chemical properties of soil in the conserved area (site 2)

Sampling Point	Units	Sample I	Sample II	Sample III	Sample IV	Mean ± Std. Dev.
P.S.A:						
Sand	(%)	79.85	79.90	83.87	80.69	81.07 ± 1.90
Silt	(%)	13.43	13.10	7.91	11.20	11.41 ± 2.53
Clay	(%)	6.72	7.20	8.22	9.01	7.79 ± 1.02
Textural Classes		Loamy sand	Loamy sand	Loamy sand	Loamy sand	
Bulk Density	(g/cm^3)	2.31	2.20	2.58	2.40	2.38 ± 0.16
Total Porosity	(%)	10.00	18.40	15.20	16.40	15.00 ± 3.59
Moisture Content	(%)	6.50	6.00	4.50	5.71	5.68 ± 0.85
pH		6.74	6.12	6.92	6.58	6.51 ± 0.34
EC	(ds/m)	0.14	0.09	0.13	0.11	0.12 ± 0.02
Organic Carbon	(%)	1.95	1.90	2.10	1.86	1.95 ± 0.11
Total Nitrogen	(%)	0.03	0.06	0.07	0.03	0.05 ± 0.02
Available Phosphorus	(mg/kg)	41.20	39.24	40.14	58.69	44.81 ± 9.28
Ex. Bases:						
Calcium	(Cmol/kg)	11.31	11.14	9.35	8.43	10.06 ± 1.40
Magnesium	(Cmol/kg)	2.70	2.50	2.90	9.00	4.28 ± 3.15
Sodium	(Cmol/kg)	0.06	0.08	0.04	0.05	0.06 ± 0.01
Potassium	(Cmol/kg)	0.10	0.07	0.12	0.12	0.10 ± 0.02
ECEC	(Cmol/kg)	16.36	13.90	14.38	18.40	15.76 ± 2.06
Bases Saturation	(%)	86.70	83.19	89.90	84.83	86.16± 2.88

*PSA = Particle Size Analysis, Ex. Bases = Exchangeable Bases and Sat. = Saturation

Effective Cation Exchange Capacity (ECEC) is an inherent soil property which as observed by many researchers such as [12], is very difficult to alter inherently. The result of this study follows suit as observed in the mean value of the cation exchange capacity (CEC) of both landscapes. There was no significant difference in effective CEC in the conserved site as p [0.961] > 0.05, which shows that the nature of soil conservation did not have any impact on soil ECEC. The desired range of ECEC is between 5-25 cmol/kg. When the effective CEC is less than 5, it is indicative of low soil fertility.

With mean values of 13.84 cmol/kg, 15.76 cmol/kg and 13.96 cmol/kg in conserved and non-conserved sites respectively (Tables 1, 2 & 3) the ECEC is in good condition for both sites as [20] reported that the CEC is considered moderate when it is between the range of 12 cmol/kg and 25c mol/kg.

Table 3. Physical and chemical properties of soil in the non-conserved area

Sampling Point		Units	Sample I	Sample II	Sample III	Sample IV	Mean ± Std. Dev.
P.S.A:							
Sand		(%)	86.86	93.86	91.86	91.86	91.11± 2.99
Silt		(%)	1.92	0.92	0.92	0.92	1.17 ± 0.50
Clay		(%)	11.22	5.22	7.22	7.22	7.72 ± 2.52
Textural Classes			Loamy sand	Loamy sand	Sandy	Sandy	
Bulk Density		(g/cm^3)	2.05	2.47	1.87	1.22	1.90 ±0.52
Total Porosity		(%)	22.60	7.00	29.40	54.00	28.25±19.56
Moisture Content		(%)	4.78	12.10	3.62	4.11	6.15 ± 3.99
pH			5.32	5.38	5.40	4.11	5.05±0.63
EC		(ds/m)	0.04	0.03	0.05	0.04	0.04 ± 0.01
Organic Carbon		(%)	1.82	2.40	1.50	1.40	1.78 ± 0.45
Total Nitrogen		(%)	0.05	0.06	0.03	0.04	0.05 ±0.01
Available Phosphorus		(mg/kg)	56.61	28.61	26.61	36.61	37.11±13.70
Ex. Bases:							
Calcium		(Cmol/kg)	12.00	9.00	8.16	8.30	9.37 ± 1.79
Magnesium		(Cmol/kg)	3.40	2.00	2.40	2.20	2.50± 0.62
Sodium		(Cmol/kg)	0.06	0.06	0.07	0.05	0.06 ± 0.01
Potassium		(Cmol/kg)	0.12	0.13	0.11	0.10	0.12 ± 0.01
ECEC		(Cmol/kg)	17.34	13.04	12.74	12.75	13.975±2.25
Bases Saturation		(%)	87.73	85.74	84.30	83.53	85.33 ±1.85

*PSA = Particle Size Analysis, Ex. Bases = Exchangeable Bases and Sat. = Saturation

CONCLUSIONS

The gabions and mattresses applied to reverse the effect of degraded land were very effective in controlling soil erosion and reducing soil loss. This agrees with the results of many other researchers [35, 13, 15] and also achieves the principles of soil and water conservation as reported in literature which include reducing runoff volume and velocity, strengthening the soil's resistance to soil erosion and conserving vital soil resources [39].

The conservation structure had a very positive impact in reducing sand and accumulating silt content. No effect was observed on clay contents of the conserved landscape. The bulk density was impacted negatively by the conservation structure. This was a direct result of the heavy earth-moving machineries used to facilitate the construction of the conservation structure. This led to soil compaction and thus, the increase in bulk density.

High bulk density affects root and shoot growth; leaf expansion rate and plant reductions are the results of increased bulk density. Soil moisture content and available phosphorus were not impacted by the conservation structure.

The conservation structure had a significant impact on the electrical conductivity of the soil. An increase in the electrical conductivity was observed in the conserved site.
This is considered a negative effect as increase in electrical conductivity signifies an increase in the measure of dissolved salts in the soil solution. A careful study of the research area (conserved site particularly) indicated that poor land management was responsible for this increment. The Effective cation exchange capacity was impacted by the conservation structure. However, the result of this soil property (Appendix) shows that it is in a favorable state regardless of the landscape category. No impact was also observed on the exchangeable cations of calcium, potassium, magnesium and sodium.

The use of heavy machinery in the construction of soil and water conservation structures should be limited to the barest minimum, or completely avoided if possible to reduce soil compaction. This must be done to avoid negative consequences on the bulk density and electrical conductivity. In line with the recommendation of [24], the practice of minimum tillage in a tropical rain-fed agroecosystem is required for a reduction in bulk density due to considerable improvement of soil organic matter under minimum tillage. Other ways of improving bulk density of the landscape include conservation crop rotation and cover cropping.

REFERENCES

[1] Avradimis, P., Nikolaou, K., and Bekiari, V.2015. Total Organic Carbon and Total Nitrogen in Sediments and Soils: a comparison of the wet oxidation-titration method with the combustion-infrared method. *Agriculture and Agricultural Science Procedia,* 4(2015). pp 425 - 430. DOI:10.1016/j/aaspro.2015.03.048

[2] Black, C. A. 1965. Methods of Soil Analysis: Part I "Physical and Mineralogical Properties". American Society of Agronomy, Madison, USA. In: Glossary of Fire Science Terminology (2017). Soil moisture Content.

[3] Black, G. R. 1965. Bulk Density in Methods of Soil Analysis (Agronomy, No. 9, part 1). C. A. Black, ed. pp 374 - 390.

[4] Breitbart, R. 1988. Soil Testing Procedures for Soil Survey. (Assessed on January 10, 2019)

[5] Damon, A., Almeida-Cerino, C., Valle-Mora, J., Bertolini, V., and Lopez-Urbina, J. (2015). Ravines as refuges for orchidaceae in South-eastern Mexico. *Botanical Journal of the Linnaean Society,* 178(2): pp 238 - 297. DOI:10.1111/boj.12278

[6] Davies, M. R., Alves, B. J. R., Karlen, D. L., Kline, K. L., Galdos, M., and Abulebdvh, D. 2018. Review of soil organic carbon measurement protocols; A U.S and Brazil comparison and recommendation. *Sustainability,* 10(53): pp 1 - 20. DOI: 10.3390/su10010053

[7] Egede, E. A., and Donatus, U. 2013. Threats and mitigation of soil erosion and land degradation in South East Nigeria. *Journal of Environment and Earth Science,* 3(13): pp 95 - 102. (Retrieved from www.iiste.org/journals/index.php/jees/article/viewfile/9875/10054)

[8] Erebor, O. 1999. Comprehensive Agricultural Science.1st edition. A Johnson Publishers, Lagos State, Nigeria, pp 87 - 98

[9] Fernandez, F. G., and Kaiser, D. E. 2018. Understanding Nitrogen in Soils. http://extension.umn.edu (Assessed on august 30, 2018).

[10] Gachene, K. C. 2003. Soil Fertility and Land Productivity; A Guide for Extension Workers in the Eastern Africa region. RELMA Technical Handbook Series 30, Nairobi, Kenya.

[11] Gebremichael, D., Nyssen, J., Poesen, J., Deckers, J., Mitiku, H., Govers, G., and Moeyersons, J. 2005. Effectiveness of stone bund in controlling soil erosion on cropland in the Tigray Highlands, Northern Ethiopia. *Soil Use & Management* 21: pp.287 – 297.

[12] Hailu, W., Moges, A., and Yimer, F. 2012. The effects of 'fanyajuu' soil conservation structure on Selected soil physical and chemical properties: The case of Goromti watershed, Western Ethiopia. *Journal of Resources and Environment*, 2(4): pp.132 - 140. DOI:10.5923/j.re.20120204.02

[13] Hailu, W. 2017. Impact of physical soil and water conservation structures on selected soil physicochemical properties in Gondar Zuriya Woreda. *Journal of Resources and Environment*, 7(2): pp 40 - 48. DOI:10.59231/j.re.20170702.02

[14] Hishe, S., Lyimo, J., and Bewket, W. 2017. Soil and water conservation effects on soil properties in the Middle Silluh Valley, Northern Ethiopia. *International Soil and Water Conservation Research*, 5(3): pp 231 - 240. (Retrieved from http://dx.doi.org/10.1016 /j.iswcr.2017.06.005)

[15] Husen, D., Esimo, F., and Getechew, F. 2017. Effect of soil bund on soil physical and chemical properties in Arsi Negelle Woreda, Central Ethiopia. *African Journal of Environmental Science and Technology,* 11(10): pp 509 - 516. DOI:10.5897/AJEST2017.2275.

[16] Junge, B., Deji, O., Abaidoo, R., Chikoye, D., and Stahr, K. 2009. Farmers' adoption of soil conservation technologies: a case study from Osun State, Nigeria. *The Journal of Agricultural Education and Extension*, 15(3): pp 257 - 274. DOI:10.1080/13892240903069769

[17] Kebede, M., Shimbir, T., Kasa, G., Abera, D., and Girma, T. 2017. Description, characterization and classification of the major soils in Jinka Agricultural Research Center, South Western Ethiopia. *Journal of Soil Science and Environmental Management*, 8(3): pp 61 - 69. DOI:10.5897/JSSEM2015.0498

[18] Kim, S. and Gwak, Y. 2016. Factors affecting Soil moisture spatial variability for a humid forest hillslope. *Journal of Hydrological Processes*, 31(2): pp 431 - 445 DOI:10.1002/hyp.11039

[19] Kurayemen, C., Gyata, B. A., and Emmanuel, A. 2013. Minimizing effect of land degradation in South East Nigeria. *Mediterranean Journal of Social Sci.*, 4(15): pp 93- 98. (Retrieved from www.mcser.org/journal/index.php/mjss/article/viewfile/2360/2335)

[20] Landon, J. R. 1991. Booker Tropical Soil Manual: A handbook for Soil Survey and Agricultural Land evaluation in the Tropics and Subtropics. Longman Scientific and technical Essex, New York, pp. 94 – 95 and pp. 447- 474.

[21] Liang, X., Liakos, V., Wendroth, O. and Vellidis, G. 2016. Scheduling irrigation using an approach based on the Van Genuchten model. *Agricultural Water Management,* 176(2016): pp 170 - 179. www.elsevier.com/locate/agwat

[22] Maiangwa, M. G., Ogunbile, A. O., Olukosi, J. O., and Atala, T. K. 2007. Land degradation: theory and evidence from the North West Zone of Nigeria. *Journal of Applied Sciences,* 7(6): pp 785 - 795. (Retrieved from https://scialert.net/abstract/?doi=jas.2007.785.795)

[23] Mgbenka, R. N., Ozor, N., Igbokwe, E. M., and Ebe, F. 2012. Soil and water conservation capabilities among farmers and extension agents in Eastern Region of Nigeria. *African Journal of Agricultural Research*, 7(1): pp 58 - 67. (Retrieved from http://www.academicjournal.org/AJAR)

[24] Mohanty, A., Mishra, K. N., Roul, P. K., and Dash, S. N. 2015. Influence of conservation agriculture production system on soil organic carbon, bulk density and water stable aggregates in a tropical rain-fed agro ecosystem. *Ecology,* 5(4): pp 111 - 114. (Retrieved from www.researchgate.com)

[25] Nina-sinkam, S. C. 1995. Land and Degradation and Desertification in Africa. (Retrieved from www.fao.org/docrep/x5318e/x5318eo2.html)

[26] Ogbodo, E. N. (2011). Assessment of soil fertility characteristics of Abakaliki urban flood plains of South-East Nigeria for sustainable crop production. *World Journal of Agricultural Science*, 7(4): pp 489 - 495. (Retrieved from https://pdfs.semanticscholar.org)

[27] Owombo, P. T., and Idumah, F. O. 2015. Determinants of land conservation technologies adoption for arable farmers in Nigeria; A multinomial logit approach. *Journal of Sustainable Development*, 8(2): pp 220 - 229. DOI:10.5539/jsd.v8n2p220

[28] Pani, P. (2017). Ravine erosion and livelihoods in semi-arid India: implications for socio-economic development. *Journal of Asian and African Studies,* 53(3): pp.437- 454. DOI:10.1177/0021909616689798

[29] Pimentel, D. 2006. Soil erosion: A food and environmental threat. *Journal of Environment, Development and Sustainability,* 8: pp 119 - 137. DOI:10.1007/s10668-005-1262-8

[30] Reeb, J., and Milota, M. 1999. Moisture Content by the Oven Drying Method for Industrial Testing. Retrieved from https://ir.library.oregonstate.edu. (Assessed on January 20, 2019)

[31] Rowell, D. 1994. Soil Science Methods and Applications, 1st Edition. Pearson Education limited, pp.79 - 86.

[32] Sena, K. N., Maltoni, K. L, Faria, G. A. and Cassiolato, A. M. R. 2017. Organic carbon and physical properties in sandy soil after conversion from degraded pasture to eucalyptus in the Brazilian Cerrado. *Revista Brasileira de Ciência do Solo,* 41: pp 1- 12. DOI:10.1590/18069657rbcs20150505

[33] Spiegel, M. R. and Stephen, L. J. 2007. Statistics, 4th edition. McGraw Hill companies Inc.; USA, pp 403 - 412. DOI:10.1036/0071485848

[34] SPSS (2013). A Simple guide to IBM SPSS Statistics for Versions 20.0 and 21.0. Australia; Belmont, CA: Wadsworth.

[35] Teressa, D. 2017. The effectiveness of stone bund to maintain soil physical and chemical properties; the case of Weday watershed, East Harage zone, Oromia, Ethiopia. *Journal of Civil and Environmental Research*. 9(12): pp 9 - 18. (Retrieved from www.iiste.org/journals/index.php/cer/article/viewfile/40279/41425)

[36] Twum, E. K. A and Nii-Annang, S. 2015. Impact of soil compaction on bulk density and root biomass of *Quercus petraea* L. at reclaimed post-lignite mining site at Lusatia, Germany. *Journal of Applied and Environmental Soil science,* 2015: pp 1 - 5. DOI:10.1155/2015/504603

[37] United States Department of Agriculture. 2017. Soil Electrical Conductivity: Soil quality kit guide for educators.

[38] Van Reeuwijk, L.R. 2002. Procedures for Soil Analysis, 6th edition, Technical paper 9. Wageningen, The Netherlands.

[39] Wolka, K. 2014. Effect of soil and water conservation measures and challenges for its adoption: Ethiopia in focus. *Journal of Environmental Science and Technology,* 7(4). pp 185-199. DOI:10.3923/jest.2014.185.199

OSOBINE ZEMLJIŠTA UZROKOVANE OBJEKTIMA ZA ZAŠTITU ZEMLJIŠTA I VODE , OBLAST IKOT AKPAN RAVINE, UYO, NIGERIA

Ifechukwude I. Ahuchaogu[1], Godwin A. Usoh[2], Rose E. Daffi[3], James M. Umana[1]

[1]Department of Agricultural and Food Engineering,
University of Uyo,Akwa Ibom State, Nigeria.
[2-]Department of Agricultural Engineering, Akwa Ibom State University, Nigeria,
[3]Department of Civil Engineering, University of Jos, Plateau State, Nigeria.

Apstrakt: Degradacija zemljišta je veliki izazov za poljoprivredu u Nigeriji. Uspostavljene su konzervacijske mere očuvanja zemljišta kako bi se popravile degradirane oblasti. Efikasnost ovakvih mera u poboljšanju osobina zemljišta nije realno i detaljno proučavano u Nigeriji, posebno u oblasti Uyo, država Akwa Ibom.

Ovim istraživanjem je procenjen uticaj mera za zaštitu zemljišta i vode (mehaničke mere: nasipi, terase, kontrola obala potoka i reka) u oblasti depresije (i vododerina) Ikot Akpan zbog očuvanja osobina zemljišta.
Ukupno je prikupljeno 12 uzoraka zemljišta sa (parcele sa tretmanima) i ne primenjenim konzervacijskim merama (parcele bez tretmana).
Urađena su ispitivanja zemljišta za utvrđivanje najvažnijih osobina zemljišta. Jednosmerna statistička analiza varijanse (ANOVA) opšteg linearnog modela pri α=0.05, pokazuje da postoji značajna razlika između dva primenjena tretmana zemljišta na parcelama .
Rezultati su pokazali da neke konzervacione mere pozitivno utiču na sadržaj frakcije peska (80,84 ± 1,26%, 81,07 ± 1,90%), frakcije praha (13,70 ±3,30%, 11,41 ± 2,53%) i vrednost pH (6,51 ± 0,26).
Međutim, na zapreminsku masu zemljišta (2,33±0,27g/cc, 2,38±0,16g/cc) i elektro provodljivost (00,12±0,02ds/m) primenjene konzervacijske mere, uticale su negativno.
Ostale osobine zemljišta kao:
sadržaj frakcije gline (7,71 ±2,54%, 7,79 ± 1,02%),
raspoloživi fosfor (30,12 ±4,55 mg/kg, 44,81 ± 9,28 mg/kg),
pristupačni azot (0,05 ±0,01%, 0,25%).
sadržaj vlage (5,48 ±0,96%, 5,68 ± 0,85%),
organski ugljenik (1,97 ± 0,04%, 1,95 ± 0,11%),
efektivni kapacitet izmene katjona (ECEC) (13,85 ± 4,30 cmol/kg, 15,76 ± 2,06 cmol/kg) i zamenljive baze, nisu bile pod uticajem konzervacijskih mera.
Konzervacijske mere su bile veoma efikasne u kontroli erozije zemljišta i smanjenju gubitka zemljišta.
Treba podsticati praksu očuvanja zemljišta.

Ključne reči: *Nasipi i terase, osobine zemljišta, konzervaciono, nekonzervaciono, ANOVA, konzervacija zemljišta.*

Prijavljen:
Submitted: **06.11.2021**.
Ispravljen:
Revised: **22.01.2022**.
Prihvaćen:
Accepted: **03.03.2022.**

Univerzitet u Beogradu
Poljoprivredni fakultet
Institut za poljoprivrednu tehniku
Naučni časopis
POLJOPRIVREDNA TEHNIKA
Godina XLVII
Broj 2, 2022.
Strane: 31 – 43

University of Belgrade
Faculty of Agriculture
Institute of Agricultural Engineering
Scientific Journal
AGRICULTURAL ENGINEERING
Year XLVII
No. 2, 2022.
pp: 31 – 43

UDK: 620.91:631.147

Original Scientific paper
Originalni naučni rad
DOI:10.5937/POLJTEH2202031S

DEVELOPMENT OF PHOTOVOLTAIC PROTOTYPE DEVICE FOR ESTIMATING PROJECTED LEAVES AREA

Sehsah M. E*[1], El-Baily M.M[2], S. Abu Zaher[3]
.
[1,3]*Kafr El Sheikh University, Faculty of Agriculture,*
Department of Agricultural Engineering, Egypt
[2] *Agricultural Engineering Research Institute, Dokki, Giza, Egypt*

Abstract: The aim of the current study was to developed a solar leave area meter to measure leaves area fast and accurate of Guava and Lemon leaves. As well as, validated this method by comparing it with the mechanical planimeter model Placom standard leaf area, image processing method and leaf area meter model (LI-COR, 30000A). This technique is depending on a projected area on the photovoltaic solar panel that change of the produced electric power due to the captured light. The accuracy and precision of this method were compared to that of a digital mechanical drawing planimeter method. The result indicated that the maximum accuracy percent of the area was 99.92 % and 99.60 % for using leaf area meter model (LI-COR, 30000A) and mechanical Planimater method respectively. On the other hand, the maximum accuracy percent of the area was 96.82% and 100% using a developed solar area meter and standard LiR COR instrument respectively.

Keywords*: Solar energy, Image process, Leaf area,*

INTRODUCTION

Many agricultural studies require rapid and accurate leaf area and defoliation measurements. Calculating leaf area removed as a result of insect herbivory can be useful for evaluating host plant resistance [13], pesticide activity [26], and plant-insect interactions [10]. Prior studies measuring herbivory have used visual estimates [22], hand tracings of injured [11] or a comparison of treated leaves to an appropriate control [26].

*Corresponding Author. E-mail: sehsah_2000@yahoo.de

Plant leaves condition and leaf area are an important variable within land ecosystems mainly concerning the interception of solar light and its conversion into biochemical energy. The leaf area can be measured by destructive methods based on leaf detachment planimetric, gravimetric, and non-destructive methods based on measurements or imagery calculation method, scanning method, imaging method [6]; [8]. Measuring leaf area is time-consuming and costly depending on the chosen method and/or the precision needed. Easy, rapid, accurate, non-destructive estimation of plant leaf areas offers researchers reliable and inexpensive alternatives in horticultural experiments. However, the interception of solar radiation is directly conditioned by the leaf area index (LAI) and the architecture of the plant canopy elements. Moreover, the photosynthetic process depends not only on the interception of light energy but also on the plant efficacy in its conversion into chemical energy [32]. The total leaf area of a plant is, in turn, measured or predicted by many approaches based on destructive and non-destructive methods as mentioned above. One way to use leaf area information is by the adoption of the LAI which is the relation of the leaf area with respect to the canopy projection in the soil expressed in m2/m2, [5]. Considered LAI, [19] as a biophysical variable used in global models of the climate, ecosystem productivity, biogeochemistry, hydrology, and ecology. Aligned with that, [23, 24] considered the LAI as a key variable in models related to carbon and water dynamics. There are many techniques to estimate the LAI or the total leaf area from isolated plants or a forest. The techniques based on optical approaches are the most widely adopted and developed, considering their reliability in contrast with destructive methodologies [23,24], [2], [9], which are hugely time-consuming and are quite impossible to use in large and medium plants.

An optical instrument used [2]; the LAI-2000 (LI-COR, 1992), a plant canopy analyzer, to calculate the LAI and the plant area index (PAI), considering that equipment as “one of the most commonly used optical instruments to estimate LAI by measuring the amount of diffuse radiation that infiltrates the canopy”. The use of LAI is relevant to get information in small plants as pointed out by [2]; [27]; where direct methods are most feasible considering the low number of leaves. Authors,[28], evaluated the LAI-2000 (LI-COR, 1992) to obtain the leaf area index in a paddy-rice (*Oryza sativa L.*) crop, and accounted for the saturation problems presented in the results related to the low density of the rice canopy. Authors [29], the use of hemispherical photography to present an optical alternative to predict the LAI of olive trees in contrast to direct methods with total defoliation of the plants. Hemispherical photography was also presented by [14] as an optical alternative to get the LAI. The adoption of optical approaches in medium-size crop plants, up to our knowledge, are rare in the literature, and the few accounts observed, such as the work of [30], used commercial equipment with a modest amount of data, and without any possibility to get favourable statistical treatment of the large variability usually observed in these sort of indirect analysis. The area of a leaf can be obtained by indirect, non-destructive methods, such as mathematical models or equations that estimate, with reasonable accuracy, leaf area as a function of linear dimensions (such as length, width and/or the product of both).

The ease and speed of execution and low cost are important (independent of modern, expensive equipment) because these methods do not destroy the plant, and this allows measurements to be made several times on the same individual sample [20], [1], [17], [15].

Recent research was conducted to develop equations that relate the diminutions of the leaf to the leaf area of some fruit trees, such as passion fruit [18], mango [15], apple [4], acerola [16] and vines [3], with a high degree of accuracy.

However, there are no reports on the estimation of leaf area in guava, and for this fruit, leaf area could be an important tool for assessing growth, productivity and phytosanitary treatments.

The Lemon (*Citrus Limon*) is a species of a small evergreen tree in the flowering plant family and is produced in Egypt in a large area. In Egypt Guava (*Psidium guajava. L*) occupies about 38000 feddan, yielded about 314000 tons as annual fruit production with an exported range about 1631238 metric tons to many countries [12]. Since the 1950s, guavas – particularly the leaves – have been studied for their constituents, potential biological properties, and history in folk medicine [31]

Objectives: The aim of this paper was to develop an accurate solar leaf area meter. As well as comparing two measuring instruments to determine the highest accuracy. We validated this method by comparing the results with the mechanical planimeter model Placom standard leaf area, image processing method and leaf area meter model (LI-COR, 30000A).

MATERIAL AND METHODS

Mechanical method

The Roller-Type Electronic Digital Planimeter made by Placom is an instrument was used to measure the surface area of an arbitrary two-dimensional shape. This method was used and recommended by [19].

Imaging process method

The software ImageJ V1.52 and digital camera Cannon ™ Powershot 45S was used to estimate the leaves area. ImageJ is a public domain Java image processing program inspired by the National Institutes of Health U.S.A. The ImageJ program can calculate area and pixel value statistics of user-defined selections. It can measure distances and angles. All analysis and processing functions are available at any magnification factor. ImageJ was designed with an open architecture that provides extensibility via Java plug-in. With the object outlined, the surface area was calculated by selecting the measure option [19].

Standard Commercial equipment Leaf Area Meter

Commercial equipment LAI-3000 (LI-COR, 30000A) in Sacha research station and all the data assembled were validated using a destructive method, considered as a standard. Thirty mature plants of Guava and Lemon crop were observed with direct and indirect methods, and models were proposed comparing with the actual leaf area from the Leaf Area Meter (Li-COR Li30000A) which has been shown to have a precision of 99% (LI-COR, 2006) compared with total defoliation measurement.

Developed solar leaves area device

The solar leaves area device consists of a black box made from PVC opened from the bottom side and fixed in the internal top side 15 LED lamp connected in three rows as the source of light that projected on the solar panel photovoltaic in bottom side. The bottom side of the black box was jointed with a small photovoltaic model Mono-crystalline silicon 18V, 36W no-load voltage 18-23VDC and Load voltage 18V to obtain the dark box inside, as well as it is connected in the electrical circuit. The block 9 Volte dry battery was used and connected with the switch as the power source of the 15 LED lamps. The electricity circuit of the device was presented as shown in figure1. The Tektronix Oscilloscope Model TPS 2024 and digital multi-meter 345 were used to measure the output voltages from the solar panel photovoltaic under different tests conditions. The two different measuring instruments were compared to know the accuracy of the developed solar leave device area meter as shown in figure 2.

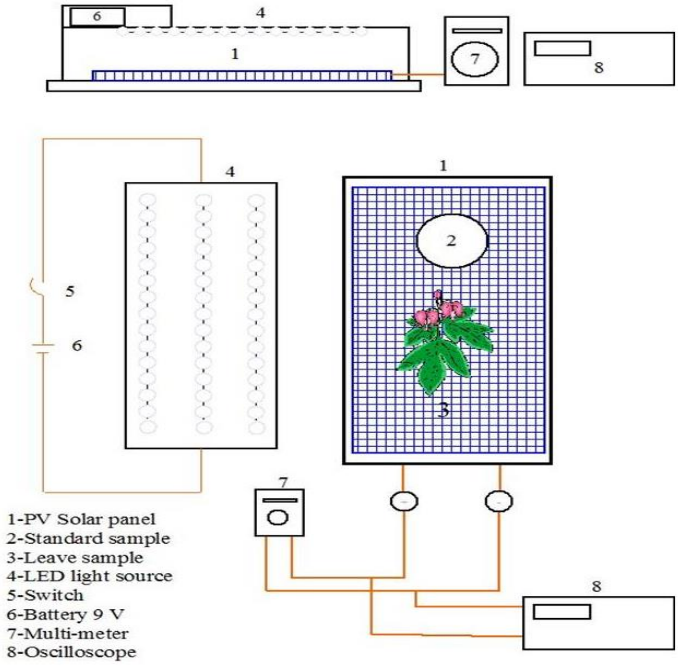


Fig.1. The components and the electrical circuit of the developed solar leaves area meter

Experimental design and data analysis

The accuracy and precision of leaf area estimates were compared from the different methods: developed solar panel leaves area device, imaging process integrated with imageJ V1.52 software, and camera, mechanical method estimates from the planimeter with portable area meter model Li-COR Li30000A.

Three separate tests were conducted using circle filter paper cards Macherey Nagel, (MN) with known area 4 cm diameter (12.56 cm^2), a single leaf, and multiple leaves. In the first test, one, two and four MN were used to evaluate the precision as shown in figure 3. The different trails test of both instruments oscilloscope and multi-meter to obtain a high accuracy were used to estimate a known area of MN (12.56, 25.12 and 50.24 cm^2). every trial was scanned three times with the Planimeter and the digital camera and area meter model Li-COR Li30000A. Descriptive statistics were used to compare the accuracy (mean) and precision (standard error of the mean, SEM) of each method.

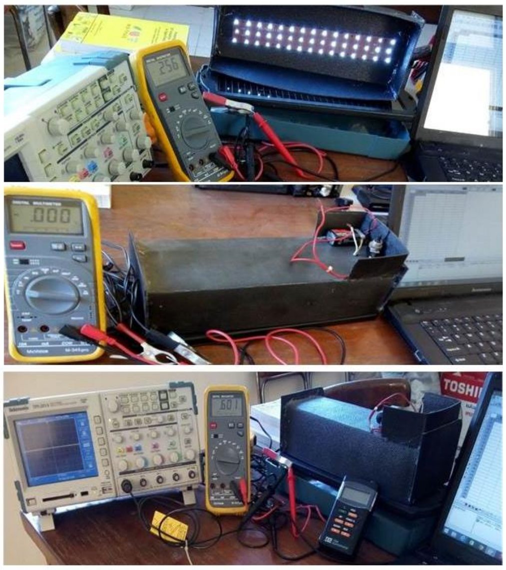


Fig.2. The developed solar leaf area meter and the instruments to measure the power and voltage

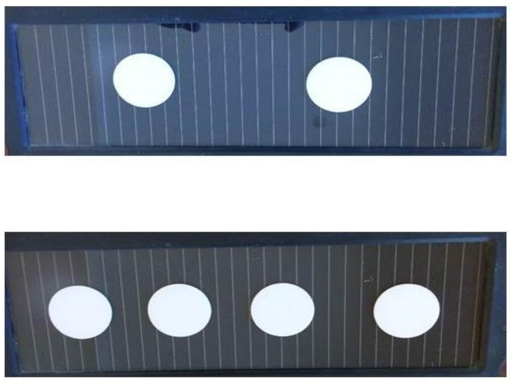


Fig. 3. The standard filter paper (Macherey Nagel, MN 4 cm diameter)
and solar panel to measure the accuracy of leaf area.

Assuming the solar cell panel with an average 10% and that average of solar energy measured by solar power meter and recorded reaches the panel was w/m2 .The following equation was used to estimate the Leaves area.

Where is:

$P_{1\ available}$= P* eff.* A_o……………………………………………… (1)

A_o projected area of standard panel

P measured solar output power in the device, W/m^2

$P_{2\ available}$= P* eff.* A_1……………………………………………… (2)

A_1 projected area of the panel when measured the leaf, cm^2

P_2 measured output solar power in the device, (W)

Leaf area= (P_1* $A_{o\ solar\ panel}$ -P_2* $A_{o\ solar\ panel}$)/X_1……………..…….. .(3)

= $A_{o\ solar\ panel}$ * ((P_1 -P_2)/P_1………………………………..... (4)

The current output was measured; it was constant value 3 A (ampere) from the panel then the leaf area could be calculated as:

Leaf area = $A_{o\ solar\ panel}$ * (V_1 -V_2)/V_1…………………………..…… (5)

Where as:

V_1 voltages output at $A_{o\ solar\ panel}$, (V)

V_2 voltages output at $A_{1\ solar\ panel}$, (V)

RESULTS AND DISCUSSION

The result of the current research presented that the different tests to find the leaf area by using a developed solar panel leaves area compared with three different leaves area methods.

Calibration of a developed solar area meter

Table 1 indicates the measured values of output voltages from the solar panel by two different instruments under different conditions. The formula (4) used to estimate the leaf area by subtracting the values from table 1. To determine the accuracy of the developed solar area meter, the standard MN were used in with five replicates to measure the output voltages and after that estimating the area using equation (4) due to the change of the solar panel projected area.

Table 1. The output voltages values from the solar panel by using two different instruments under different conditions

Trail		Output voltages V					
		1 card		2 card		4 card	
		Osci.	Multi-meter	Osci.	Multi-meter	Osci.	Multi-meter
P2		8.54	8.58	8.35	8.29	7.53	7.47
		8.52	8.57	8.13	8.08	7.31	7.26
		8.53	8.51	8.13	8.12	7.32	7.30
		8.53	8.59	8.03	8.11	7.24	7.18
Av		8.53	8.57	8.13	8.08	7.31	7.26
P1		8.93	8.89	8.93	8.89	8.93	8.89
		8.93	8.89	8.93	8.89	8.93	8.89
		8.93	8.89	8.93	8.89	8.93	8.89
		8.93	8.89	8.93	8.89	8.93	8.89
Av		8.93	8.89	8.93	8.89	8.93	8.89

After testing the accuracy of a developed solar leaves area meter by using the standard know areas MN, a developed solar leaves area used to measure the leaves area for both *Citrus Limon* and *Psidium guajava. L*, three leaves from guava trees and lemon were collected and measured by different methods developed solar leaves area device, imaging process software, mechanical method planimeter and area meter model Li-COR Li30000A.

Fig. 4: Portable area meter model Li-COR Li30000A measured the area of lemon (*Citrus Limon*) and guavas (*Psidium guajava. L*)

The first test result of the calibration a developed solar area meter indicated that the using of oscilloscope compatible with solar panel gave a high accuracy value of leaves area for standard know area (filter papers). Table 2 indicated that the estimated area values by using two different instruments compared with standard MN under different conditions. Using the multi-meter with a developed solar panel gave low accuracy values of leaves compared to oscilloscope instrument. The average values of standard MN were 12.10 cm^2, 23.57cm^2 and 47.58 cm^2 for oscilloscope compared with 10.03 cm^2, 23.08 cm^2 and 47.58 cm^2 using the multi-meter.

The oscilloscope combined with solar panel recorded -4.8% area differences in al trials compared with -10.9% in the case of using the multi-meter. It is recommended to use a highly accurate instrument to measure the output power in developed solar area meter. It will guarantee better results and reliability calculating leaves area.

Table 2. The estimated area values by using two different instruments compared with standard filter papers (MN)

Trails	Filter papers area, cm^2					
	1 card		2 card		4 card	
	Osci.	Multi-meter	Osci.	Multi-meter	Osci.	Multi-meter
1	11.76	9.43	21.51	18.22	42.39	43.13
2	12.33	9.74	24.13	24.60	48.92	49.51
3	12.22	11.54	24.01	23.39	48.79	48.29
4	12.31	9.72	24.10	24.61	48.91	49.50
5	12.30	9.70	24.12	24.58	48.90	49.49
Ava.	12.10	10.03	23.57	23.08	47.58	47.98
Ac.area	12.56	12.56	25.12	25.12	50.24	50.24
Differ. %	-3.0	-20.2	-6.2	-8.1	-5.3	-4.5

The second test result of the calibration a developed solar area meter indicated that the using of oscilloscope combined with a developed solar area may be made a competition with the mechanical planimeter, image processing and leaf area meter model (LI-COR, 30000A) for the standard MN. Figure (3) indicated that the test area values by using different leaves area methods compared with the actual area for standard filter papers. The mechanical planimeter and leaf area meter model (LI-COR, 30000A) gave the highest accuracy to measure the known area of MN compared to the image processing method and a developed solar area meter. The area for 1, 2 and 4 MN were 12.50, 25.10, 50.44 cm^2 for using leaf area meter model (LI-COR, 30000A) compared with 12.10, 23.88, 48.70 cm^2 for using a developed solar area meter. The maximum accuracy percent of the area was 99.92 % and 99.60 for using leaf area meter model (LI-COR, 30000A) and mechanical Planimater method respectively. On the other hand, the maximum accuracy percent of the area was 96.34 for using a developed solar area meter as shown in figure 5 and table 3. A developed solar area meter may be able to apply as leaves area meter and it is not expansive compared with leaf area meter model (LI-COR, 30000A) and mechanical Planimater methods.

Table 3. Present the accuracy percent of different methods to measure the areas for standard filter cards.

Leaf area methods	Area, cm^2			Accuracy percent of area, %			
	1 MN	2 MN	4 MN	1 MN	2 MN	4 MN	LSD
Ac. area	12.56	25.12	50.64	100	100	100	0.24
Solar devl.	12.10	23.88	48.70	96.34	95.06	96.17	0.24
Li-COR	12.50	25.10	50.44	99.52	99.92	99.61	0.24
Image	12.06	24.72	49.34	96.02	98.41	97.43	0.24
Plani.	12.46	25.02	50.24	99.20	99.60	99.21	0.24

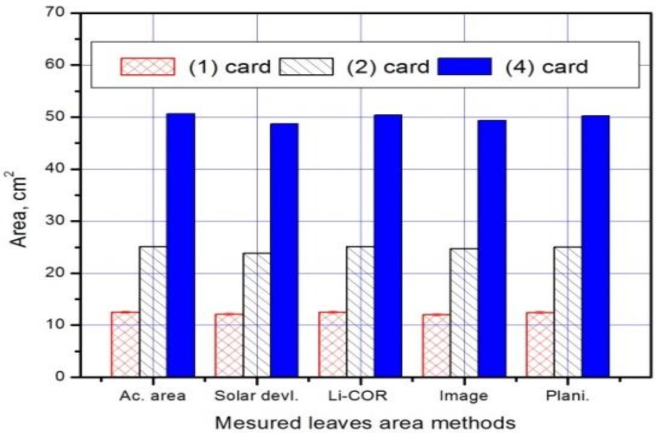


Fig 5: The test area values by using different leaves area methods compared with the actual area for standard filter papers.

Evaluation of a developed solar leaves area device

From the above results and tests, a developed solar leaves area device used to measure the leaves area for *Citrus Limon and Psidium guajava*. L. As well as, comparing the leaves area values measured by the developed device with Li-COR leaves area meter, imaging processing and mechanical planimeter method. Figure 6 illustrates the comparison between laves area methods planimeter, image processing, standard LiR COR instrument and a developed photovoltaic leaves area meter device for Guava and Lemon leaves. The leaves area of Guava and Lemon was 38.9 cm^2 and 14.17 cm^2 respectively by using the standard LiR COR instrument. The leaf area of Guava and Lemon was 37.66 cm^2 and 13.49 cm^2 respectively using a developed photovoltaic leaves area meter device comparing with 38.84 cm^2 and 13.67 cm^2 using image processing method as shown in figure 5 and table 4. The accuracy percent of the area of standard LiR COR instrument was used as a 100 % standard for leaf area of both plants. The accuracy percent of area of a developed photovoltaic leaves area meter device was 96.82% and 95.20 % for leaf area of Guava and Lemon respectively as shown in table 4. The developed device may be able to measure the leaf area of the plant with accuracy of 96.82%.

Table 4: Display the leaf area of Guava and Lemon using different Leaves area methods

Plant	Leaf area, cm^2				Accuracy percent of area, %			
	Li-COR	Plani-meter	Image Proc.	Solar Dev.	Li-COR	Plani-meter	Image Proc.	Solar Dev.
Guava	38.65	38.74	38.84	37.66	100.0	99.60	99.85	96.82
Lemmon	14.14	14.06	13.67	13.49	100.0	99.25	96.47	95.20

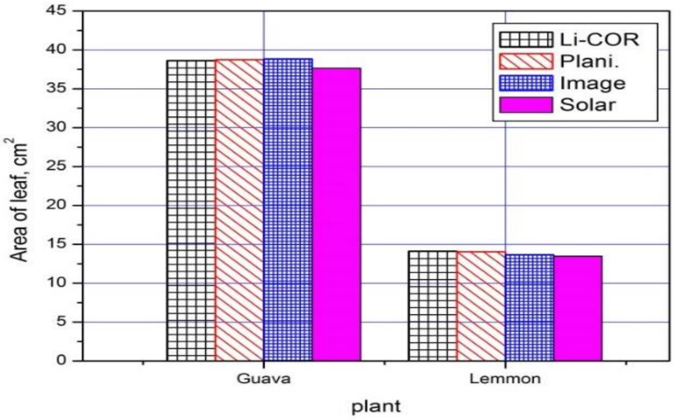


Fig. 6: The difference between laves area methods planimeter, image processing, and standard LiR COR instrument compared with developed photovoltaic leaves area meter for Guava and Lemon leaves.

CONCLUSIONS

The following conclusions are drawn from this investigation on developing the solar PV Planimeter. It is recommended to use a highly accurate instrument to measure the output power in developed solar area meter. It will guarantee better results and reliability calculating leaves area. The developed solar area meter able to estimate leaves area, offering accurate, rapid, and reliable method. It is not expansive compared with leaf area meter model (LI-COR, 30000A) and mechanical Planimeter methods. The developed device may be able to measure the leaf area of the plant with an accuracy of 96.82%. It is recommended to start of fabrication of the solar device leaf area meter; the device then should be integrated with high accuracy short electricity circuit for measuring the voltage and programing it to calculate the leaves area directly.

REFERENCES

[1] Araújo, E. C. E., Santos, E. P., & Prado, C. H. B. A. 2005. Leaf area estimation of mango (Mangifera indica L.) cvs tommy atkins and haden, using linear dimensions. Revista Brasileira de Fruticultura, 27(2), 308-30. https://doi.org/10.1590/S0100-29452005000200030.

[2] Arias, D.; Calvo-Alvarado J.and Dohrenbusch A. 2007) Calibration of LAI-2000 to estimate leaf area index (LAI) and assessment of its relationship withstand productivity in six native and introduced tree species in Costa Rica. Forest Ecology and Management, v.247, pp.185-193.
[3] Borghezan, M., Gavioli, O., Pit, F. A., & Silva, A. L. 2010. Mathematical models for the estimation of leaf area of grape varieties to the field (Vitis vinifera L.). Ciência e Técnica Vitivinícola, 25(1), 1-7.
[4] Bosco, L. C., Bergamaschi, H., Cardoso, L. S., & Paula, V. A. 2012. Selection of regression models for estimating leaf area of 'royal gala' and 'fuji suprema' apple trees under hail net and in open sky. Revista Brasileira de Fruticultura, 34(2), 504-514. https://doi.org/10.1590/S0100 29452012000200024
[5] Bréda, N. J. J. 2003. Ground-based measurements of leaf area index: a review of methods, instruments and current controversies. Journal of Experimental Botany, v.54, pp.2403-2417.
[6] Coelho Filho, M. A.; Angelocci, L. R.; Vasconcelos, M. R. B.; Coelho, E. F. 2005. Estimativa da área foliar de plantas de lima ácida 'Tahiti' usando métodos não-destrutivos. Revista Brasileira de Fruticultura, v.27, pp.163-167.
[7] De Boer, H.J. and Cotingting C. (2014). "Medicinal plants for women's healthcare in southeast Asia: a meta-analysis of their traditional use, chemical constituents, and pharmacology". J Ethnopharmacol. 151 (2): 747–67. doi:10.1016/j.jep.2013.11.030.
[8] Flumignan, D. L.; Adami, M.; Faria, R. T. 2008. Área foliar de folhas íntegras e danificadas de cafeeiro determinada por dimensões foliares e imagem digital. Coffee Science, v.3, p.1-6,
[9] Garrigues, S. NShabanov. V., Swanson K., Norisette J. T., Baret F., and Myneni R. B.2008. Intercomparison and sensitivity analysis of Leaf Area Index retrievals from LAI-2000, AccuPAR, and digital hemispherical photography over croplands. Agricultural and Forest Meteorology, v.148, pp.1193-1209.
[10] Hammond, R. B., Higley L. G., Pedigo L. P., Bledsoe L., Spomer S. M., and Degooyer T. A.. 2000. Simulated insect defoliation on soybean: inßuence of row width. Journal of Econ. Entomol. 93: 1429-1436.
[11] Hoy, C. W., and Hall F. R.. 1993. Feeding behavior of Plutella xylostella and Leptinotarsa decemlineata on leaves treated with Bacillus thuringiensis and esfenvalerate. Pestic.
[12] Ismail, O. M., Abd El-Moniem, A. E., Abd-Allah, A. S. E., & M. A. A. El-Naggar, (2010). Influence of some post-harvest treatments on guava fruits. Agric. Biol. JN Am, 1(6), 1309-1318.
[13] Jansky, S., Austin-Phillips S., and McCathy C.1999. Colorado potato beetle resistance in somatic hybrids of diploid interspeciÞc Solanum clones. Hortic. Sci. 34: 922-927.
[14] Jonckheere, I.; Fleck, S.; Nackaerts, K.; Muys, B.; Coppin, P.; Weiss, M.;Baret, F. 2004. Review of methods for in situ leaf area index determination: Part I. Theories, sensors and hemispherical photography. Agricultural and Forest Meteorology, v.121, pp.19-35.
[15] Lima, R. T. D., Souza, P. J. O. P., Rodrigues, J. C., & Lima, M. J. A. 2012. Models for estimating leaf area of mango, using linear measures. Revista Brasileira de Fruticultura, 34(4), 974-980. https://doi.org/10.1590/ S0100-29452012000400003
[16] Lucena, R. R., Batista, T. M. V., Dombroski, J. L. D., Lopes, W. A. R., & Rodrigues, G. S. O. (2011).Measurement of acerola leaf area. Revista Caatinga, 24(2), 1-5.
[17] Maldaner, I.C., Heldwein, A.B., Loose, L.H., Lucas, D.D.P., Guse, F.I., & Bortoluzzi, M.P. 2009. Models for estimating leaf area in sunflower. Ciência Rural, 39(5), 1356-1361. https://doi.org/10.1590/S0103-847 82009000500008
[18] Morgado, M. A. D. O., Bruckner, C. H., Rosado, L. D. S, Assunção, W., & Santos, C. E. M. 2015. Estimação da área foliar por método não destrutivo, utilizando medidas lineares das folhas de espécies de Passiflora1.Revista Ceres, 60(5), 662-667. https://doi.org/10.1590/S0034-737X2013000500009.
[19] Sehsah, E.E. and Hassen H. 2015. Imaging Process Technique to Evaluate the Incidences of Insect Pests. International Journal of Agriculture Innovations and Research. Vol. (4) No. (2) 2319-1473.

[20] Silva, L. C., Santos, J. W., Vieira, D. J., Beltrão, N. E. M., Alves, I., & Jerônimo, J. F. 2003. A simple method to estimate leaf area of sesame plants (Sesamum indicum L.). Revista Brasileira de Oleaginosas e Fibrosas, 6(1), pp.491-496.
[21] Simões, M. P.; Pinto-Cruz, C.; Belo, A. F.; Ferreira, L. F.; Neves, J. P.; Castro, M. C. 2007. Utilização de fotografia hemisférica na determinação do índice de área foliar de oliveiras jovens (Olea europaea L.). Revista de Ciência Agrárias, vol.30, p.527–534.
[22] Stotz, H. U., Pittendrigh B. R., Kroymann J., Weniger K., Fritsche J., Bauke A., Mitchell-Olds T.. 2000. Induced plant defense responses against chewing insects: ethylene signaling reduces resistance of Arabidopsis against Egyptian cotton worm but not diamondback moth. Plant Physiol. 124: 1007D1019.
[23] Stroppiana, D.; Baschetti, M.; Confalonieri, R.; Bocchi, S.; Brinio, P. A. 2006. Evaluation of LAI-2000 for leaf area index monitoring in paddy rice. Field Crops Research, v.99, p.167-170.
[24] Stroppiana, D.; M. Baschetti,. R. Confalonieri, S. Bocchi,.and P. A. Brinio. 2006. Evaluation of LAI-2000 for leaf area index monitoring in paddy rice. Field Crops Res., v.99, pp.167-170.
[25] Tavares Júnior, J. E.; Favarin, J. L.; Dourado Neto, D.; Maia, A. H. N.; Fazuoli, L. C.; Bernardes, M. S. 2002. Análise comparativa de métodos de estimativa de área foliar em cafeeiro. Bragantia, v.61, pp.199-203,
[26] Wheeler, D. A., and Isman M. B. 2001. Antifeedant and toxic activity of Trichilia americana extract against the larvae of Spodoptera litura. Entomol. Exp. Appl. 98: 9-16. Received for publication 19 February 2002; accepted 26 June 2002.
[27] Setiyono T.D., Weiss A., Specht J.E., .Cassman K.G, Dobermann A. 2008. Leaf area index simulation in soybean grown under near-optimal conditions. Field Crops Research Vol.108, Issue 1. pp.82-92.
[28] Daniela Stoppiana; Mirco Boschetti, Roberto Confalonieri, Stefano Bocchi, Pietro Alessandro Brivio. 2006. Evaluation of LAI-2000 for leaf area index monitoring in paddy rice. Field Crops Research Vol.99, pp.167-170.
[29] Martine Simoes, Jean Philippe Avouac,Olivier Beyssac, Bruno Goffe´,Kenneth A. Farley, Yue-Gau Chen. 2007. Mountain building in Taiwan: A thermokinematic model. Journal of Geophysical Research, Vol. 112, pp.1-25. B11405, doi:10.1029/2006JB004824.
[30] Angelocci, L. R.; Marin, F. R.; Pilau, F. G.; Righi, E. Z.; Favarin, J. L. 2007. Radiation balance of coffee hedgedrows. Revista Brasileira de Engenharia Agrícola e Ambiental, Vol.12, pp.274-281.
[31] Hugo J. de Boer, Crystle Cotingting. 2014. Medicinal plants for women's healthcare in southeast Asia: A meta-analysis of their traditional use, chemical constituents, and pharmacology. Journal of Ethnopharmacology.Vol.151, Issue 2. pp. 747-767.
[32] Taiz, L. and Zeiger, E. 2013. Fisiologia Vegetal. 5th Edition, Artmed, Porto Alegre, 918

RAZVOJ FOTONAPONSKOG PROTOTIPA UREĐAJA ZA PROCENU PROJEKTOVANJA POVRŠINE LIŠĆA

Sehsah M. E[1], El-Baily M.M.[2]., S. Abu Zaher[3]

.

[3]*Kafr El Sheikh University, Faculty of Agriculture*
Department of Agricultural Engineering, Egypt.
[2] *Agricultural Engineering Research Institute, Dokki, Giza, Egypt*

Apstrakt: Cilj ove studije je razvoj solarnog uređaja za meranje površine lišća za brzo i precizno određivanje površine listova za Guavu (*Psidium guajava L*) i Limun (*Citrus Limon*).

Metoda je potvrđena upoređenjem sa modelom mehaničkog planimetra Placom standard kod određeivanja površine lista, metodom obrade slike i modelom merenja površine lista (LI-COR, 30000A).
Ova tehnika zavisi od veličine površine na fotonaponskom solarnom panelu koja izaziva promenu proizvedenog (indukovanog) električnog impulsa, zbog usmerenja svetlosti prema površini lista.
Tačnost i preciznost ove digitalne metode je upoređena sa metodom mehaničkog planimetra Placom standard.
Rezultat je pokazao da je najveći procenat tačnosti metode izmerene površine od 99,92 % i 99,60 % kod korišćenja modela LI-COR, 30000A, u odnosu na metod Mehaničkog planimetara, respektivno
Sa druge strane, najveći procenat tačnosti određivanja površine lista je 96,82% i 100% korišćenjem razvijenog solarnog tipa planimetra u odnosu na standardni LiR COR instrumenta, respektivno .

Ključne reči: *Solarna energija, procesiranje slike, površina lista*

Prijavljen:
Submitted: **01.12.2021.**
Ispravljen:
Revised: **10.02.2022.**
Prihvaćen:
Accepted: **01.03.2022.**

Univerzitet u Beogradu
Poljoprivredni fakultet
Institut za poljoprivrednu tehniku
Naučni časopis
POLJOPRIVREDNA TEHNIKA
Godina XLVII
Broj 2, 2022.
Strane: 44 – 50

University of Belgrade
Faculty of Agriculture
Institute of Agricultural Engineering
Scientific Journal
AGRICULTURAL ENGINEERING
Year XLVII
No. 2, 2022.
pp: 44 – 50

UDK: 338.43.1.

Pregledni rad
Review paper
DOI: 10.5937/PoljTeh2202044S

THE IMPORTANCE OF DETERMINING THE RELATIONSHIP BETWEEN POORLY RECORDED AND ARCHIVED CONTRACTS, DECISIONS, OPINIONS AND INSTRUCTIONS IN RELATION TO THE INTRODUCED FORM OF ARCHIVING IN AGRICULTURAL ENTERPRISES IN REPUBLIC OF SERBIA

Slobodan Stanojević*[1], Dejan Jeremić[2]

[1]Faculty of Applied Management, Economics and Finance, Jevrejska 24-1,
11000 Belgrade, Republic of Serbia
[2]College of Management and Economics, Karadjordjeva 52,
34000 Kragujevac, Republic of Serbia

Summary: Emphasizing the importance of establishing the link between poorly archived 4 forms of documentation in relation to the introduced form of archiving in agricultural enterprises in Serbia is one of the important issues in the movement of documentation in these companies. The authors analyzed 4 forms of documentation, namely: contracts, solutions, opinions and instructions on archiving in relation to the two forms of archiving documentation in companies (a new way of archiving - electronic and classic way of archiving documentation). The focus of the research of the authors of this study was the question of discovering a possible connection between poor record keeping, i.e. poor archiving of documentation in an agricultural company and the established form of archiving in the mentioned companies. The authors conducted research in 144 agricultural enterprises, and the results they obtained indicate that much fewer errors occurred in the case of electronic archiving of documentation (about 100% fewer errors) compared to classical archiving in agricultural enterprises.

Keywords: Documentation, error, electronic archiving.

*Coresponding Author. Email: sloba_leo@yahoo.com

INTRODUCTION

In the studies of numerous authors that deal with the practical functioning of companies, the importance of real management in companies is essentially emphasized. This means that top management should make valid business decisions but they must be based on valid documentation that accompanies business decisions.

One of the important forms of improving corporate governance in Focus is following the problems of documentation movement in companies, but within that monitoring of documentation movement it is necessary to point out that continuous care is taken to reduce real risks for decision makers in companies [1-5].

The observation of management in companies is closely related to the making of key management decisions by top management, especially in large companies that have the characteristics of corporate companies [6-10].

In the practical functioning and observation of business, especially of manufacturing companies, the observation of keeping records in companies, which is based on as few risks as possible, i.e. as few errors as possible at all stages of documentation movement in companies, is becoming more and more pronounced [11-15].

The basis for the existence of a properly organized system of movement of documentation, as well as for the proper storage of all forms of documentation in companies lies in the formation of a realistic accounting policy in companies [16].

Only when a large number of companies, especially companies operating in primary agricultural production, manage to realistically establish the movement of documentation in them can significant expectations be expected in the socio-economic sense [17].

MATERIALS AND METHODS

For the purposes of this study, the authors conducted a survey in 144 agricultural companies in the Republic of Serbia during the first half of 2021. A survey was conducted with which the authors of the study wanted to discover and gain insight into the actual archiving of documentation in companies.

In order to achieve that, the authors first guaranteed that they would not publish the generals of the company, but that they would use the data obtained in the survey for the preparation of this study and for other purposes.

The aim of this research was to discover the real movement of four forms of documentation in companies in terms of archiving, i.e. it was monitored through two forms of archiving, namely classic archiving and electronic archiving, which is a fundamentally new way of archiving documentation in these companies.

In addition to the stated primary goal, the authors of this study also set an auxiliary goal, which is to determine the difference in terms of errors in archiving documentation in relation to the two forms of archiving in agricultural enterprises.

This was achieved through the use of classical statistical processing, where through detected errors, as well as their (%) in two forms, the documentation was classified into four forms of documentation: contracts, solutions, opinions and instructions that are regularly used in the business of surveyed companies.

After that, the authors explained the presentation of all four forms of archiving and the detected errors that occur during archiving in agricultural companies through a graphic presentation.

RESEARCH RESULTS

The obtained results regarding the determination of the connection between bad records, i.e. poor archiving of documentation in an agricultural enterprise, are presented by the authors through descriptive indicators.

They are presented according to the number of errors that occur during the archiving of documentation, namely: contracts, solutions, opinions and instructions in two forms of archiving in the mentioned companies. Namely, the authors made the observation in relation to the new way of archiving documentation (electronic archiving of documentation - a new way of archiving in companies) and by presenting the classic archiving of documentation in agricultural companies.

After the presentation in Table 1, authors made a graphical presentation to express the mentioned connections even more clearly, all with the aim of clearer presentation of the analyzed connections in terms of tracking errors that occur when archiving and archiving documentation in real business (Figure 1).

Table 1: Overview of descriptive indicators regarding the number of errors related to archiving: contracts, solutions, opinions and instructions in the electronic office and the classic office of an agricultural enterprise

Error filing and archiving documentation		Form of filing and archiving documentation			
		Electronic office		Classic office	
		Frequency	%	Frequency	%
Contract	NO	79	98.8%	62	96.9%
	YES	1	1.3%	2	3.1%
The solution	NO	79	98.8%	61	95.3%
	YES	1	1.3%	3	4.7%
Opinion	NO	78	97.5%	59	92.2%
	YES	2	2.5%	5	7.8%
Instruction	NO	77	96.3%	58	90.6%
	YES	3	3.8%	6	9.4%

Source: Authors' calculation (2021).

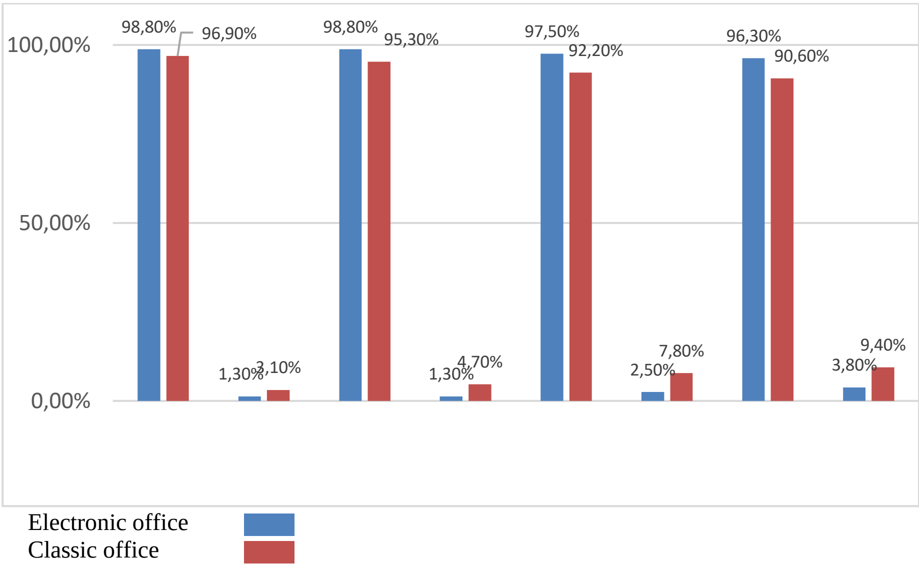


Figure 1: Graphic presentation of differences in errors in archiving contracts, solutions, opinions and instructions in the electronic and classic office of the company
Source: Authors' calculation (2021).

DISCUSSION

Comparing the results given in Table 1 (crossing) of different documents (contracts, solutions, opinions and instructions), he sees that there is no statistically significant difference in the number of errors in relation to the type of document and archiving of documentation in agricultural enterprises in relation to the form of office companies (electronic and classic offices in agricultural companies).

In general, the success of archiving is over 90%, regardless of the form of the introduced office in the agricultural company. Regardless of the 4 analyzed types of documents that are archived. It can be noticed that there is a certain tendency of difference.

The obtained results indicate that the least errors during archiving are in contracts and solutions, in companies that have adopted an electronic office for filing documentation. There are slightly more errors in the form of opinion documents and instructions in the same form of archiving in agricultural enterprises.

The obtained results also indicate that the least errors during archiving are in contracts and solutions, in companies that have adopted the classic office of filing documentation. There are slightly more errors in the form of opinion documents and instructions in the same form of archiving in agricultural enterprises, but it must be pointed out that the number of errors in this form of archiving is almost 100% higher than in electronic archiving of agricultural enterprise documentation.

Authors point out that it is noticeable that the fewest mistakes are made when archiving contracts, and the most when archiving instructions, especially in companies that have a classically organized office in companies.
The obtained results of the author's research largely coincide with the obtained results of archiving and movement of documentation in very heterogeneous forms of manufacturing companies as well as with the results that can primarily be related to doing business in public companies [18] local self-government in the Republic of Serbia.

CONCLUSION

The importance of establishing the connection between poorly recorded and archived contracts, solutions, opinions and instructions in relation to the introduced two forms of archiving in agricultural enterprises in Serbia has been proven in this paper by the authors of this study. Namely, it can be clearly seen that the obtained results indicate several important conclusions, namely: First, that a much smaller number of errors during archiving occur in the electronic office of an agricultural company than in a classic office. Secondly, a smaller number of errors occur in the archiving of contracts and decisions, in both forms of archiving documentation. Third, the classic office makes more mistakes in all 4 forms, namely in contracts, solutions, opinions and instructions. Fourth, the number of errors in the classic office is almost 100% higher than the number of archiving errors in all 4 observed types of documentation analyzed by the authors in this study. Fifth, there is a real need to switch to an electronic office in terms of archiving the documentation of an agricultural company, because the number of archiving errors is reduced by switching to a new way of archiving documentation.

Disclosure statement
No potential conflict of interest was reported by the Authors.

REFERENCES

[1] Allen, J. 2010. „Depth-charge in the archive: the documentation of performance revisited in the digital age“, Research in Dance Education, 11(1), pp. 61-70.
[2] Chen, R. 2019. „Internal Control Audit Fee and Internal Control Audit Quality—Evidence from Integrated Audits“, Open Journal of Business and Management, 7, pp. 292-311.
[4] Cantino, V. 2009. Korporativno upravjanje, merenje performansi i normativna usaglašenost sistema internih kontrola, Beograd, Data Status.
[5] Damodaran, A. 2007. Korporativne finansije: teorija i praksa, Podgorica, Modus.
[6] Williams, C. 2010. „Principi menadžmenta“, Beograd: Data Status.
[7] Popović S, 2015. Implementacija heterogenih rizika u radu interne revizije, Revizor 69/2015.
[8] Williams, C. 2012. „On The Record: Towards a Documentation Strategy“, Journal of the Society of Archivists, 33(1), pp.23-40.
[9] Popović, S., Tošković, J., Majstorović, A., Brkanlić, S., Katić, A. 2015. The importance of continuous audit of financial statements of the company of countries joining the EU,
Annals of the „Constantin Brâncuşi” University of Târgu Jiu, Economy Series, Special Issue, pp.241-246.

[10] Popović, S., Novaković, S., Đuranović, D., Mijić, R., Grublješić, Ž, Aničić, J. & Majstorović, A. (2017). Application of international accounting standard-16 in a public company with predominantly agricultural activities, Economic Res.-Ekonomska Istraživanja, 30(1):1850–1864.
[11] Radović, M., Vitomir, J. & Popović, S. 2021. Impact of internal control in enterprises founded by local self government units: the case of Republic of Serbia, Inzinerine Ekonomika-Engineering Economics, 32(1): 82–90.
[12] Swarts, J. 2015. „Help is in the Helping: An Evaluation of Help Documentation in a Networked Age", Technical Communication Quarterly, 24(2), pp.164-187.
[13] Nikolić, G. 2020. „Does it make sense to deepen the economic cooperation of the western balkan economies?", Economic Research-Ekonomska Istraživanja, 33(1), 3453-3475.
[14] Fusco, F. & Ricci, P. 2019. „What is the stock of the situation? A bibliometric analysis on social and environmental accounting research in public sector", Int.Journal of Public Sector Management, 32(1), pp. 21-41.
[15] Panikarova, S. 2019. „Analysis of the effectiveness of the regional innovation system. A case study on polyethnic regions of the Russian Federation", Transylvanian Review of Administrative Sciences, Special Issue 2019, pp. 41-58.
[16] Mijić, R. & Popović, S. 2016. „Finansijsko Računovodstvo", Banja Luka: City print.
[17] Popović S. 2014. Socio-ekonomski faktori ograničenja razvoja agrara, Monografija, Fimek, Novi Sad.
[18] Radović, M., Vitomir, J., Laban, B., Jovin, S., Nastić, S., Popović, V. & Popović S. 2019. Management of joint stock companies and farms by using fair value of agricultural equipment in financial statements on the example of IMT 533 Tractor, Economics of Agriculture, 1: pp. 35-50.

ZNAČAJ UTVRĐIVANJA VEZE IZMEĐU LOŠE EVIDENTIRANIH I ARHIVIRANIH UGOVORA, REŠENJA, MIŠLJENJA I UPUTSTAVA U ODNOSU NA UVEDENI OBLIK ARHIVIRANJA U POLJOPRIVREDNIM PREDUZEĆIMA U REPUBLICI SRBIJI

Slobodan, Stanojević[1], Dejan Jeremić[2]

[1]Fakultet za primenjeni menadžment, ekonomiju i finansije,
Jevrejska 24-1, 11000 Beograd, Republika Srbija,
[2]Visoka škola za menadžment i ekonomiju,
Karadjordjeva 52, 34000 Kragujevac, Republika Srbija,

Sažetak: Isticanje značaja utvrđivanja veze između lošeg arhiviranja i to 4 oblika dokumentacije u odnosu na uvedena dva oblika arhiviranja u poljoprivrednim preduzećima u Srbiji jedno je od bitnih pitanja u posmatranju kretanja dokumentacije u pomenutim preduzećima. Autori su analizirali 4 oblika dokumentacije i to: ugovore, rešenja, mišljenja i uputstva po pitanju arhiviranja i to u odnosu na dva obika arhiviranja dokumentacije u preduzećima (nov način arhiviranja – elektronski i klasičan način arhiviranja dokumentacije). U fokusu istraživanja autora ove studije bilo je pitanje otkrivanja eventualne veze između loše vođenje evidencije, odnosno lošeg arhiviranja dokumentacije u poljoprivrednim preduzećima i uspostavljenog oblika vođenja arhiviranja u preduzećima.

Autori su uradili istraživanje u 144 poljoprirvredna preduzeća, a rezultati do kojih su došli ukazuju na to da je mnogo manje grešaka nastalo u slučaju elektronskog arhiviranja dokumentacije (oko 100% manje grešaka) u odnosu na klasično arhiviranje sva četiri oblika dokumentacije u poljoprivrednim preduzećima.

Ključne reči: *Dokumentacija, greška, elektronsko arhiviranje.*

Prijavljen: **06.11.2021.**
Submitted: .
Ispravljen: **12.12.2021.**
Revised:
Prihvaćen: **02.03.2022.**
Accepted

Univerzitet u Beogradu
Poljoprivredni fakultet
Institut za poljoprivrednu tehniku
Naučni časopis
POLJOPRIVREDNA TEHNIKA
Godina XLVII
Broj 2, 2022.
Strane: 51 – 57

University of Belgrade
Faculty of Agriculture
Institute of Agricultural Engineering
Scientific Journal
AGRICULTURAL ENGINEERING
Year XLVII
No.2, 2022.
pp: 51 – 57

UDK: 338.43.1.

Pregledni rad
Review paper
DOI: 10.5937/PoljTeh2202051A

THE IMPORTANCE OF BUSINESS DECISION-MAKING OF TOP MANAGEMENT IN AN AGRICULTURAL COMPANY THAT USES THE PRACTICAL APPLICATION OF NEW APPROACHES TO SOFTWARE SOLUTIONS IN THE IT SECTOR IN THE REPUBLIC OF SERBIA

Ivan Arnautović[1], Tatjana Davidov[2], Sanda Nastić[3], Slobodan Popović*[4]

[1] High School of Entrepreneurship, Majke Jevrosime 15, 11000 Beograd, Serbia
[2] Info-stan Technologies d. o. o. Narodnih heroja 30, 11000 Beograd, Serbia
[3] Public utility company „Tržnica", Žike Popovića 4, 21000 Novi Sad, Serbia
[4] Public utility company „Gradsko Zelenilo", M. Leskovca 1, 21000 Novi Sad,R.Serbia

Summary: Valid making important business decisions is of particular importance in agricultural companies. Top management in agricultural companies should be in an innovative mood for the application of new technical solutions that will facilitate the business of the company and through which it will achieve better business results. In this paper, the Authors emphasize the importance of using new approaches regarding the practical application of software solutions in agricultural companies. Business management decisions of top management can be based on the application of new software solutions. The application of new software solutions in agricultural companies is related to the processes of previously established internal control processes in the regular operations of the mentioned companies. In this paper, the Authors emphasized the importance of developing software solutions whose application leads to a better overall business in an agricultural enterprise in a safe way.

Key words: *agricultural enterprise, business, software application.*

*Corresponding Author. Email: slobodan.popovic49@gmail.com

INTRODUCTION

Modern business decision-making in agricultural companies in the Republic of Serbia requires top management to implement new business solutions whose application can significantly improve corporate governance [1], [2], [3].

In such conditions, business management may involve the application of new software solutions. This is of great importance for the business of companies that operate in agriculture, because the turnover of capital in such companies is far less than in other activities such as: industry, trade and others.

The application of new software solutions is of special importance, especially in conditions when it is desired to improve the overall management through the use of developed new software applications [4]. Management decisions of top management should be based on the application of realistic and rational business decisions [5], [6], which will include the application of innovative technical solutions. In such solutions, the application of new and specialized software solutions can mean the improvement of the overall business of the agricultural company in a very short time.

The application of business decision-making of top management in agricultural companies should include the introduction of numerous standards in all parts of the agricultural company [7], [8], [9].

In addition, the improvement of business decision-making means the introduction and application of new technical solutions such as the application and implementation of new software solutions. Top management should adopt the application of new software that is very often developed by specialized software companies [10].

In this paper, the Authors emphasize the importance of software development according to the requirements of the top management of the agricultural enterprise towards the software development company. The required software solutions should correspond to the development of the business of the agricultural enterprise (service provider).

METHODOLOGIES RELATED TO THE APPLICATION OF SOFTWARE SOLUTIONS IN AN AGRICULTURAL ENTERPRISE

The long-term (development) goal of software engineering development in agricultural enterprises is primarily aimed at finding new, predictable processes or methodologies, which would raise the level of productivity and quality of development flows and ready-made software solutions.

Based on that, it can be concluded that the software project management process is a very responsible task that is primarily done for the needs of the agricultural company by software companies that develop software within the given deadline and in relation to the received budget.

Therefore, successful management of software projects is a very demanding job, both in relation to the set time and in relation to the costs approved by the client or agricultural company. It is most often used in the practice of making and developing software, the so-called waterfall model.

Namely, it is one of the traditional models in the development of software solutions, with a sequential approach.

The mentioned model has its positive and negative effects on the final product, i.e. on the delivered software to the client, i.e. to the agricultural company.

Clients and software companies are constantly looking for finding a more flexible, faster, cheaper and more modern way of understanding the development of software solutions. In addition, software companies should evaluate the so-called "good" practice of software solutions development according to:

• iterative software development,
• managing user and development team requirements,
• use of component architecture,
• language for visual modeling,
• continuous assessment of the quality of development solutions and finished products,
• change management.

The research was done in the first half of 2021, in 72 agricultural companies in the Republic of Serbia, with the aim of revealing the vision of the top management of the mentioned companies regarding the introduction of software solutions in companies.

This was done in such a way that it was proposed that 4 groups of influences (factors) namely: analysis of software application problems, understanding user needs, system definition and possible system scope and timely management of user request changes, evaluation of top management through the evaluation interval of 1-10 And through a description in relation to the three levels of impact (low, Medium and high impact) on the purchase of a software solution.

REALISTIC APPLICATION OF GOOD BUSINESS PRACTICE REGARDING THE IMPLEMENTATION OF SOFTWARE IN AGRICULTURAL ENTERPRISES

Good business practice regarding the implementation of software in agricultural enterprises depends on the desire and resources that top management wants to invest. In this sense, the Authors presented in Figure 1, which presents the possibility of a general scheme that will know how to apply software development in agricultural companies that are committed to the application of innovative solutions for the application of software in management processes.

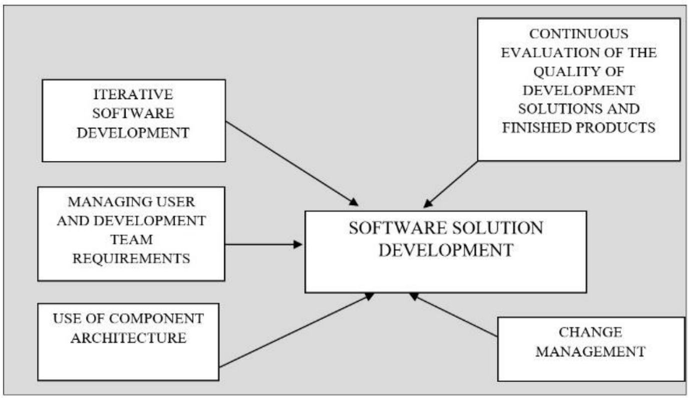


Figure 1. Development of software solutions in the system of "good practice" in agricultural enterprises

Below, the Authors provide an overview of the relationship between software development and the practical requirements of top management who are important software buyers.

The Authors present some of the important factors influencing the software solutions intended for the market of agricultural companies that want to buy software solutions for the business of their companies in Table 1.

Table 1. Overview of factors influencing software solutions intended for the agricultural company's market

Factors influencing software solutions of agricultural companies	Top management rating	
	Average rating of top management (in the range of 1-10)	Descriptive assessment of top management on the level of significance of the impact on the market-based software package of an agricultural enterprise
Analyzes software application problems	4,3	Low level
Understanding user needs	6,2	Intermediate level
System definition and possible system scope	6,1	Intermediate level
Timely management of user request changes	7	Intermediate level

General overview of factors influencing software solutions in agricultural companies that are in demand in the market, the Authors presented:

$$ASAP + I = ETP \quad (1)$$

$$UUN + I = ETP \quad (2)$$

$$SDS + I = ETP \quad (3)$$

$$TMU + I = ETP \quad (4)$$

Where symbols are marked:

ASAP = Analyzes software application problems;
UUN = Understanding user needs;
SDS = System definition and possible system scope;
TMU = Timely management of user request changes;
I = Influence;
ETP = assessment of top management.

DISCUSSIONS

Modern management of agricultural enterprises implies making valid business decisions of top management. In agricultural companies, valid business decision-making in the Republic of Serbia is becoming more and more important, and real and valid management increasingly depends on real applications of software solutions developed by IT companies for the needs of agricultural companies.

Requests for the development of new software solutions are obtained by order of the top management of the company, which are also called service customers.

Thus observed flow of the implementation of new software solutions leads to the optimization of management decisions of top management of agricultural enterprises in terms of business decision-making in agricultural enterprises.

Based on the presentation in Table 1, it is clear that the analysis of the software solution is the worst evaluated by top management, because the ocean average is 4.3 (low level of impact), while in the other 3 factors the impact is at the level of medium level of impact. All this indicates that there is a high level of misunderstanding of the overall issue regarding the introduction of software in agricultural companies in Serbia.

CONCLUSION

Making business decisions in agricultural companies in the Republic of Serbia increasingly depends on the real application of software solutions approved by the top management of the company. The aim of the paper was to emphasize the importance of introducing new processes that could improve the business result in the regular operation of agricultural enterprises. In this particular case, the Authors focused on the application of new software solutions according to the requirements of top management while maintaining a realistic framework (means-time of implementation of new software). Within Figure 2, the Authors presented frequently used factors, namely: analysis of software application problems, system definition and possible scope of software application system, understanding of user needs (agricultural enterprise), numerous management of changes in user requirements (agricultural enterprise). In addition to the basic contribution of the Authors who emphasized the importance of applying these 4 factors, the Authors emphasized the importance of the continuous process of applying software solutions to the general business of an agricultural enterprise. The comprehensive development of new software solutions in the mentioned companies is of great importance for the existence of the expected business success in the companies that decide to apply the software, especially within the regular functioning of the agricultural company.

The study indicates that in the future, top management must be further educated in the field of practical application of software solutions in the functioning of agricultural enterprises.

REFERENCES

[1] Popović S, 2015. Implementacija heterogenih rizika u radu interne revizije, Revizor 69/2015.

Popović, S., Novaković, S., Đuranović, D., Mijić, R., Grublješić, Ž, Aničić, J. & Majstorović, A. (2017). Applicationof international accounting standard-16 in a public company with predominantly agricultural activities, Economic Research-Ekonomska Istraživanja, 30(1):1850–1864.

[2] Radović, M., Vitomir, J., Laban, B., Jovin, S., Nastić, S., Popović, V. & Popović S. 2019. Management of joint stock companies and farms by using fair value of agricultural equipment in financial statements on the example ofIMT 533 Tractor, Economics of Agriculture, 1: 35-50

[3] Popović, S., Tošković, J., Majstorović, A., Brkanlić, S., Katić, A. 2015. The importance of continuous audit of financial statements of the company of countries joining the EU, Annals of the „Constantin Brâncuşi" University of Târgu Jiu, Economy Series, Special Issue, pp. 241-246.

[4] Toković, T.2011. Softverske komponente u razvoju arhitektura poslovnih aplikacija, Magistarska teza, Ekonomski Fakultet u Subotici.

[5] Radović, M., Vitomir, J. & Popović, S. 2021. Impact of internal control in enterprises founded by local self government units: the case of Republic of Serbia, Inzinerine Ekonomika-Engineering Economics, 32(1): 82–90.

[6] Cantino, V. 2009. Korporativno upravjanje, merenje performansi i normativna usaglašenost sistema internih kontrola, Beograd, Data Status.

[7] Bojović, R., Popović, V., Ikanović, J., Živanović, Lj., Rakaščan, N., Popović, S., Ugrenović, V. & Simić, D.2019. Morphological characterization of sweet sorghum genotypes across environments, The Journal of Anim. Plant Sciences, 29 (3): 721-729.

[8] Terzić, D., Popović, V., Malić, N, Ikanović, J, Rajičić, V., Popović, S., Lončar, M. & Lončarević. V. 2019.Effects of long-term fertilization on yield of siderates and organic matter content of soil in the process of recultivation, The Journal of Anim. Plant Sciences. 29 (3): 790-795.

[9] Ugrenović, V., Popović, V., Ugrinović, M., Filipović, V., Mačkić, K., Ljubičić, N., Popović, S. & Lakić, Ž.2021. Black Oat (*Avena strigosa Schreb*.) Ontogenesis and Agronomic Performance in Organic Cropping System and Pannonian Environments, *Agriculture* 2021, 11(1): 55.

[10] Williams, C. 2010. Principi menadžmenta, Data Status, Beograd.

ZNAČAJ POSLOVNOG ODLUČIVANJA TOP MENADŽMENTA U POLJOPRIVREDNOM PREDUZEĆU KOJA KORISTE PRAKTIČNU PRIMENU NOVIH PRISTUPA SOFTVERSKIH REŠENJA IT SEKTORA U REPUBLICI SRBIJI

Ivan Arnautović[1], Tatjana Davidov[2], Sanda Nastić[3], Slobodan Popović[4]

[1] Visoka strukovna škola za preduzetništvo, Majke Jevrosime 15, 11000 Beograd, Republika Srbija
[2] Info-stan Tehnologije d.o.o. Narodnih heroja 30, 11000 Beograd, R. Srbija
[3] Javno komunalno preduzeće "Tržnica", Žike Popovića 4, 21000 Novi Sad, R.Srbija
[4] Javno komunalno preduzeće „Gradsko Zelenilo", Mladena Leskovca 1, 21000 Novi Sad, Republika Srbija

Sažetak: Validno donošenje važnih poslovnih odluka je od posebnog značaja u poljoprivrednim preduzećima.

Top menadžment u poljoprivrednim preduzećima trebalo bi da bude inovativno raspoložen za primenu novih tehničkih rešenja pomoću čije primene će moći olakšati poslovanje preduzeća i pomoću čije primene će ista ostvariti bolje poslovne rezultate.

U ovom radu autori ističu važnost korišćenja novih pristupa u vezi praktične primene softverskih rešenja u poljoprivrednim preduzećima. Donošenje poslovnih odluka top menadžmenta može se zasnivati na primeni novih softverskih rešenja. Primena novih softverskih rešenja u poljoprivrednim preduzećima povezana je sa procesima prethodno uspostavljenih procesa interne kontrole u redovnom poslovanju pomenutih preduzeća. Autori su u ovom radu naglasili značaj razvoja softverskih rešenja pomoću čije se primene se na siguran način dolazi do boljeg ukupnog poslovanja u poljoprivrednom preduzeću.

***Ključne reči**: Poljoprivredno preduzeće, poslovanje, primena softvera.*

Prijavljen: **06.09.2021.**
Submitted:
Ispravljen: **21.12.2021**.
Revised:
Prihvaćen: **01.03.2022.**
Accepted:

Univerzitet u Beogradu
Poljoprivredni fakultet
Institut za poljoprivrednu tehniku
Naučni časopis
POLJOPRIVREDNA TEHNIKA
Godina XLVII
Broj 2, 2022.
Strane: 58 – 71

University of Belgrade
Faculty of Agriculture
Institute of Agricultural Engineering
Scientific Journal
AGRICULTURAL ENGINEERING
Year XLVII
No. 2, 2022.
pp: 58 – 71

UDK: 631.51:631.44

Original Scientific paper
Originalni naučni rad
DOI: 10.5937/PoljTeh2202058O

ANALYSIS OF ENERGY OF DIFFERENT OLIVE CULTIVATION SYSTEMS IN A SEMIARID REGION

Sakine Ozpinar*

[a]Agriculture Faculty, Canakkale Onsekiz Mart University,
17020 Canakkale, Republic of Turkey

Abstract: The objective of this study was to determine the input-output energy of olive cultivation in a semiarid region of Çanakkale, Republic of Turkey. Data were collected from olive farmers by a questionnaire for traditional-flat/sloping and intensive-flat systems in last growing season. The results revealed that net energy gain was higher in intensive system than in traditional flat and sloping ones. Similarly, energy ratio was higher in intensive by 1.46 MJ ha^{-1} than in sloping and flat of traditional by 1.42 and 1.38 MJ ha^{-1}, respectively. The highest energy productivity was recorded in the intensive (0.93 MJ ha^{-1}), but the lowest was in the traditional-sloping (0.75 MJ ha^{-1}), and then in the traditional-flat (0.92 MJ ha^{-1}). Indeed, the intensive system produced higher olive yields which allow using a higher level of fertilizer, water and mechanization, but also the energy analysis revealed that its efficiency in the energy was higher than two traditional systems. The results suggested that intensive system could be a better cultivation system in flat areas for the region farmers in an increasingly competitive without worsening environmental sustainability.

Keywords*: Energy, land situation, olive cultivation, semiarid.*

INTRODUCTION

The olive (*Olea europaea* L.) is known as a drought-resistant tree with a less than 200 mm, but high olive yields can be obtained in rainfed areas where annual rainfall is up to 600 mm [1].

*Corresponding Author. E-mail: sozpinar@comu.edu.tr

In worldwide, olive grows more than 10 million hectares, of which 98% are located in country of Mediterranean basin [2]. Approximately, 20 million ton of olives were produced worldwide, 77% of which were harvested in the basin including Spain, Italy, Greece, Portugal, Tunisia, Turkey, Morocco, Syria, and Egypt [3]. Turkey is fifth country of world having around 846 thousand hectares with approximately 180 million trees. Olive cultivating is mostly concentrated in the southwest part of the country where the Aegean, Mediterranean and southern Marmara areas. Canakkale is one of the regions in the southern Marmara and represents 3.8% (32340 hectares) of the cultivating area and 5.2% (103 thousand ton) olive production [4]. Olive is the most widespread crop in the region, but its cultivation is far from homogeneous due to the structural variables; these are the age and density of the tree, cultivation system (rainfed, irrigated) as traditional or intensive, the slope of hilly (mountains, flat). In the region, the traditional systems are typically located in mountainous on frequently found on sloping areas (≥20%) and represent around 50% of the olive cultivation area [4]. These systems characterised with the lack of mechanization associated with low density, resulting from the wide spacing between trees, low olive production by unit of ground (1800 kg ha^{-1}).

Olive in sloping areas may also be a disadvantage because of the difficult access to cultivation factors such as weeding, fertilizing, spraying, harvesting, pruning and transporting. Unlike the sloping systems, traditional-flat systems found on moderately sloping areas (<20%) and occupies 35% of the olive cultivation area of the region. The traditional systems, especially on sloping, have high labour costs, due to the lack of mechanized agricultural practices, especially in harvesting [5].

In fact, cultivation systems in agriculture are not only energy user in one form or another, but they are also energy supplier in the form of bioenergy [6, 7]. Therefore, a comprehensive energy analysis is needed to specify for different crop cultivation systems which have the highest energy consumption to improve sustainable agriculture. In considering olive cultivation, it has faced augmentations in cultivation on the base of increasing consumptions of direct inputs mainly in the form of fuels and indirect inputs such as crop protection products and fertilizers [8]. Energy requirement for olive cultivation varies according to the system intensity and usually meets from fossil fuels which are decreasing steadily. Input energy must be reduced by improving the energy efficiency of cultivation from renewable sources, which tend to have positive impact of the environment. Several researchers have been conducted on energy analysis in different countries and regions for olive [6, 8, 9, 10, 11, 12, 13], but there is no study about energy analysis for traditional and intensive olive cultivation on sloping and flat (lowland) lands in a semiarid area of western Turkey. The purpose of the study was to investigate the input-output energy analysis per unit area in one growing period of olive cultivation, specifying a relationship between input-output energy and yield (olive fruit and pruning residues as main and by-product, respectively) in a region located in western Turkey.

It also identifies operations where energy savings could be achieved by changing current practices to increase the energy ratio and suggests improvements to reduce energy consumption for olive cultivation.

MATERIALS AND METHODS

Study Location and Experimental Design

The study was conducted in an area located in Canakkale region (39°30′-40°45′ N latitude and 25°35′-27°45′ E longitude). The region has a few plains due to lands in the foothill of mountain in topological view, while the altitude of the olive cultivation belt ranged from 8 to 388 m. These are 80-100 olive trees ha^{-1} in sloping and 140-299 olive trees ha^{-1} in flat, and 250-300 olive trees ha^{-1} in intensive-flat. Olive has been grown in the traditional way under rainfed conditions of the region, where long periods of soil water deficit are usually present during the dry season. The region is characterised by a semiarid climate with an annual rainfall of around 620 mm (mean 1975-2020) and an annual temperature ranging from 12 to 15 ºC, (average, National Meteorological Service). Olive cultivation based mainly on local varieties (Ayvalık), contributing to the maintenance of the regional agricultural biodiversity.

The data were collected from farmers by a questionnaire with face-to-face interviews in the study region during the last growing season. Most data were collected through farmers by means of specific and detailed questionnaires concerning with machinery/tool inventory (type, weight, power, dimensions, etc.).

Products used for each cultivation practice (type, quantity), inputs for setting up irrigation system (type of materials, diameter, weight, length), detailed description of each practice (performance, time, and efficiency, applied inputs, labour, transportation, machinery, etc.). Missing or incomplete data were obtained from current official statistical yearbook [4], literature reports of public agencies, the representatives of local management, manufacture of material agencies, expert knowledge (regional department of agriculture, technicians of farmer associations). The size of required sample was determined using Neyman method to collect data from the study region [14]. During the questionnaire survey, it was chosen 5-year-old olive trees as criterion due to the fact that olive is a perennial crop and its requirements, energy usage and output yield are not constant during its economic life. In the study region, inputs also vary according to olive cultivation systems being flat or sloping olive growing areas. The cultivation practices for traditional-sloping system were usually performed by the human labour except olive fruit transporting by tractor with trailer from olive growing area to the mill. In traditional-flat, inputs are human labour for almost all practices such as pruning, spraying, fertilizing, manuring, irrigation (flood), harvesting, tractor with trailer for transportation, when machinery are used rarely for tillage to control weed, but sometimes herbicides are used instead of tillage operations. On the other hand, cultural practices under intensive-flat system were performed usually by machinery, for example, soil management (plough, cultivator, disc or tine harrow, rotary tiller), the fuel consumption and the number of operations needed for weed control, and time in each operation. The output is only olive fruit yield and by-product including pruning residues (leaves and thin branches) as energy source [15].

Traditional-sloping has not usually used fertilizers, but the traditional-flat used a small amount of fertilizers, instead of it, the system has the highest consumption of farmyard manure. The inputs for fertilizers were mainly the nitrogen (N), phosphate (P_2O) and potassium (K_2O) with their application and distribution and transportation.

The fertilization varied in both traditional and intensive-flat systems, due to the use of different amounts and because of the different methods used for their applications (mechanical or manual). Harvesting is performed in the traditional systems with a hand-held combs and shakers, while it was performed by a combination of a tractor-mounted or self-propelled olive branch shakers and harvester from the ground in the intensive ones.

The inputs and outputs are evaluated and then converted into energy values by using appropriate energy conversation coefficients (Table 1). Energy conversation coefficient is a value which explains the input energy consumed in the production and distribution of a unit physical material. Then, classical mathematical equations (from 1 to 8) are used to estimate the equivalent energy sources of the olive cultivation systems.

Table 1. Energy conversion coefficient of different inputs and outputs

Item (unit)	$(E_{eq})^*$	Item (unit)	(E_{eq})
A. Inputs		5.Crop protection products (kg)	120 [16]
1.Human labour (h)	1.96 [16]	6. Water for irrigation (m^3)	1.02 [6]
2.Machinery (kg)	86.77 [17]	7. Electricity (kWh)	12.1 [20]
3. Fuel		8. Pruning (kg)	16.91 [7]
(a)Diesel (L)	47.78 [19]	10.Transportation (ton^{-1} km^{-1})	9.22 [18]
(b)Gasoline (L)	42.32 [19]	B. Outputs (kg)	
4. Fertilizers (kg)		Olive fruit (main product)	11.8 [7]
(a)Nitrogen (N)	78.1 [20]	Dry-pruning residues (by-product)	16.75 [7]
(b)Phosphate (P_2O_5)	17.4 [20]		
(c)Potassium (K_2O)	13.7 [20]		
(d)Farmyard manure (kg)	0.30 [16]		

*Energy conversion coefficient (MJ $unit^{-1}$).

The total energy per unit area in each olive cultivation system was determined as the summation of energy from all the sources [17].

$$\text{Total input energy} = E_f + E_m \quad (1)$$

Where, E_f, input energy in farm operations (MJ ha^{-1}); E_m, machinery energy (MJ ha^{-1}).

$$E_f = \sum_{k=1}^{k=r} (Phy + Chem + Bio)_k \quad (2)$$

Where, Phy, Chem and Bio are physical, chemical and biological input energy in farm operations k^{th} (MJ ha^{-1}); k, farm operation k^{th}. Physical energy was calculated as total input energy from human labour and mechanical power sources. N-P_2O_5-K_2O and crop protection products were considered as chemical input energy and their energy conversation coefficient are presented in Table 1.

Biological input energy includes seed and hormone which were no record data for those variables during questionnaire and were not considered. The general expression to calculate machinery energy as an integral part of the total input energy for olive cultivation is given in following equation:

$$E_m = \sum_{m=1}^{m=t} \frac{(M + T + R)}{L} \quad (3)$$

Where is:

E_m is machinery energy (MJ ha^{-1});
M is energy in manufacturing for machinery m^{th} (MJ),
the weight of machinery or equipment (kg) x 86.77 (MJ kg^{-1});
T is energy in transportation or distribution for machinery m^{th} (MJ), the weight of machinery or equipment (kg) x 8.8 (MJ kg^{-1}) [18];
R is energy in repair and maintenance for machinery m^{th} (MJ), energy in manufacturing (MJ) x conservation factor (6%);
L is the economic lifetime of the machinery m^{th} (h) [18].

The weight of machinery or equipment was received from brochures of various manufacturers. In calculation of tractor manufacturing and repair inputs, a single-wheeled of an average weight 915 and 2600 kg was taken for <45 hp and >45 hp, respectively. There is no exact lifetime for agricultural tractors and varies according to the average annual usage, level of service, and speed of technical and economic development. ASAE D497.5 gives a 12000 and 16000-hour lifetime for 2- and 4-wheel drive tractor, respectively. In Turkey, tractor operating inputs are calculated according to the value of 500-hour which assumed average annual usage. Available data for fuel consumption of machinery in unit area used for calculation of diesel fuel inputs. For tractor, there are no data available for diesel consumption of unit area (Table 1).
The amount of output energy (MJ ha^{-1}) estimated by multiplying the olive fruit (main product) and pruning residues (by-product) yield (kg ha^{-1}) by their energy conversation coefficient (MJ kg^{-1}) (Table 1).
Total output energy (MJ ha^{-1})=(Olive fruit yield x E_{eq}) + (Pruning yield x E_{eq}) (4)
The energy evaluation of in each olive cultivation system, the values of inputs and outputs energy and yield per unit area were used for obtaining the following energy indices [17].

$$\text{Energy ratio } (dimensionless) = \frac{\text{Output energy } (MJ\ ha^{-1})}{\text{Input energy}(MJ\ ha^{-1})} \quad (5)$$

$$\text{Energy productivity } (kg\ MJ^{-1}) = \frac{\text{Olive fruit yield } (kg\ ha^{-1})}{\text{Input energy}(MJ\ ha^{-1})} \quad (6)$$

$$\text{Specific energy } (MJ\ kg^{-1}) = \frac{\text{Input energy}(MJ\ ha^{-1})}{\text{Olive fruit yield } (kg\ ha^{-1})} \quad (7)$$

Net energy gain (MJ ha^{-1}) =Output energy (MJ ha^{-1})-Input energy (MJ ha^{-1}) (8)

There are two forms of input energy which are divided into direct and indirect. Direct energy is required to perform various tasks related to olive cultivation operations (tilling, fertilizing, spraying, irrigation, harvesting, transportation).
It represents the energy that are released directly from the sources in olive cultivation system (human or animal, fuel, water for irrigation, electricity) and it calculated by summation of their energies used in performing the operations.

Indirect energy consists of the energy used in the manufacture, packing and transport of fertilizers, plant protection products and farm machinery and it computed by summation of their energies used in performing the operations. Input energy also can be divided into another two groups, renewable and non-renewable energy.

Renewable energy consists of human labour, animal, farmyard manure and water for irrigation, and non-renewable energy includes fertilizers, plant protection products, diesel fuel, machinery, and electricity [6]. Fuel energy per unit area is a function of the quantity of the fuel consumed by the machinery used to power engines in performing the various operations in olive cultivation systems multiplied by an energy conversion factor. Input energy for family and hired labour (person) in olive cultivation systems was calculated based on the number of farm labours engaged in an operation per unit area. The energy for plant protection products is evaluated based on the quantity of the chemicals sprayed per unit area multiplied by an energy conversion coefficient (Table 1). The energy for fertilizers was estimated according to the quantity of fertilizer per unit area and the percentage composition of the basic primary elements contained in the fertilizer multiplied by an energy conversion coefficient for the compound fertilizers (N-P_2O_5-K_2O) (Table 1). Electricity energy refers to the electricity used to operate irrigation pump in the cultivation systems. The energy in irrigation water was evaluated based on the quantity of water used for irrigation in m^3 per unit area, then multiplied by an energy conversion coefficient (Table 1). Transportation energy per unit area is expressed as energy intensity per weight and unit of distance travelled, then multiplied by an energy conversion factor (Table 1). After harvesting, the olive fruits were transported to the olive mill and distance assumed equal to 10 km.

RESULTS AND DISCUSSION

Output energy includes olive fruit and pruning residues which were recorded different level in three olive cultivation systems (Table 2). The highest share of output energy found for olive fruit energy with 73.32% compared to the pruning energy with 26.68% in intensive-flat cultivation system (Table 2).

In contrast, the pruning energy was higher than olive fruit energy in traditional-sloping and flat systems by 91.52% and 54.11%, respectively. Both systems were provided the greatest amount of pruning energy compared with fruit energy, since the very ancient olive trees and their canopy volume (height and width) allows the obtaining a higher quantity of pruning residues. Total output energy in the intensive-flat system is higher than in both due to higher olive fruit yield with 8800 kg ha^{-1} and the greatest amount of pruning residues with 767 kg ha^{-1}, since the greater plant density allows the obtaining a higher quantity of plant residues in unit area.

Table 2. Inputs and outputs energy per unit area

Input/output	Traditional-sloping		Traditional-flat		Intensive-flat	
	(MJ ha^{-1})	(%)[a]	(MJ ha^{-1})	(%)	(MJ ha^{-1})	(%)
A. Inputs						
Human labour	6786.00	91.94	1145.00	8.01	964.32	3.09
Diesel fuel	191.20	2.59	1840.30	12.88	2876.47	9.22
Machinery	403.30	5.46	8238.00	57.64	22322.40	71.55
Chemical fertilizer			1848.00	12.93	2791.00	8.95
Nitrogen (N)			1562.00	84.52[b]	2343.00	83.95[b]
Phosphorus (P_2O_5)			121.80	6.59[a]	174.00	6.23[b]
Potassium (K_2O)			164.40	8.90[b]	274.00	9.82[b]
Farmyard manure			1192.00	8.34	596.00	1.91
Plant protection products			30.00	0.21	30.00	0.10
Water for irrigation					918.00	2.94
Electricity					600.00	1.92
Total energy input	7380.50	100.00	14293.30	100.00	31098.19	100.00
B. Outputs (through the cultivation period)						
Olive fruit (main product)	890.46	8.48	9055.79	45.89	33308.98	73.32
Pruning (by product)	9608.34	91.52	10675.93	54.11	12121.62	26.68
Total energy output	10499.00	100.00	19732.00	100.00	45431.00	100.00

[a] Percentage from input energy of total chemical fertilizer.

In contrast, olive fruit and pruning residues yield were lower in both traditional systems and recorded as 724 and 5544 kg ha^{-1} in flat, and 584 and 1820 kg ha^{-1} in sloping, respectively, when they are the predominant with the highest surface occupation in the region [4]. Regarding output energy, i.e., the amount of olive energy contained in the yield (main and by-product), it increases with the degree of intensification because of increasing olive production by 58.73% in intensive-flat respect to traditional-flat. Authors [21] showed that the traditional systems were characterized by higher production energy caused by lower yields.

Therefore, the traditional systems should improve their productivity by optimizing the use of farmyard manure and cover crop such as legumes during their growing period since certain good practices are not yet widely used by farmers in the studied area. Similar results were obtained by others in different countries [e.g., 12, 13] who concluded that high density olive tree systems return the highest amount of energy due to greater amount pruning residues. When comparing the results obtained by Authors [7] who collected pruned residues in olive growing area based on 278 tree ha^{-1} with 9.08 kg pruning weight per tree for high density cultivation systems (6x6 m planting density).

They were also recorded higher output energy (only pruning) with 153.5 MJ $tree^{-1}$ and 42672.2 MJ ha^{-1} than the results obtained from the present study. In terms of pruning residues by one hectare of surface on average 275 tree ha^{-1}, the higher amount of output energy would be obtained from the intensive cultivation system with 45431.0 MJ ha^{-1} (Table 2), followed by traditional-flat and sloping with 19732.0 and 10499.0 MJ ha^{-1}, respectively. There were differences between references and the results obtained from the study which may be the results of different climate conditions and pruning methods. Comparing the results obtained by Authors [7] who collected pruned residues in the olive trees 2524 kg ha^{-1} which is higher than in intensive-flat, traditional-flat and sloping systems by 767, 724 and 584 kg ha^{-1}, respectively. In general, the olive farmers in the studied region have no experience in preparation and use of pruning residues for producing energy. Therefore, there is a need for introducing new technologies in the use of this type of residues to produce energy for consumption at the regional level. It is clear that among the three olive cultivation systems, the traditional-sloping is the one that requires less amounts of input energy per hectare under rainfed conditions with large planting frames and steep slopes when compared to the other systems. Although some practices have been done by using hand-held pneumatic tools such as scissors and saws, the system is still characterised by very low productivity. Instead, the complete mechanization of the intensive-flat system involves a higher use of energy and material sources (31198.2 MJ ha^{-1}) than traditional-flat (14893.3 MJ ha^{-1}) and sloping (7380.5 MJ ha^{-1}). The higher energy use in intensive is explained by a larger number of practices and the increased mechanization of cultivation practices. In fact, in this system up to 71.55% of the energy consumption is due to the use of machineries (particularly maintenance, lubricants, and fuel). On the other hand, it was found that human labour was the major contributors to input energy in traditional-sloping and had the highest share of total input energy with the share of 91.94% because of the high human labour requirements in harvesting, pruning as well as transporting harvested olive fruits from orchard to transporting area. In this system, tree growing conditions such as inaccessibility of routes and excessive tree height and wide slow down tree maintenance and increasing the required hours of labour, but using mechanization allows the survival of this type of olive growing by reducing work energy [5]. Several researchers have shown that human labour is the most important energy consumption items in agricultural systems [e.g., 6, 8]. Authors [6] reported that the highest use of human labour was recorded in harvesting (56%) and pruning (23%) operations, while Authors [5] declared the similar results, labour input for the olive harvesting and pruning operations performed with non-mechanized methods have a high level on total growing expenses being around 50%. In fact, despite the higher use of inputs (water, fertilizers, crop protection products, etc.), the intensive-flat system shows lower labour inputs respect to the traditional systems completely due to the use of mechanization.

In particular, harvesting together with pest and weed control, consumed the largest amount of energy used (Table 2). Input energy in fertilizers recorded higher in traditional-flat and intensive-flat by 12.93% and 8.95%, respectively in total energy. In traditional and intensive olive cultivation systems on flat lands, excessive use of fertilizers usually occurs from lack of knowledge by farmers about their optimal dosage.
Most of farmers themselves were not aware of the actual amount of fertilizers to be applied to the olive.

Farmers often believe that increasing the amount of fertilizers will increase the fruit yield due to no-soil testing to determine the more accurate level of fertilizers and decrease their use. Additionally, in recent years, government fertilizer subsidies contributed to increased use of fertilizers in both annual and perennial crops in the region. According to Table 2, the nitrogen fertilizer had the greatest share from total fertilizer energy input with 84.52% and 83.95% in traditional and intensive, respectively, on flat lands due to its heavy usage in both systems. Authors, [13] reported that nitrogen fertilizer had the highest share from total energy input in their studies. In a study conducted by Authors. [12] obtained that the production and application fertilizer is the most production factors, which require a considerable amount of energy and constitutes 72% of the total input energy requirement for traditional centenary olive system. They also explained that this type of energy contribution is lower in both intensive and super-intensive systems which are distinguished by the high number of trees per unit area and by an intensive mechanization of cultivation practices. Authors [21] come to a similar conclusion with regard to using of fertilizers, which were clearly the highest contributor in all traditional and intensive olive growing systems due to the consumptions produced during the manufacturing processes and their application to the crop, mainly as nitrogen fertilizers. They also suggested that fertilization was the priority to optimize olive growing among all other inputs. Similarly, Authors [10] found that fertilizer application was one of the highest energy inputs in either traditional or intensive olive cultivation systems. Applying high quantity of nitrogen fertilizer which consumed 1562.0 and 2343.0 MJ ha^{-1} energy consumption (Table 2) for traditional and intensive systems on flat lands, respectively. The use of large amounts of farmyard manure as well as cultivation of cover crops can be considered to supply the required consumption of nitrogen. The farmyard manure application was lower in olive cultivation than in annual crops such as wheat, maize, sunflower, etc.; therefore, there is need new cultivation practices for improvement. These practices include the increased use of coverings, manure application and pruning residues reused as organic matter. At the same time, it considers, for both flat systems, that the chemical fertilization is adjusted considering the nutrients from mineralization of pruning residues. Sheep and goat manure (generally include 0.8% N, 0.23% P_2O_5 and 0.67% K_2O) with high potential availability in the study region [22] are suitable substitutes in order to reduce the high amount of nitrogen application and using legumes as cover crops absorbing atmospheric nitrogen during winter season between tree rows [10]. As mentioned before, input energy of farmyard manure was found higher as 1192.0 MJ ha^{-1} in traditional-flat with the share of 8.34% than in intensive-flat as 596.0 MJ ha^{-1} with 1.91% (Table 2) due to lower amount application. The energy input of farmyard manure application was significantly higher in the traditional-flat system than in the study by Authors, [13] who found 916 MJ ha^{-1} with the share of 4.80% for olive in Iran. The high energy consumption for farmyard in the study according to the earlier results may be attributed to transportation distance.

The traditional-sloping system requires the lowest machinery input due to lack of machinery traffic with only hand-held tools for pruning and harvesting, and their low weight by 403.3 MJ ha^{-1} with 5.46%, followed by traditional-flat by 8238.0 MJ ha^{-1} with 57.64%. These results show less tendency to mechanized cultivating operation in larger olive growing areas which are mainly located in the sloping and foothills of the area.

Under intensive-flat which used machinery in almost all cultural practices from tillage to olive transportation, the highest input was found with machinery by 71.55% due to high number of field traffic and weight self-propelled harvester followed by diesel fuel and fertilizers by 9.22% and 8.95%, respectively. The consumption of diesel referred to cultivation practices in the high-density tree of systems results as being higher than that of the traditional system, since soil cultivation, weed control and harvesting are the cultural practices that require more fuel [12]. In the study, fuel was consumed for weed control which is conducted by harrowing in the traditional-flat system, mowing, and the application of herbicides in the intensive-flat system. The intensive-flat system is one that require higher amounts of fuel, since it is a fully mechanized and, therefore, requires a higher consumption of fuel for machinery. This is due to the fact that the system is mostly mechanized allow to perform harvesting procedures more efficiently. It has also been reported that the energy input of fertilizers has the highest share of the total energy input in agricultural production [8, 12] in regardless of machinery. In a comparative study, Kaltsas et al. [10] investigated the energy budged in conventional and organic olive cultivation systems in Greece, and they found that irrigation and fertilizer application had the highest amount of total energy consumption in both systems. They also reported that irrigation and fertilizer application energy demand accounted for approximately 21% and 12% of the total energy consumption, respectively, in conventional Greece olive growing areas. Authors, [11] reported that irrigation represented the greatest input energy in olive cultivation. Authors, [21] recorded that intensive and super-intensive olive growing systems are responsible for high environmental impacts due to the electricity consumed during cultivation period; for example, for irrigation. The electricity energy in the studied region was only used for pump to water from water wells or source. It had the share of about 2% from total input energy for intensive-flat system and was lower than the study concluded by Authors, [13] with 4%. On the other hand, Authors, [21] reported that the deficit irrigation in olive growing did not reduce the production and quality of the harvesting.

Energy ratio was determined as 1.46, 1.38 and 1.42 for intensive-flat, traditional-flat and traditional-sloping systems, respectively (Table 3) that is one of the best energy indices that express the efficient use of energy in crop cultivation period. This indicating that energy consumption in olive cultivation in the studied region is efficient, i.e., energy production was greater than energy consumption for 3-type of olive systems. It says that to produce the olive under intensive-flat increase crop productivity using mechanical power for olive cultivation practices. This shows better energy performance of intensive-flat than the traditional cultivation systems on both sloping and flat lands. Lower energy ratio in both traditional systems is highly attributed to the lower olive fruit yield and then less output energy compared to the intensive-flat system. The energy ratio for olive has been reported by several researchers in similar or different growing conditions e.g. [8, 9, 13, 23]. Authors, [10] reported the energy ratio of conventional olive growing in Thasos Island of Greece to be 3.02, which is higher than those of the study.

Authors, [13] also defined higher energy ratio of 3.02 for olive cultivation period in Iran. In similar studies on horticulture crops, energy ratio was lower by 1.16 for apple [6] who reported that energy ratio was increased by increasing olive orchard size. In contrast, Authors,. [23] reported that energy ratio decreased by increasing olive parcel size for traditional olive growing area (range in 1.67-1.97) in Iran.

Authors [8], concluded that energy ratio was higher for flat and sloping areas by 1.60 and 1.47, respectively. The low energy use ratio in the study suggests the need for more efficient use of input energy because a higher energy use ratio requires better management of production inputs and optimize the use of inputs such as fertilizers and fossil fuels, which have high per unit energy conversion coefficient (Table 1). Energy productivity (the ratio of olives produced to the energy inputs for their production) was 0.93 kg MJ^{-1} for intensive-flat system followed by traditional-flat and traditional-sloping systems by 0.92 and 0.75 kg MJ^{-1}, respectively (Table 3). Authors, [10] and [13] recorded lower energy productivity with 0.07 and 0.08 kg MJ^{-1} in Thasos, Greece for conventional olive cultivation system and in Guilan province of Iran, respectively. The specific energy for traditional-slope, traditional-flat and intensive-flat system was calculated as 1.34, 1.09 and 1.07 6.37 MJ kg^{-1}, respectively. For producing one kilogram of olive fruit, 1.34, 1.09 and 1.07 MJ of energy was spent in traditional-slope, traditional-flat and intensive-flat system, respectively. This means that each kilogram of olive produced by intensive-flat system will save approximately 0.30 MJ compared with the traditional-sloping system. Most of the above-mentioned indices were lower in traditional-sloping and flat systems than in intensive-flat, except for specific energy, which was higher in both traditional systems. Comparing two traditional systems, specific energy was higher in traditional-sloping than in flat ones, but energy productivity, which tended to be lower in traditional-sloping system. It must be noted that energy ratio, productivity and specific energy are based on the sequestered energy for fuel, fertilizers, machinery, human labour, etc.

Table 3. Energy indices in the questionnaire farms for three olive cultivation systems

Cultivation system		Energy ratio	Energy Produc.	Specific energy	Net energy gain	Direct energy	Indirect energy	Renew. energy	Non-renew. energy	Total energy input
			(kg MJ^{-1})	(MJ kg^{-1})	(MJ ha^{-1})					
Traditional sloping	Quantity	1.42	0.75	1.34	3118.48	6977.20	403.30	6786.00	594.50	7381
	(%)					94.53	5.46	91.94	8.05	
Traditional flat	Quantity	1.38	0.92	1.09	5438.30	2984.72	11308.20	2336.72	11956.20	14894
	(%)					20.04	75.92	15.69	80.28	
Intensive-flat	Quantity	1.46	0.93	1.07	14332.81	5358.32	25739.40	2478.32	28619.40	31098
	(%)					17.23	82.77	7.97	92.03	

Net energy gain is shown the value of produced or consumed energy in a cultivation system, and it has been produced higher in both traditional and intensive systems on flat lands compared with traditional-sloping. Higher net energy gains and energy ratio and energy productivity of intensive system indicate that excessive use of inputs to produce higher level of yield.

Authors [12], concluded that intensive olive cultivation systems provide the most energy return due to the amounts of pruning residues are generated in the system. Authors [11] studied that organic olive systems have higher energy efficiency in comparison with the conventional for olive in Spain.

Traditional-sloping and intensive-flat were almost similar in use of direct energy, but both systems increased direct energy compared with traditional-flat. Considering intensive-flat, the greater number of trees per unit area cause to consume higher amount of energy inputs such as diesel fuel, water for irrigation and electricity. Indirect energy was the highest in intensive-flat due to the highest machinery and fertilizer inputs, while it was the lowest in traditional-sloping because there are no inputs such as fertilizers or plant protection products, etc. This type of energy was half of intensive-flat system in the traditional-flat because of lower fertilizers, pesticides or machinery using compared with intensive-flat ones. Thus, the rate of renewable energy in traditional-sloping by 91.94% was more than traditional-flat by 15.69%, while it was the lowest rate was in the intensive-flat by 7.97% due to using more human labour in the traditional-sloping. Non-renewable energy was obtained with highest rate by 93.03% in intensive-flat due to using more machinery, and also fertilizers and pesticides, this also refer to the consumption of electricity for irrigation. This rate was 84.30% in traditional-flat using similar inputs as in intensive-flat, while it was 8.05% in the traditional-sloping due to using only hand type harvester tools (Table 2). The rates of direct and renewable energy were greater than that of indirect and non-renewable energy consumption in traditional-sloping. Considering traditional and intensive on flat lands, indirect and renewable energy were higher agreement with similar studies on olive [13].

CONCLUSIONS

Output energy (with by-product residues allocation) was calculated as high for the intensive-flat, followed by traditional-flat, while it was the lowest for traditional-sloping. In addition, fruit and pruning yields affecting energy output varied according to cultivation systems when higher fruit yield per unit area obtained with the use of more inputs (fertilizers, crop protection products, water, fuels, etc.) in intensive-flat, followed by traditional-flat and sloping. The most widely used input in the olive cultivation was nitrogen fertilizer with around 84%, followed by potassium fertilizer (9%) for both intensive-flat and traditional-flat systems due to excessive use of fertilizers, except machinery energy, and human labour (91.94%) for traditional-sloping. Also, among energy sources, machinery energy had the highest value in both intensive-flat and traditional-flat.

As a result, it is seen that harvesting is a critical aspect of traditional-sloping system done by hand, which increased the labour input energy. In regard to the mechanization efficiency of traditional olive cultivation system, traditional-flat farms are favoured by mechanization advantages in relation to the conditions faced by flat lands. Alternative and suitable mechanization applications are needed in order to reduce the harvest labour input energy. It needs to reduce fertilizer and crop protection product and use these more efficiently and promising organic fertilizer and pest control, and industrial energy resources replaced with biological ones based natural farming systems. Use of farmyard manure and cover crops of soil protecting in the olive growing areas can be considered as the beneficial ways in order to supply the required consumption of nitrogen.

Results also show that reduce in diesel fuel, fertilizer and crop protection product inputs are important for energy saving and decreasing the environmental risk problem in the region.

Both fertilizer and crop protection product are applied due to the lack of pests and soil analysis leading unconscious use of them.

On the other hand, machinery is extensively used for soil tillage, weed control, spraying, harvesting, pruning and transportation, etc., in cultivation period leading to a high level of required diesel fuel energy, especially in intensive systems. Furthermore, if potential energy from pruning residues accounted, it can be calculated that this sector of agriculture contributes to the energy consumption in agriculture as well as all other sectors. Consequently, converting the pruning residues into energy can increase the value of waste materials and contribute the environmental protection.

REFERENCES

[1] Wiesman Z, 2009. Desert olive oil cultivation. Amsterdam, Netherland: Elsevier Publication, 6, pp.87-133.

[2] Zohary, M. and Spiegel-Roy, P. 1975. Beginnings of fruit growing in the old world. *Science*, 187, pp.319-327.

[3] FAOSTAT. 2020. The Food and Agriculture Organization (FAO) of the United Nations (UN) Statistical Database. http://www.faostat3.fao.org.

[4] Turkish Statistical Institute (TUIK). 2021. Available from: http://www.tuik.gov.tr.

[5] Bernardi, B., Falcone, G., Stillitano, T., Benalia, S., Strano, A., Bacenetti, J. and De Luca, A.I. 2018 Harvesting system sustainability in Mediterranean olive cultivation. *Sci of the Total Envir*, 625, pp.1446-1458.

[6] Rafiee, S., Mousavi-Avval, S.H. and Mohammadi, A. 2010. Modelling and sensitivity analysis of energy inputs for apple production in Iran. *Energy*,35(8), pp.3301-3306.

[7] Bilandzija, N., Voca, N., Kricka, T., Matin, A. and Jurisic, V. 2012. Energy potential of fruit tree pruned biomass in Croatia. *Spanish Journal of Agri Res*, 10(2), pp.292-298.

[8] Hemmati, A., Tabatabaeefar, A. and Rajabipour, A. 2013.Comparison of energy flow and economic performance between flat land and sloping land olive orchards. *Energy*, 61, pp.472-478.

[9] Sánchez-Escobar, F., Coq-Huelva, D. and Sanz-Cañada, J. 2018. Measurement of sustainable intensification by the integrated analysis of energy and economic flows: Case study of the olive-oil agricultural system of Estepa, Spain. *Journal of Cleaner Production*, 463-470.

[10] Kaltsas, A.M., Mamolos, A.P., Tsatsarelis, C.A., Nanos, G.D. and Kalburtji, K.L. 2007. Energy budget in organic and conventional olive groves. *Agric Ecosyst Environ*, 122(2), pp.243-251.

[11] Guzmán, G.I. and Alonso, A.M. 2008. A comparison of energy use in conventional and organic olive oil production in Spain. *Agricultural System*, 98(3), pp.167-176.

[12] Cappelletti, G.M., Ioppolo, G., Nicoletti, G.M. and Russo, C. 2014. Energy requirement of extra virgin olive oil production. *Sustainability*, 6, pp.4966-4974.

[13] Rajaeifar, M.A., Akram, A., Ghobadian, B., Rafiee., S. and Heidari, M.D. 2014. Energy-economic life cycle assessment (LCA) and greenhouse gas emissions analysis of olive oil production in Iran. *Energy*, 66, pp.139-149.

[14] Yamane, T. 1967. Elementary sampling theory. New Jersey: Prentice-Hall Eng.Cliffs, Inc.

[15] Romero-García, J.M., Niño, L., Martinez-Patiño, C., Alvarez, C., Castro, E. and Negro, M.J. 2014. Biorefinery based on olive biomass. State of the art and future trends. *Bioresourc Technology*, 159, pp.421-432.

[16] Singh, S. and Mittal, J.P. 1992. Energy in production agriculture. NewDelhi: Mittol Publications.

[17] Pimentel, D., Hurd, L.E, Belloti, A.C., Forster, M.J., Oka, I.N., Sholes, O.D. and Whitman, R.J. 1973. Food production and the energy crisis. *Science*, 182, pp.443-449.

[18] Mikkola, H.J. and Ahokas, J. 2010. Indirect energy input of agricultural machinery in bioenergy production. *Renewable Energy*, 35, pp. 23-28.

[19] Kitani, O. 1999. Energy and Biomass Engineering. CIGR, handbook of agricultural engineering, vol. V. St Joseph, MI: ASAE Publication.
[20] Mudahar, M.S. and Hignett, T.P. 1987. Energy requirements, technology and resources in fertilizer sector. Energy in Plant Nutrition and Pest Control. Energy in World Agriculture. 2. ed. Helsel, Z. R., pp. 25-61. Amsterdam: Elsevier.
[21] Romero-Gámez, M., Castro-Rodríguez, J. and Suárez-Rey, E.M. 2017. Optimization of olive growing practices in Spain from a life cycle assessment perspective. *Journal Cleaner Production*, 149, pp.25-37.
[22] Özpınar, S. 2018. An assessment of biogas production potential from animal manures in Çanakkale. *COMU Journal Agriculture Faculty*, 6(2), pp.109-116.
[23] Paydar, L., Firouzi, S. and Aminpanah, H. 2017. Energy audit of organic and non-organic olive (*Olea europaea* L.) production in agro-ecosystems in Rudbar region, Iran. Esta publicación científica en formato digital es continuación de la Revista Impresa: Depósito legal, pp. 196802ZU42, ISSN 0378-7818.

ANALIZA ENERGIJE RAZLIČITIH SISTEMA GAJENJA MASLINE U SEMIARIDNOM REGIONU

Sakine Ozpinar
Agriculture Faculty, Canakkale Onsekiz Mart University,
17020 Canakkale, Republic of Turkey

Apstrakt: Cilj ovog istraživanja je da se utvrdi ulazno-izlazna energija za gajenje maslina u semiaridnom regionu Čanakale, Republika Turska. Podaci su prikupljeni od maslinara putem anketiranja (upitnik) za tradicionalno-ravne/kose i intenzivno-ravne sisteme u prošloj vegetacionoj sezoni.
Rezultati su pokazali da je netto energetski dobitak veći u intenzivnom sistemu gajenja maslina nego u tradicionalnim ravnim i kosim sistemima gajenja maslina.
Slično, energetski odnos je bio veći u intenzivnom za 1.46 MJ ha^{-1} nego u tradicionalno kosom i ravnom sistemu gajenja maslina, za 1.42 i 1.38 MJ ha^{-1}, respektivno.
Najveća potrošnja energije zabeležena je u intenzivnom (0,93 MJ ha^{-1}). ali je najmanja u tradicionalno-kosom (0,75 MJ ha^{-1}), i tradicionalno-ravnom sistemu (0,92 MJ ha^{-1}).
Zaista, intenzivni sistem gajenja daje veće prinose maslina koji omogućavaju korišćenje većeg nivoa primene đubriva, navodnjavanja i upotrebe odgovarajuće mehanizacije, ali je energetska analiza pokazala da je njegova efikasnost u energiji dva puta veća od tradicionalnog sistema.
Rezultati istraživanja sugerišu da bi intenzivni sistem gajenja maslina mogao biti bolji sistem uzgoja u područjima sa ravnim reljefom (terenom) za poljoprivrednike u region, u sve konkurentnijim uslovima, bez pogoršanja ekološke održivosti.

Ključne reči: *Energija, stanje zemljišta, gajenje maslina, semiarid.*

Prijavljen:
Submitted: **31.12.2021**.
Ispravljen:
Revised: **14.02.2022.**
Prihvaćen:
Accepted **02.04.2022.**

Univerzitet u Beogradu
Poljoprivredni fakultet
Institut za poljoprivrednu tehniku
Naučni časopis
POLJOPRIVREDNA TEHNIKA
Godina XLVII
Broj 2, 2022.
Strane: 72 – 88

University of Belgrade
Faculty of Agriculture
Institute of Agricultural Engineering
Scientific Journal
AGRICULTURAL ENGINEERING
Year XLVII
No. 2, 2022.
pp: 72 – 88

UDK: 620.9:636.084

Original Scientific paper
Originalni naučni rad
DOI: 10.5937/PoljTeh2202072E

EFFECT OF MOISTURE CONTENT ON PHYSIOCO-MECHANICAL PROPERTIES OF CASHEW-APPLE-NUT VARIETIES RELEVANT FOR ITS PROCESSING

Ide Patrick Ejike[*1], Eze Paul Chukwuka[2], Eze Chikaodili Nkechi[3]

[1,2,3] *Department of Agricultural and Bioresource Engineering, Faculty of Engineering, Enugu State University of Science and Technology, Enugu State, Nıgerıa.*

Abstract:The physioco-mechanical properties of Red and Yellow apple cashew nuts which are essential for the design and fabrications of its processing and storage facilities were studied. The major, minor and intermediate diameter of the cashew nut varied from 21.81–30.43mm,14.01–17.18mm,4.72–10.55mm and 19.83–27.13mm, 16.09–20.27mm, 6.38–13.97mm for Red and Yellow apple respectively. The average values of bulk weight, surface area and volume of the samples were 20.58189.5g, 826.07–342.33g, 137.67–57.05 (mm^3) and 229.8–211.8g,699.97–305.40mm^2,173.13–70.63mm^3.The average values of sphericity, porosity and aspect ratio of the samples were 56.23–50.47%, 73.39–28.83%, 56.19 – 64.05% and 70.08–62.09%,66.82–24.71%,74.60–81.00%. It was observed that all the physical properties studied increased with an increase in moisture apart from bulk density and aspect ratio that decreased across the moisture content. The mechanical properties of Red and Yellow apple cashew nut were found to be moisture content and loading positions dependent. The relationship that existed between moisture content and the mechanical properties was statically significant at ($p < 0.05$) level. It is also economical to load both Red and Yellow apple cashew nut at major axis loading position at 4.26% (wb) moisture content to reduce energy demand required to crack or compress the samples.

Keywords: *Physical property, mechanical property, cashew nut, moisture content, loading position.*

[*]Corresponding Author. Email: patrick.ide@esut.edu.ng

INTRODUCTION

The effect of moisture content on the engineering properties of biomaterials such as physical and mechanical parameters are essential in the design and adjustment of machines used during harvesting, cleaning, separation, handling and storage [1] The information on the physical and mechanical properties of biomaterials is a prerequisites in the processing of agricultural products into different bio products [2]. It is also necessary in the analysis and investigation of the efficiency of a machine operation, development of a new products and finished quality of products [3]. These properties are not only essential to engineers but also to food processors, plant and animal breeders and other scientist who may exploit them in their various disciplines [4] The physical and mechanical damages that occur in agricultural products are mainly due to external forces under stationary or dynamic conditions [5] .The physical bruises and internal forces that causes physical and mechanical damages in agricultural products include variation in temperature and moisture content and when this physical and mechanical damages occurs, the agricultural products become vulnerable to infection and deterioration [6] Therefore the study of physical and mechanical properties of agricultural materials gives insight on how to withstand these physical and mechanical damages that occur during harvesting, processing and postharvest of the products. Physical and mechanical properties of cashew nut have been reported by some researchers [3]; [7]; [4]; [8]; [9] and many others but there is no literature on effect of moisture content and three axial loading positions on the physical and mechanical properties of two varieties freshly harvested cashew using Instron 3345 Universal Testing Machine with bluehill software. Cashew tree (*Anacardium occidentale Linn*.) is broadly cultivated beyond the coastal regions of the tropics and it is known for its potential benefits [10]. The fruits, the leaves, the bark, the wood and the roots have been investigated to be valuable for commercial uses such as food, medicine, industry and environmental applications. The major commercialized cashew products are raw cashew nut, cashew kernel and cashew nut shell liquid. Cashew nut (*Prunus Dulcis*) is a kidney like shape seeds that is attached to the bottom of the cashew apple [10]. The cashew apple is light reddish to yellow fruit whose pulp can be processed into a sweet, astringent fruit drink or distilled into liquor. It can grow as high as 14m but the dwarf cashew growing up to 6m, has proven more profitable, with earlier maturity and higher yields . [4] .

Cashew nut is very nutritious with high amount of energy as it contains protein, minerals, fats, carbohydrate, vitamins and fibre, all of which contribute enormously to good health from its consumption [3]. Cashew nut kernel can be eaten raw, fried, roasted and sometimes pre-treated with salt or sugar. Other useful products made from cashew are jam, juice, syrup, chutney and beverage [3]. Although the processing of cashew and its products in an old practice for which traditional methods are more available, new methods will not only reduce the drudgery of handling but will expand the areas in which most of the products are effectively being utilized [4]. Data on engineering properties of a biomaterial are dependent on a number of factors such as species, or variety and the climatic environment where it is cultivated [1] and [4]. This makes it desirable that the engineering properties of locally cultivated varieties be determined.

Therefore, the study is concentrated in determining the effect of moisture content and loading positions on the physicomechanical properties of locally harvested Red and Yellow apple varieties of cashew nut relevant to its properties.

MATERIALS AND METHODS

Source of the sample

The Red and Yellow apple cashew nut samples used for this research work were collected from a local farm located Ukehe, Igbo-Etiti LGA Enugu State at a stable harvest moisture.

Preparation of the Sample.

The cashew samples were properly cleaned and sorted to select viable seeds. After that, the sample was wrapped with polythene bag and covered in plastic containers to avoid change in moisture contents. Then the sample were taken to the laboratory where the physical and mechanical properties were carried out. The apparatus used include; veneer caliper, for measuring the axial dimensions; Mettler -Toledo Electric digital weighing balance with model number XP204 and 0.001 sensitive, for weighing the samples at intervals; Multi- Purpose Oven Dryer, drying the sample; and Instron Universal Testing Machine, for force-deformation characteristics.

Determination of Physical properties of the samples.

The physical dimensions suchlike major, minor and intermediate diameters of the cashew nut were determined from randomly selected 30 seeds from the bulk sample using a digital Vernier caliper with accuracy of 0.001mm. The geometric mean diameter, arithmetic mean diameter, equivalent mean diameter, harmonic mean diameter, square mean diameter of the cashew nut seeds were calculated using the following equations (1 - 5) reported by [11].

$$\mathrm{AMD} = \frac{a + b + c}{3} \quad \ldots\ldots\ldots\ldots\ldots (1)$$

$$\mathrm{GMD} = \frac{(axbxc)}{3} \quad \ldots\ldots\ldots\ldots\ldots\ldots (2)$$

Where; a = Major diameter; b = Minor diameter; c = Thickness; AMD = Arithmetic Mean Diameter (mm); GMD = Geometric Mean Diameter (mm).

According to [11], Harmonic Mean, Square mean, and Equivalent Mean Diameters were calculated using;

$$H\mathrm{MD} = \frac{1}{a} + \frac{1}{b} + \frac{1}{c} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots (3)$$

$$\mathrm{SMD} = \sqrt{\boldsymbol{axb}} + (\boldsymbol{bxc}) + (\boldsymbol{c}x\boldsymbol{a}) \quad \ldots\ldots\ldots\ldots\ldots\ldots (4)$$

$$\mathrm{EQMD} = \frac{\mathrm{SMD} + \mathrm{GMD} + \mathrm{AMD}}{3} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (5)$$

Where is:

a = major diameter (mm);

b = minor diameter (mm);

c = thickness (mm);

HMD = harmonic mean diameter (mm);

SMD = square mean diameter (mm);

EQMD = equivalent mean diameter (mm)

Bulk Volume

The following mathematical equation (6) stated by [12] and [13] can be used to calculate the volume of the seeds.

$$V = \frac{\pi B a^2}{6(2a - B)} \quad \ldots\ldots\ldots\ldots(6)$$

Where, $B = (ba)^{1/2}$, a and b are major and minor diameter of the sample (mm), V = volume (m^3).

Surface Area

Surface area of the sample was calculated using equation (7) reported by [3].

$$\text{Surface Area} = \frac{\pi B a^2}{(2a - B)} \quad \ldots\ldots\ldots.7)$$

Where $B = (bc)^{1/2}$, a and b are major and intermediate diameter of the sample (mm)

Sphericity

Sphericity is used in fluid flow and heat and mass transfer calculations and in the design of aerodynamic, sorting and separating machine. It can be calculated using the equation (8) reported by [14].

$$\text{Sphericity } (\%) = \frac{GMD}{a} \quad \ldots.\ldots.(8)$$

GMD = geometric mean diameter of sample (mm), a = major diameter (mm).

Aspect ratio

It is used to calculate aerodynamic, sorting, separation, thermal load and size characteristics of agricultural materials. It is calculated using the equation (9) reported by [15].

$$R_a = \frac{b}{a} \text{ x } 100 \quad \ldots\ldots.(9)$$

Where b and a are minor and major diameter of the sample respectively in (mm)

Bulk weight of 30 seeds.

Bulk weight of agricultural material describes its market value. To obtain the 30 seed weight, the seed was weighed using a precision electronic weighing balance with accuracy of 0.001g. It is used to measure the moisture content of agricultural materials.

Bulk density

The bulk density, ρb was calculated as the ratio of weight of the material to the volume of the cylinder using the equation (10) reported [16] and [17]

$$\rho_b = W_S / V_C \quad \text{... ...(10)}$$

Where is:
$W_S = weight\ of\ the\ sample\ (kg)$,
$V_C = Volume\ (m^3)$

True density

True density, ρt (kg m^3) of the samples was calculated by dividing the unit mass of each s ample by its true volume. It is determined using the equation (11) reported by [18].

$$\rho_t = M_u / V_u \quad \text{....(11)}$$

Where is;
ρ_t = true density (kg/m^3), M_u= unite mass of the sample (kg), V_u = unite volume of the sample (m^3)

Porosity

Porosity (ρ), was determined in terms of bulk density (ρb) and true density (ρt) using the following equation (12) reported by [19]

$$\rho = \left(1 - \frac{\rho_b}{\rho_t}\right) x\ 100 \quad \text{.... (12)}$$

Where p = porosity, p_b = bulk density (kg/m^3) and p_t = true density (kg/m)

Determination of the Mechanical Properties.

Compression tests were carried out on the sample at three different moisture levels under three different loading orientations namely; major, minor and intermediate, using an INSTRON Universal Testing Machine (IUTM), of BlueHill 3 software, and Dell computer system of windows 8 software. The samples were compressed at the cross-head load of 5KN at speed of 5mins. As the compression began and progressed, a load deformation curve was plotted automatically in relation to the response of each sample under compression. Thirty randomly selected samples were tested at each loading orientation and at three different moisture contents. The load-deformations curves and its parameters were obtained. At the end of the compression test, maximum load, compressive extension, energy at maximum load and slope at maximum load were tabulated.

Compressive strength (N/mm)

This measures the strength at which each sample under compressive test will crack. It was calculated as the ratio of applied force to the area of the sample, it is denoted as δc, calculated by adopting equation (13) reported by [15].

$$\delta c = \frac{f_c}{A} \qquad \ldots\ldots\ldots(13)$$

Where; ∂c = compressive strength (N/mm^2);
fc = $maximum\ load\ at\ fracture$ (N);
A = $crosssectional\ area\ of the sample$ (mm^2).

Stiffness (N/mm^2)

Stiffness is rigidity of a material and the extent at which it resists deformation in response to applied force. The stiffness, St, o f a material is measure of the resistance offered by an elastic material to deformation. It is the ratio of the stress to strain (δ/ε), [1]

$$S_t = \frac{f}{\partial} \qquad \ldots\ldots(14)$$

Where is:
St = stiffness (N/mm^2);
F = force on the material;
δ = deformation on the material.

Toughness (J/M^3)

This is the amount of energy per unit volume that a material can absorb before rupturing occur. It is also defined as a material's resistance to fracture when stressed. It is approximated under the stress–strain curve. Mathematically, toughness can be calculated using equation (15) as reported by [1];

$$\text{Toughness} = \frac{\text{Rupture energy}}{\text{Volume of material}} \qquad \ldots\ldots(15)$$

Deformation Energy (N/MM)

This is the total spent energy of a sample under compressive test at which deformation occur. It is given as;

$$\text{Deformation energy} = \text{Rupture force X deformation at rupture} \qquad \ldots\ldots\ldots\ldots(16)$$

RESULTS AND DISCUSSION

Physical properties of cashew nut

The mean value of the three axial dimensions of two varieties (Red and Yellow apple) of cashew nut seeds such as major, minor and intermediate were studied at three different moisture content and they are presented in table 1. From fig.1, it was observed that the three dimensions displayed linear trend apart from minor dimeter both Red and Yellow apple that showed logarithm trend dependent on the moisture content.

Eminent correlation was observed among the axial dimensions of the samples and moisture content which indicated that as the sample absorbs water, the cashew nut swells in all the main dimensions (major, minor and intermediate) within the moisture range of 4.226 % to 11.69% (wb). The major, minor and intermediate diameter of the cashew nut varied from 21.81 - 30.43mm, 14.01 – 17.18mm, 4.72 – 10.55mm and 19.83 – 27.13mm, 16.09 – 20.27mm, 6.38 – 13.97mm for Red and Yellow apple respectively as the moisture content increased from 4.29 – 11.69% (wb). The arithmetic and geometric mean were also fund to increase with corresponding increase in moisture content from 19.37 -13.18mm, 17.16 -11.02mm and 20.45 – 14.10mm, 19.15 – 12.35mm for Red and Yellow apple cashew nut respectively and these were similar with what [20]; [1]; [14]; [23], [24]; [25] and [24] reported on different agricultural materials. It was observed that major, minor, intermediate, arithmetic mean and geometric mean diameters are statically significant at $p < 0.05$. The relationship that existed among the cashew nut dimensions and moisture content range are shown below with their values for coefficients of determination (R^2)

Major (Red) = 8.5876ln (mc) + 9.5791	$R^2 = 0.9909$
Major (Yellow) = 7.2267ln (mc) + 9.3349	$R^2 = 0.9999$
Minor (Yellow) = 4.1984ln (mc) + 10.261	$R^2 = 0.9487$
Minor (Red) = 0.4298mc + 12.087	$R^2 = 0.9925$
Intermediate (Yellow) = 1.0233mc + 1.9681	$R^2 = 0.9996$
Intermediate (Red) = 0.7943mc + 1.0565	$R^2 = 0.9799$

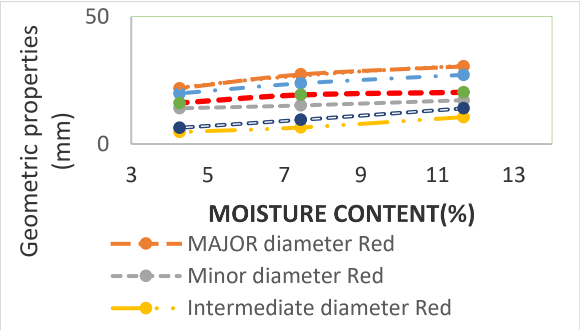


Figure.1. Effect of moisture content on some geometric properties of Red and Yellow apple cashew nut

Bulk weight, surface area and volume of cashew nut.

The mean value of the bulk weight, surface area and volume of two varieties (Red and Yellow apple) of cashew nut seeds such as major, minor and intermediate were studied at three different moisture content and they are presented in table 1. From fig.3, it was observed that Bulk weight, surface area and volume of the samples showed linear trend apart from bulk weight of Yellow sample that displayed logarithm trend with corresponding increase in moisture content.

The average values of bulk weight, surface area and volume of the samples were 205.8 -189.5g, 826.07 – 342.33g, 137.67 – 57.05 (mm^3) and 229.8 – 211.8g, 699.97 – 305.40mm^2, 173.13 – 70.63mm^3 at moisture range of 4.26 – 11.69% (wb).
This is similar to what [27] reported in effect of moisture content on the physical properties of sesame seeds . From the findings it was observed that bulk weight, surface area and volume are statically significant at $p < 0.05$. The relationship that existed among bulk weight, surface area and volume of the cashew nut and moisture content range are shown below with their values for coefficients of determination (R^2)

Area (Red) = 65.513mc + 51.444	$R^2 = 0.9947$
Area (Yellow) = 52.882mc + 86.583	$R^2 = 0.9975$
Bulk weight (Yellow) = 17.743ln (mc) + 185.69	$R^2 = 0.9929$
Bulk weight (Red) = 2.154mc + 181.48	$R^2 = 0.9546$
Volume (Yellow) = 13.756mc + 13.162	$R^2 = 0.9989$
Volume (Red) = 10.918mc + 8.5737	$R^2 = 0.9947$

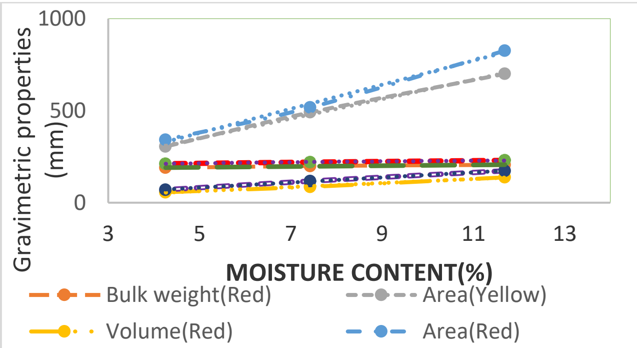


Figure.2. Effect of moisture content on some gravimetric properties of Red and Yellow apple cashew nut

Sphericity, Porosity and Aspect ratio

The average value of the sphericity, porosity and aspect ratio of two varieties (Red and Yellow apple) of cashew nut seeds samples were studied at three different moisture content and they are presented in table 1. From fig.2, it was observed that sphericity, porosity and aspect ratio of the samples displayed linear trend apart from sphericity of Yellow sample that displayed logarithm trend with corresponding increase in moisture content. The average values of sphericity, porosity and aspect ratio of the samples were 56.23 – 50.47%, 73.39 – 28.83%, 56.19 – 64.05% and 70.08 – 62.09%, 66.82 – 24.71%, 74.60 – 81.00% at moisture range of 4.26 – 11.69% (wb). From the findings it was observed that sphericity, porosity increased with corresponding increase in moisture content despite aspect ratio that displayed negative sign in the regression equation and this is due that the aspect ratio decrease down the line as moisture content increases across the properties.

The relationship that existed among sphericity, porosity and aspect ratio of the cashew nut and moisture content range are shown below with their values for coefficients of determination (R^2)

Aspect ratio (Yellow) = -0.8946mc + 85.602 $R^2 = 0.9006$
Sphericity (Yellow) = 7.9055ln (mc) + 50.59 $R^2 = 0.9996$
Porosity (Red) = 5.9691mc + 4.2208 $R^2 = 0.9969$
Porosity (Yellow) = 5.5718mc + 3.7534 $R^2 = 0.9605$
Aspect ratio (Red) = -0.9892mc + 66.269 $R^2 = 0.598$
Sphericity (Red) = 0.8241mc + 45.541 $R^2 = 0.6713$

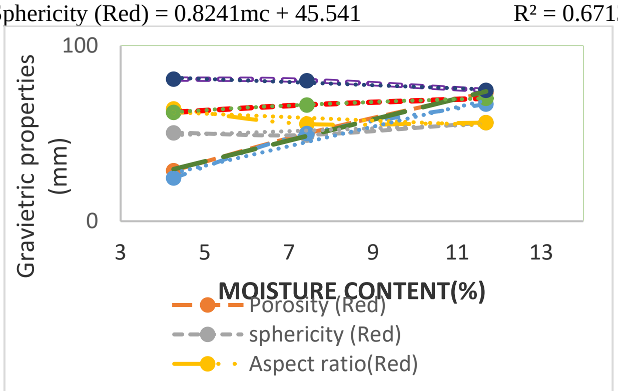


Figure 3. Effect of moisture content on the some gravimetric properties of Red and Yellow apple cashew nut

Bulk density and true density

The average bulk and true density of Red and Yellow apple cashew nuts varied from 321.49–604.15g/mm^3, 1208.30 – 847.98 g/mm^3 and 419.16 – 631.21 g/mm^3, 1263.17 – 838.32g/mm^3 respectively at moisture range of 4.26 – 11.69% (wb). It was observed that increase in moisture content decreases the bulk density and increase true density of the samples it is so because the volumetric expansion of the samples was found to be lesser than mass of the sample when it absorbs water, this similar and contrary with [21]; [28]; [29]; [30] [13], [31] and [32] on different biomaterials for bulk and true density. The relationship that existed between bulk and true densities of the cashew nut and moisture content range are shown below with their values for coefficients of determination (R^2), (see fig.4)

True density (Yellow) = 427.08ln (mc) + 246.95 $R^2 = 0.9426$
True density (Red) = 359.19ln (mc) + 342.8 $R^2 = 0.9771$
Bulk density (Yellow) = -29.085mc + 770.95 $R^2 = 0.9533$
Bulk density (Red) = -38.88mc + 794.09 $R^2 = 0.9393$

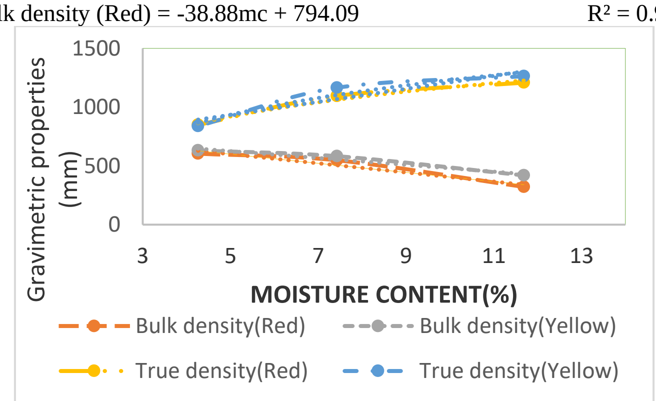


Figure 4. Effect of moisture content on some gravimetric properties of Red and Yellow apple cashew nut

Table 1.Effect of moisture content on Physical properties of Red and Yellow apple cashew nut

Properties	Moisture content/ Samples					
	11.69%		7.43%		4.26%	
	Red apple cashew nut	Yellow apple cashew nut	Red apple cashew nut	Yellow apple cashew nut	Red apple cashew nut	Yellow apple cashew nut
Major Diameter (mm)	30.43 (0.81)	27.13 (0.82)	27.28 (2.34)	23.78 (1.09)	21.81 (2.13)	19.83 (0.27)
Minor Diameter (mm)	17.18 (1.35)	20.27 (1.32)	15.12 (0.98)	19.25 (0.45)	14.01 (0.32)	16.09 (0.88)
Intermediate diameter(mm)	10.55 (2.13)	13.97 (1.36)	6.47 (0.92)	9.48 (0.82)	4.72 (0.76)	6.38 (2.16)
Arithmetic mean diameter (mm)	19.37 (0.94)	20.45 (0.94)	16.29 (0.32)	17.49 (0.97)	13.18 (0.64)	14.10 (3.13)
Geometric mean diameter (mm)	17.16 (1.43)	19.15 (1.82)	13.51 (0.86)	15.86 (1.97)	11.02 (1.84)	12.35 (1.09)
Harmonic mean diameter (mm)	0.18 (0.01)	0.15 (2.31)	0.25 (0.91)	0.19 (2.13)	0.32 (0.05)	0.26 (2.09)
Square mean diameter (mm)	32.11 (0.68)	34.81 (3.05)	26.20 (0.21)	29.42 (3.09)	21.25 (2.43)	23.41 (0.29)
Equivalent mean diameter (mm)	22.88 (0.99)	24.80 (0.03)	18.66 (0.076)	20.92 (0.21)	15.15 (0.63)	16.62 (0.02)
Bulk weight (g)	205.8 (0.18)	229.8 (0.97)	199.5 (2.08)	220.4 (2.04)	189.5 (0.12)	211.8 (0.76)
Volume (mm^3)	137.67 (5.01)	173.13 (4.06)	86.27 (1.05)	117.35 (1.65)	57.05 (2.64)	70.63 (1.65)
Sphericity	56.23 (0.12)	70.08 (0.07)	49.19 (2.23)	66.35 (1.97)	50.47 (3.06)	62.09 (2.09)
Porosity (%)	73.39 (1.04)	66.82 (0.97)	50.00 (3.65)	50.00 (0.65)	28.83 (1.74)	24.71 (0.28)
Bulk density (g/mm^3)	321.49 (1.13)	419.16 (0.05)	547.60 (1.82)	582.46 (0.92)	604.15 (1.73)	631.21 (0.92)
True density (g/mm^3)	1208.30 (2.13)	1263.17 (0.81)	1095.21 (2.34)	1164.92 (3.04)	848.98 (0.45)	838.32 (2.03)
Surface area (mm^2)	826.07 (1.17)	699.97 (0.27)	517.62 (4.12)	490.77 (0.98)	342.33 (1.95)	305.40 (0.03)
Aspect ratio	56.19 (0.18)	74.60 (0.06)	55.44 (3.04)	80.23 (0.91)	64.05 (1.12)	81 (0.06)

Note: the values in brackets are the standard deviation of the three replication of each properties.

Mechanical properties of cashew nut

The compressive force required to crack the cashew nut at major, minor and intermediate loading positions ranged from 302.21 – 158.47N, 307.43 – 148.23N and 856.45 – 221.41N for Red apple cashew nut at moisture content range of 11.6 - 4.26% (w.b) respectively while 769.35 -149.46N, 824.49 – 341.20N and 443.14 – 151.73N for Yellow apple cashew nut at moisture content range of 11.69 – 4.26% (w.b) respectively (see table 2).

It was observed that for the both samples (Red and Yellow apple cashew nut), the compressive force is solely dependent of moisture content because increase in moisture content increased the force required to crack the samples.

From fig.5 – 7, it was observed that force needed to crack the sample were higher at 11.69% moisture content and lower at 4.26% moisture content which is the storage moisture content of cashew nut. For loading positions, it was noticed that intermediate and major diameter recorded highest and lowest rupture force across the moisture content respectively for Red apple cashew nut while minor and major averagely recorded highest and lowest rupture force across the moisture content respectively for Yellow apple cashew nut. It was also observed that the Yellow apple cashew nut displayed the highest rupture force at all conditions than Red apple cashew nut. The values of compressive force show that, the samples required lesser compressive force to crack the samples at storage moisture content (4.26% wb) irrespective of the loading positions and varieties.

Compressive extension presented in table 2, the major, minor and intermediate loading positions the compressive extensions ranged from 10.82 - 2.40mm, 9.76 – 6.82mm and 14.26 – 4.86mm for Red apple cashew nut respectively while 14.68 – 3.72mm, 7.32 – 5.27mm and 6.18 -3.82mm for Yellow apple cashew nut at moisture content range of 11.69 - 4.26% (wb). It implies that as the moisture content increased the compressive extension averagely increased but highest values of compressive extension were recorded at 11.69% (wb) which is harvest moisture content for both samples while lowest compressive extensions were recorded at 4.26% (wb) which is storage moisture content for both samples. The results of compressive extensions in table 2, indicated that the samples is more sticky than brittle at 11.69% (wb) moisture content and this equally resulted the increase in compressive force and toughness of the samples irrespective of the loading positions when moisture content increases.

Deformation energy required to cause rupture on the samples at major, minor and intermediate loading positions are 3.26 – 0.38kJ, 3.00 – 1.33kJ and 12.21 -1.08kJ for Red apple cashew nut while 11.29 - 0.56kJ, 6.04 – 2.34kJ and 2.74 – 0.93kJ for Yellow apple cashew nut sample at moisture content range of 11.69 – 4.26% (wb). It was observed that, the increase in moisture content increased the deformation energy required to initiate cracking in the samples for both loading positions and samples varieties. From the result above, it was noticed that, the Yellow apple cashew nut sample averagely recorded the highest deformation energy while Red apple cashew samples had lowest deformation energy. It implies that at all conditions Yellow apple cashew nut would be tougher and stronger than Red apple cashew nut. It was recommended that when conservation of energy is needed, Red and Yellow apple cashew nut should be loaded at major diameter at 4.26% (wb) moisture content.

The stiffness of the samples are presented in the table 2. The major, minor and intermediate loading positions ranged from 66.02 – 27.93 N/mm, 31.49 – 16.48N/mm and 60.05 -33.86 N/mm for Red apple cashew nut while 70.85 – 40.17N/mm, 119.05 - 49.81 and 84.22 – 24.75 N/mm for Yellow apple cashew nut as the moisture content varied from 4.26 – 11.69% (wb).

The variation of moisture content and the stiffness of the both samples displayed parabolic trend, it implies that, the stiffness of the samples were not solely dependent on moisture content and loading positions but slightly dependent on the varieties. It was observed that, the Yellow apple sample cashew nut had highest average stiffness values than Red apple cashew nut.

The toughness of the both samples are presented in table 2. The major, minor and intermediate loading positions ranged from 23.67 – 6.66J/mm^3, 23.31 – 16.92J/mm^3 and 18.93 -88.69J/mm^3 for Red apple cashew nut while 65.21 – 7.93J/mm^3, 34.89 -28.21J/mm^3 and 15.83 – 10. 48J/mm^3 for Yellow apple cashew nut at 11.69 – 4.26% (wb) moisture content range. The result also showed that, as moisture content increases the toughness of the samples also increases irrespective of loading positions. The both samples noticed to be tougher at 11.69% moisture content which is an indication that the samples are sticky and elastic at this condition. The result presented in the table 2, showed that the toughness is solely dependent on moisture content but not on loading positions. From the findings, it was obvious that Red apple cashew nut samples are averagely tougher than Yellow apple cashew nut.

Compressive strength of the Red and Yellow apple cashew nut are presented in table 2. The major, minor and intemediate positions ranged from 0.46 – 0.36N/mm^2, 0.43 – 0.37N/mm and 1.04 – 0.5N/mm^2 for Red apple nut samples while 1.10 -0.49Nmm^2, 1.21 – 0.03Nmm^2 and 0.65 – 0.44N/mm^2 for Yellow apple cashew nut at 11.69 – 4.26% (wb) moisture content range. It is observed that the Yellow apple cashew sample recorded higher compressive strength at average which implies that it requires more energy and rupture force to process or to extract the cashew nut kernel than that of Red apple cashew nut. The effect of moisture content and loading positions were not pronounced in compressive strength for the both samples but varieties are effected compressive strength.

Table 2. Effect of moisture content and loading positions on the mechanical properties of Red and Yellow cashew apple nut.

Moist. content (%)	Varieties	Loading position	Comp. force at Rupture (N)	Compr. extension (mm)	Max. Energy at rupture (J)	Stiffness (N/mm)	Toughness (J/mm^3)	Def. Energy (kJ)	Compr. strength (N/mm^2)
11.69 %	Red apple cashew nut	a	302.21	10.82	1.67	27.93	23.67	3.26	0.36
		b	307.43	9.76	1.94	31.49	21.79	3.00	0.37
		c	856.45	14.26	3.64	60.05	88.69	12.21	1.04
	Yellow apple cashew nut	a	769.35	14.68	5.07	52.40	65.21	11.29	1.10
		b	824.49	7.32	4.71	112.63	34.89	6.04	0.03
		c	443.14	6.18	0.14	71.70	15.83	2.74	0.63
7.43%	Red apple cashew nut	a	199.62	5.37	0.21	37.17	12.40	1.07	0.38
		b	214.16	6.82	0.74	31.40	16.92	1.46	0.41
		c	262.14	7.74	1.56	33.86	23.53	2.03	0.5
	Yellow apple cashew nut	a	509.42	7.19	0.84	70.85	31.19	3.66	1.04
		b	627.43	5.27	1.21	119.05	28.21	3.31	1.21
		c	321.73	3.82	2.20	84.22	10.48	1.23	0.65
4.26%	Red apple cashew nut	a	158.47	2.40	0.19	66.02	6.66	0.38	0.46
		b	148.23	8.99	2.04	16.48	23.31	1.33	0.43
		c	221.41	4.86	0.55	45.55	18.93	1.08	0.64
	Yellow apple cashew nut	a	149.46	3.72	0.34	40.17	7.93	0.56	0.49
		b	341.20	6.85	0.37	49.81	33.13	2.34	1.12
		c	151.73	6.13	0.35	24.75	13.17	0.93	0.44

a, b and c are major, minor and intermediate diameters respectively

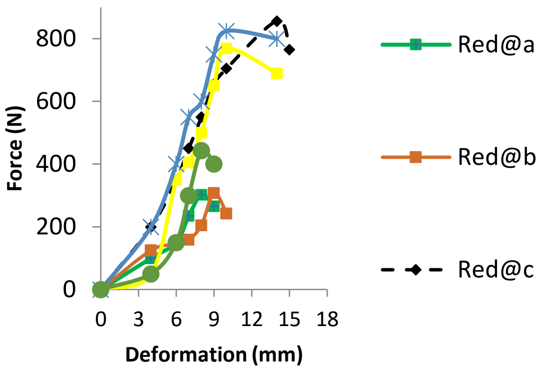


Figure 5. Force-deformation curves of Red and Yellow apple cashew nut at 11.69% (w.b) under three geometric (a,b.c) loading positions

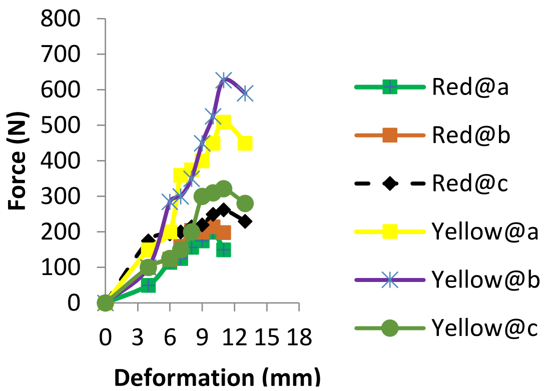


Figure 6. Force-deformation curves of Red and Yellow apple cashew nut at 7.43% (w.b) under three geometric (a,b.c) loading positions

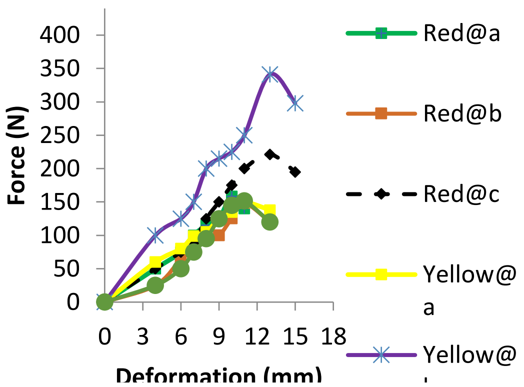


Figure 7. Force-deformation curves of Red and Yellow apple cashew nut at 4.26% (w.b) under three geometric (a,b.c) loading positions

CONCLUSION

It was concluded that physical and mechanical properties of Red and Yellow apple cashew nut are solely dependent on moisture content. The data generated from physical properties of Red apple cashew nut cannot be used in designing of food processing and storage system for Yellow apple cashew nut as the physical properties of both samples varied significantly at ($p<0.05$) with moisture content. Most of the physical properties were found to increase with correspond increase in moisture content (4.26 – 11.69% wb) apart from bulk densities, harmonic mean diameter and aspect ratio that decreased across the moisture content studied. The mechanical properties of Red and Yellow apple cashew nut were found to be moisture content and loading positions dependent. The relationship that existed between moisture content and the mechanical properties was statically significant at ($p< 0.05$) level. It is also economical to load both Red and Yellow apple cashew nut at major axis loading position at 4.26% wb moisture content to reduce both strength and energy demand required to crack or compress the samples.

REFERENCES

[1] Ide, P.E., Eze, P.C., Offor, B.C. 2019. Effect of Moisture Content on the Physicomechanical Properties of Mucuna Sloanei *International Journal of Scientific Engineering and Research (IJSER)* ISSN (Online): 2347-3878 Impact Factor (2018): 5.426 Volume 7 Issue 2, www.ijser.in.

[2] Seifi M. R. and R. Alimardani. 2010. Comparison of moisture-dependent physical and mechanical properties of two varieties of corn (Sc 704 and Dc 370). *AJAE* 1(5):170-178 (2010) ISSN: 1836-9448.

[3] Bart-Plange, Mohammed-Kamil, P., addo, and Teye, E. 2012. Some physical and mechanical properties of cashew nut and kernel grown in Ghana. *Internal Journal of Science and Nature*. I.J.S.N., vol. 3(2): 406-415 issn 2229 – 6441

[4] Nejo, R, Oloko, S.A. 2016. Determination of Some Physical Properties of Cashew Nut. *International Journal of Innovative Science, Engineering & Technology*, Vol. 3 Issue. ISSN.

[5] Sunmonu M. O., M. O. Iyanda, M. M. Odewole, A. N. Moshood (2015) Determination of Some Mechanical Properties of Almond Seed Related to Design of Food Processing Machines. *Nigerian Journal of Technological Development, 12 (1).*

[6] Chukwu, O. and Sunmonu, M. O. 2010. Determination of selected Engineering properties of cowpea (Vignaunguiculata) related to design of processing machines. *Pakistan Journal of Agriculture, Agricultural Engineering & Veterinary Sciences*. A Peer Reviewed Journal Published by Sindh Agriculture University, Tandojam, 26(2): 70 – 79.

[7] Ogunsina, B.S. and Bamgboye, A.I. 2012. Effect of Moisture Content, Nut Size and Hot-Oil Roasting Time on the Whole Kernel "Out-Turn" of Cashew Nuts *(Anacardium occidentale)* During Shelling. Official *Journal of Nigerian Institute of Food Science and Techonology*, NIFOJ Vol. 30 No. 2, pages 57 – 65.

[8] Chaudhari, A.P., Thakor, N.J., Sonawane, S.P. and Sawant, A.A. 2013. Physical properties of cashew nut shells. *Internat. J. Agric. Engg.*, **6**(1): 254-260.

[9] Okele A.I., P.A.P.Mamza, P.Nkeonye, A.J.Marut. 2016. Mechanical properties of cashew nut shell powder (CNSP) filled natural rubber vulcanizate. *ISSN: 0974 – 7443 Volume 11 Issue 2.Indian Journal*.

[10] Isa J. and Aderotoye M.A. 2017. Effect of moisture content on the physical and aerodynamic properties of cashew nut. *Journal of Engineering and Engineering Technology. FUTAJEET* 11(2) (96-102).

[11] Mohsenin N.N.1986. Physical properties of plant and animal materials, Structure, physical characteristics and mechanical properties. Gordon and breach, sci pub NY 94-96

[12] Altuntas, E. and Erkol, M. 2010 'Physical properties of shelled and kernel walnuts as affected by the moisture content', *Czech Journal of Food Sciences*, 28(6), pp. 547–556.

[13] Altuntaş, E., Ozgoz, E. and Taşer, O. F.2005.'Some physical properties of fenugreek (Trigonella foenumgraceum L.) seeds', *Journal of Food Engineering*, 71(1), pp. 37–43. doi:10.1016/j.jfoodeng.10.015.

[14] Agu and Oluka. 2013. On Selected Physical and Mechanical Properties of NERICA PADDY *Journal of Experimental Research,* Vol 1.

[15] Eze P.C. and Eze C.N. 2017. Determination of Some Physical and Mechanical Properties of Horse Eye-Bean (Mucuna Sloanei) from South East Nigeria.*Jounal of Experimental Research*.Vol.5. No1

[16] Aviara, N. A., Ibrahim, E. B. and Onuoha, L. N. 2015. 'Physical properties of Brachystegia Eurycoma seeds as Affected by moisture content', *International Journal of Agricultural and Biological Engineering*, 7(1), pp. 84–93. doi: 10.3965/j.ijabe.20140701.010.

[17] Asoegwu, S. N. et al. 2006. 'Physical Properties of African Oil Bean Seed (Pentaclethra macrophylla)', VIII, pp. 1–16.

[18] Okey Francis Obi & Lucky Chikadibia Offorha. 2015. Moisture-dependent physical properties of melon (Citrullus colocynthis L.) seed and kernel relevantin bulk handling, Physical properties of watermelon seed as a function of moisture content and variety *Int. Agrophysics*, 21, 349-359

[19] Chavoshgoli, E. et al. 2015.'Engineering properties of sunflower seeds and materials other grain as moisture content for equipment of separator', *Agricultural Engineering International: CIGR Journal*, 17(1), pp. 10– 21.

[20] Tavakoli H., Rajabipour A., Mohtasebi S.S. 2009. "Moisture-Dependent Some Engineering Properties of Soybean Grains". *Agricultural Engineering International: the CIGR Ejournal. Manuscript 1110*. Vol. XI.

[21] Tavakoli, H., Mohtasebi, S. S. and Jafari, A. 2009.'Physical and mechanical properties of wheat straw as influenced by moisture content', *International Agrophysics, 23*(2).

[22] Eze P. C. and S. I. Oluka (2014) SELECTED PHYSICAL AND AERODYNAMIC PROPERTIES OF NERICA. *Journal of Agricultural Engineering and Technology (JAET*), Volume 22.

23] Kingsly, A.R.P., D.B. Singh, M.R. Manikantan and R.K. Jain. 2006. Moisture dependent physical properties of dried pomegranate seeds (Anardana). *J. Food Eng*., 75: 492-496.

[24] Oluka, S.I. and Nwuba E.I.U., (2001). Physical and Aerodynamic Properties of Cowpea Seeds, Hulls and Stalks. JEAS, 1: 35 43 Oxidative Stability of Sesame Seed, Sesame Paste, and Olive Oils. *Journal of Agriculture, Science and. Technology*. 12: 585-596.

[25] Tunde-Akintunde T.Y. and B.O. Akintunde. 2007."Effect of Moisture Content and Variety on Selected Properties of Beniseed". *Agricultural Engineering International: the CIGR Ejournal. Manuscript FP 07 021. Vol. IX.*

[26] Tunde-Akintunde, T.Y., & Akintunde, B.O. 2004. Some physical properties of Sesame seed.

[27] Akinoso, Rahman; Olayanju, Tajudeen Adeniyi; Idehai, John Ohioma; and Igbeka, Joe (2008).The Effects of Varieties and Moisture Content on Some Physical and Aerodynamic Properties of Sesame Seeds (*Sesamum indicum L*) as Related to Cleaning," *International Journal of Food Engineering*: Vol. 4: Iss. 8, Article 7.doi**:** 10.2202/1556-3758.1303

[28] Pradhan, R.C., S.N. Naik, N. Bhatnagar, and S.K. Swain. 2008. Moisture-dependent physical properties of Karanja (*Pongamia pinnata*) kernel. *Industrial Crops and Products*, 28(2), 155-161.Properties of Sesame Seeds (Sesamum indicum L) as Related to Cleaning," International Journal of Food Engineering: Vol. 4: Iss. 8,
[29] Yalçin, İ., C. Özarsalan, and T. Akbaş. 2007. Physical properties of pea (*Pisum sativum*) seed. Journal of Food Engineering, 79(2), 731-5.
[30] Garnayak, D.K., R.C. Pradhan, S.N. Naik, and N. Bhatnagar. 2008. Moisture-dependent physical properties of Jatropha seed (*Jatropha curcas* L.). *Industrial Crops and Products*, 27, pp.123–129.
[31] Koocheki, A., S.M.A. Razavi, E. Milani, T.M. Moghadan, M. Abedini, S. Alamatiyan and S. Izadikhah. 2007. Physical properties of watermelon seeds as a function of moisture content and varieties.*Int. Agrophysics,* 21: pp.349-359.
[32] Altuntaş, E. and M. Yildiz. 2007. Effect of moisture content on some physical and mechanical properties of faba bean (*Vicia faba* L.) grains. *Journal of Food Engineering*, 78, pp. 174–183.

UTICAJ SADRŽAJA VLAGE NA FIZIČKO-MEHANIČKA SVOJSTVA SORTI INDIJSKOG ORAHA KOJI JE RELEVANTAN ZA NJIHOVU PRERADU

Ide Patrick Ejike[1], EzePaul Chukwuka[2], Eze Chikaodili Nkechi[3]

[1,2,3] Department of Agricultural and Bioresource Engineering, Faculty of Engineering, Enugu State University of Science and Technology, Enugu State, Nıgerıa.

Apstrakt: Proučavane su fizičko-mehaničke osobine crvene i žute okrugle (jabučaste) sorte indijskog oraha koje su neophodne za projektovanje i izradu objekata za preradu i skladištenje.

Glavni, manji i srednji prečnik indijskog oraha varirao je od 21.81–30.43 mm, 14.01–17.18mm,4.72–10.55mm i 19.83–27.13mm, 16.09–20.27mm, 6.38–13.97mm za Crvenu i Žutu okrugli oblik , respektivno .

Prosečne vrednosti zapreminske mase, površine i zapremine uzoraka bile su 826.07–342.33g, 137.67–57.05 (mm^3) and 229.8–211.8g, 699.97–305.40 mm^2, 173.13–70.63 mm^3.

Prosečne vrednosti za sferičnost, poroznost i odnos širina/ visina uzoraka iznosili su 56,23–50,47%, 73,39–28,83%, 56,19 – 64,05% i 70,08–62,09%, 66,82–24,71%, 74,60–81,00%.

Primećeno je da se vrednosti parametara za sve proučavane fizičko-mehaničke osobine povećavaju sa povećanom vrednosti sadržaja vlage (w.b), osim nasipne zapremine i odnosa širine i visine koji se smanjuju sa manjim sadržajem vlage.

Utvrđeno je da mehanička svojstva Crvenog i Žutog indijskog oraha zavise od sadržaja vlage i položaja (načina) utovara oraha u skladište.

Odnos koji je postojao između sadržaja vlage i mehaničkih osobina bio je statistički značajan na nivou ($p<0,05$).

Takođe je ekonomično ubaciti zajedno crvene i žute okrugle sorte indijskog oraha po glavnoj osi utovara skladišta, sa sadržajem vlage od 4,26% (wb), kako bi se smanjila potrošnja energije potrebna za lom ili kompresiju uzoraka.

Ključne reči: *Fizička svojstva, mehanička svojstva, indijski orah, sadržaj vlage, položaj* utovara .

Prijavljen:
Submitted: **05.10.2021.**
Ispravljen:
Revised: **20.12.2021.**
Prihvaćen:
Accepted **17.02.2022.**

CIP Каталогизација у публикацији
Народна библиотека Србије, Београд
631(059)
ПОЉОПРИВРЕДНА техника : научни часопис = Agricultural Engineering : Scientific Journal / одговорни уредник Мићо В. Ољача – Год. 1, бр. 1 (1963)- . Београд; Земун : Институт за пољопривредну технику, 1963 - Београд. (Штампарија: DUGA MOTIV , 11030 Београд). - 25 цм
Тромесечно. – Прекид у излажењу од 1987-1997. године
ISSN 0554-5587 = Пољопривредна техника
COBISS.SR-ID 16398594