Natural Resources and Sustainable Development
Volume 10, Issue 1, 2020
DOI: 10.31924/nrsd.v10i1.039

ANTIMICROBIAL ACTIVITY OF CHAMOMILE FLOWERS ESSENTIAL OIL (*MATRICARIA CHAMOMILLA L.)*

Tocai Alexandra*#, Burescu Laviniu, Nemeth Sebastian*****

*University of Oradea, Doctoral School of Biomedical Sciences, Faculty of Medicine and Pharmacy, 10 December 1st Square, Oradea, Romania, email: tocai.alexandra@gmail.com
**University of Oradea, Faculty of Environmental Protection, 26 Gen. Magheru St., 410048, Oradea, Romania
***University of Oradea, Faculty of Medicine and Pharmacy, Department of Pharmacy, 29 Nicolae Jiga St., Oradea, Romania

Abstract

Chamomile is a highly appreciated plant due to a whole range of therapeutic characteristics providing numerous benefits for the human body and being well accepted both by human body organs and systems, and skin. The purpose of this research is the chemical determination and studying the antimicrobial activity of the essential oil obtained from the flowers of Matricaria chamomilla L.

The volatile oil was highlighted by hydrodistillation, and the quality of the mixture was achieved by thin-layer chromatography (TLC) method. Two samples were considered and processed, namely Chamomillae aetheroleum obtained from the chamomile flowers from the Crişul Negru Plain at the village of Talpoş, Bihor county as compared to the Solaris chamomile oil extract which is industrially obtained. The results obtained by thin-layer chromatography indicated the presence of three volatile compounds namely: bisabolol oxide, bisabolol, and farnesene.

The antimicrobial activity of the volatile oil was studied by the standardized Kirby-Bauer Disk Diffusion Susceptibility Test Protocol. Following the evaluation of the antimicrobial activity of the volatile oil of Matricaria chamomilla, a strong antimicrobial activity could be observed against all the microorganisms subjected to testing. Significant levels in terms of antibacterial potential were determined in the case of Escherichia coli and Staphylococcus aureus.

Key words: Chamomillae flos, volatile oil, thin-layer chromatography, antimicrobial activity

INTRODUCTION

The chamomile is a medicinal plant from Europe and West Asia. Since ancient times, its phytotherapeutic properties were highly appreciated by the Egyptians, Romans and Greeks (Vikas et al., 2010). Chamomile (*Matricaria chamomilla L.*) is a medium-sized (under 50 cm), glabrous (hair free), aromatic plant. It is an alternate-leave plant (single leave per each node), deeply divided into filiform lobes. Capitula (inflorescences) are less than 2 - 2.5 cm in diameter, the female flowers are ligulate and ranging between 12-18 flowers, being arranged on the edge of the capitulum. Each one of the white ligule is three teeth and crossed by four ribs. The core of the capitulum is filled by the bisexual yellowish flowers. High conical receptacle is hollow inside. The plant is ruderal and it gowns both on the plains and in hilly areas, and in agricultural crops (Szabo, 2009).

The aim of this research is to analyze the volatile oil obtained from the chamomile flowers from the Crişul Negru Plain, village of Talpoş, Bihor

Corresponding author

county, Romania in comparison with an industrially obtained volatile oil called Solaris. Research works on the plant product Chamomillae flos were carried out in the past by Nemeth et al., 2000, Mogoşanu, Popescu, 2010 and Nemeth, 2011, who found about 120 chemical compounds of vegetable oil and secondary metabolites such as: flavonoids, tannins, coumarins, polyphenolic acids, higher fatty acids, mucilage, etc.

According to Nemeth et al., 2000, Tiţă, 2008, Mogoşanu, Popesscu, 2010 and Pallag, 2015, chamomile volatile oil has more than 63 bioactive components classified into monoterpenes (terpene, caren, myrcene, borneol) and sesquiterpenes (farnesene, chamazulene - compound with double conjugated bonds obtained by hydrolysis of proazulens during distillation and generating the blue colour of the volatile oil, and bisabolol).

All the aformentioned compounds were found in different quantities and in different parts of the chamomile inflorescence, depending to a large extent on the stage of plant development and the choice of harvest time.

Although the concentration of volatile oil is higher and richer in active substances from flowers, it is also present in leaves, stem and even in the root of the plant, and its composition in this plant encloses elements derived from chamazulene: linalool, geraniol, and α-farnesol (Vikas et al., 2010; Pallag, 2015; Tiţă, 2008).

The amount of α-bisabolol and α-bisabolol-oxide A and B in the flowers reaches its peak concentration when plants are at their maximum blooming, and subsequently their levels decreases (Nemeth et al., 2000).

The content of farnesol gradually decreases with the growth and development of the plant (Nemeth et al., 2000).

Objectives proposed:

(i) Obtaining volatile oil,

(ii) Analysis of volatile oil by thin-layer chromatography,

(iii) Analysis of the antimicrobial activity of the volatile oil.

MATERIAL AND METHOD

In order to reach the proposed objectives, we started with the isolation of the volatile oil according to the procedures described below.

The determination of the volatile oil of the chamomile flowers was done in the Pharmacognosy laboratory of the Department of Pharmacy - Faculty of Medicine and Pharmacy of Oradea.

From 400 grams of dried chamomile flower powder, we used a two-liter capacity percolator, at a constant temperature (150 °C) and pressure (8 bar) (Fig. 1). Hydrodistillation lasted five hours, and following the process we obtained 3 mL of light white-yellowish volatile oil whose refractive index was determined the help of an Abbe refractometer and the level obtained at 20 °C was 1.478 (the refraction index found in the literature

ranges between 1.470 - 1.485). The volatile oil was then collected and stored in a dark environment at + 4 ˚C before being subjected to chromatographic analysis (Nistreanu, 2001; Krishna et al., 2012).

Fig. 1. A-Plant product; B-Volatile oil obtained

Another working method was thin-layer chromatography (TLC). The method chosen for the qualitative analysis of the bioactive components present in the extract we obtained was TLC, using as:

• Mobile phase: toluene and ethyl acetate (93:7) v/v,

• Stationary phase: Silica gel GF254 (Merck-10cm) - activated glass plates,

• Sample 1 - Solution subjected to analysis: - 30 µL,

• Sample 2 (calibration sample) - industrially obtained volatile oil - SOLARIS - 30 µL,

• Developer - Freshly prepared vanillin in sulphuric acid solution (Bone, Mills, 2013).

After removing the plate from the chromatography bench, it is sprayed with a solution of vanillin in sulphuric acid and, in order to increase the speed of the chemical reaction, the compound is heated to 110 °C for 10 min. The appearance of coloured spots which are characteristic for volatile oil compounds is noted. The developed spots are encircled and the retention factor (Rf) is then calculated. In the absence of calibration substances, the volatile terpenes are identified by comparing the retention factor (Rf) with that cited in the dedicated literature.

Antimicrobial activity is the last working method we used.

From Sample 1 we weighed an amount of 600 g dried flowers of Chamomillae flos which was subjected to hydrodistillation for eight hours using a specific distillation system. After extraction, the amount of 5 ml of volatile oil with refractive index of 1.478 was obtained. The volatile oil was collected and stored in a dark environment at + 4 °C before being subjected to analysis (Singh et al., 2011).

Sample 2 used was obtained from volatile oil Solaris.

The microbial strains were one Gram-positive bacterium: Staphylococcus aureus ATCC 25923 - LOT 819700 - 31.08.2018 and two Gram-negative bacteria: Pseudomonas aeruginosa ATCC 27853 - LOT 912867 - 14.08.2018 and Escherichia coli - ATCC 25922 - LOT 9603 – 22.06.2018.

The Mueller-Hinton Agar plates were seeded within 15 minutes of calibration using new, sterile pads.

Microbial suspensions were prepared in a 0.9 % sterile saline and adjusted as inoculum to a final concentration of 0.5 McFarland standard. A volume of 20 mL Mueller-Hinton Agar for bacterial strains was inoculated with 20 µL of microbial suspension and then poured into a Petri dish (cell-culture dish). The cell-culture dishes were left at room temperature for 15 minutes to allow the culture medium to solidify.

Each 6 mm diameter paper disk was impregnated with 35 µg of volatile oil solution (Sample 1-Chamomillae flos Talpoş; Sample 2-Chamomillae flos Solaris) and then manually applied to the surface of Agar dishes inoculated with microorganisms: Ampicillin, Oxacillin and Colistin (30 µg/disk) were used as positive reference standards to determine the sensitivity of Gram-positive and Gram-negative bacterial species. The cell-culture dishes were kept at 4 ºC for 2 h to allow diffusion and then incubated for 24 h at 37 ºC. The antimicrobial activity was determined by using a ruler to measure the diameters of the inhibition zones, including the diameter of the disk (6 mm).

RESULTS

Following the hydrodistillation, we obtained a 3 mL volatile oil with refractive index of 1.478 (Fig. 2).

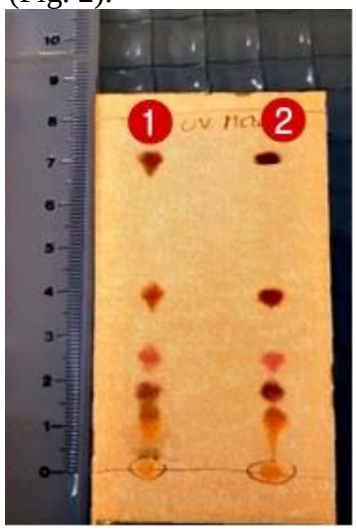

Fig. 2. TLC from Chamomillae oil Talpoş (1) and Chamomillae oil Solaris (2)

From the analysis of the volatile oil obtained from Chamomillae flos (Talpoș) by the chromatographic method it was possible to highlight following compounds according to the table below (Table 1):

Table 1

Centralization of the results following the chromatography

Migration distance of mobile phase			**8.1 cm**
Spot	**Rf spot**	**Spot colour**	**Found**
Chamomillae flos (Talpoș) aetheroleum			
CFT - a_1	0.12	Yellowish brown	bisabolol oxide
CFT - a_2	0.17	Brown	*unidentified*
CFT - a_3	0.21	Brown	bisabolol
CFT - a_4	0.30	Violaceous	pollen
CFT - a_5	0.48	Brown	*unidentified*
CFT - a_6	0.88	Brown-violaceous	farnesene
Chamomillae flos (Solaris) aetheroleum			
CFS - a_1	0.12	Yellowish brown	bisabolol oxide
CFS - a_2	0.17	Brown	*unidentified*
CFS - a_3	0.21	Brown	bisabolol
CFS - a_4	0.30	Violaceous	pollen
CFS - a_5	0.48	Brown	*unidentified*
CFS - a_6	0.88	Brown-violaceous	farnesene

After the reading of the chromatogram corresponding to the two volatile oils, six spots were developed from which four compounds were found based on the Rf and the colour cited in the literature and characteristic for this chromatographic system: bisabolol-oxide (Rf = 12), bisabolol (Rf = 0.21), pollen (Rf = 0.30) and farnesene (Rf = 0.88).

The spots corresponding to the volatile terpenes of Chamomillae flos aetheroleum (Talpoș) are less intense compared to those of Chamomillae flos aetheroleum (Solaris oil), which would also mean a lower concentration thereof.

After applying the last method for identifying volatile oil by highlighting antimicrobial activity one can notice the results from Table 2.

The inhibition zone of the volatile oil obtained from the flowers of *Matricaria chamomilla L.* (Talpoș) was 17 mm against Escherichia coli compared to 18 mm in the case of Ampicillin, 18 mm against Staphylococcus aureus in comparison with 22 mm in the case of Oxacillin, and 10 mm against Pseudomonas aeruginosa compared to 20 mm in the case of Colistin.

The inhibition zone of the volatile oil obtained from the flowers of Matricaria chamomilla L. (Solaris) was 20 mm against Escherichia coli compared to 18 mm in the case of Ampicillin, 19 mm against

Staphilococcus aureus in comparison with 22 mm in the case of Oxacillin, and 10 mm against Pseudomonas aeruginosa compared to 20 mm in the case of Colistin (Fig. 3).

Table 2

Antimicrobial activity of selected antibiotics and chamomile flowers essential oil

Microorganism	**Essential oil Talpoş**	**Essential oil Solaris**	**Ampicillin**	**Oxacillin**	**Colistin**
Escherichia coli	18	20	18		
Staphylococcus aureus	18	19		22	
Pseudomonas aeruginosa	10	10			20

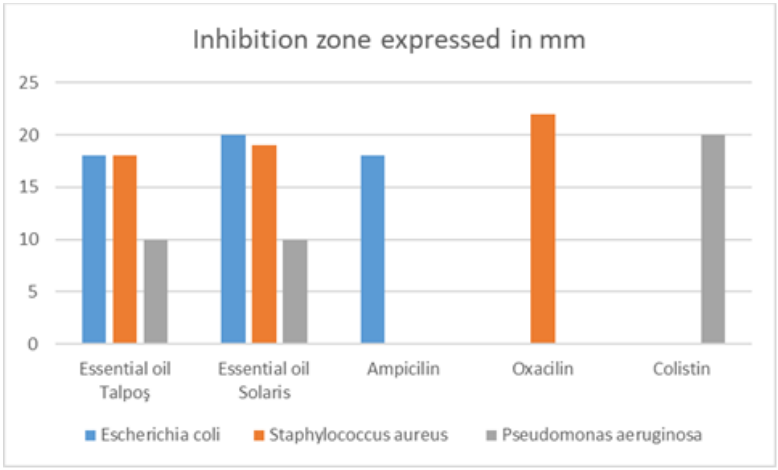

Fig. 3. Inhibition zone of Essential oil Talpoş, Essential oil Solaris and selected antimicrobial agents on *Escherichia coli, Staphylococcus aureus, Pseudomonas aeruginosa*

The strongest antimicrobial activity of the volatile oil was found against Escherichia coli with an area of inhibition of 20 mm, this bacteria being responsible for infections of the digestive and urinary tract.

Another significant level in terms of the antibacterial potential was found against Staphylococcus aureus, with an inhibition area of 19 mm, therefore the volatile oil can be recommended in respiratory infections.

These results confirm the potential of volatile chamomile flowers oil in pharmaceutical therapies for infectious diseases of digestive, respiratory and excretory systems of human body.

DISCUSSION

To check the reliability of our research, we compared the results we obtained with two other reference works published in the past four years.

According to Ljiljana et al., 2016, antimicrobial activity was tested on different bacterial cultures: *Escherichia coli, Listeria monocystogenes, Salmonella enterica, Staphylococcus aureus, Pseudomonas aeruginosa* using the disk-diffusion agar method (Table 3, Fig. 4).

Table 3

Antimicrobial activity of selected antibiotics and chamomile flowers essential oil

Microorganism	**Essential oil**	**Inhibition zone (mm) Antibiotic**				
		A	**D**	**C**	**S**	**G**
Listeria monocytogenes	13.33±0.25	13.0	28.0	30.0	28.0	26.0
Pseudomonas aeruginosa	0.0±0.00	n.d.	n.d.	34.0	n.d.	18.0
Escherichia coli	31.0±0.37	n.d.	26.0	31.0	20.0	21.0
Salmonella enterica	25.0±0.26	n.d.	25.0	36.0	22.0	23.0
Staphylococcus aureus	40.0±0.51	14.0	35.0	35.0	15.0	22.0

A-Amoxicillin; D-Doxycycline, C-Ciprofloxacin; S-Streptomycin; G-Gentamicin

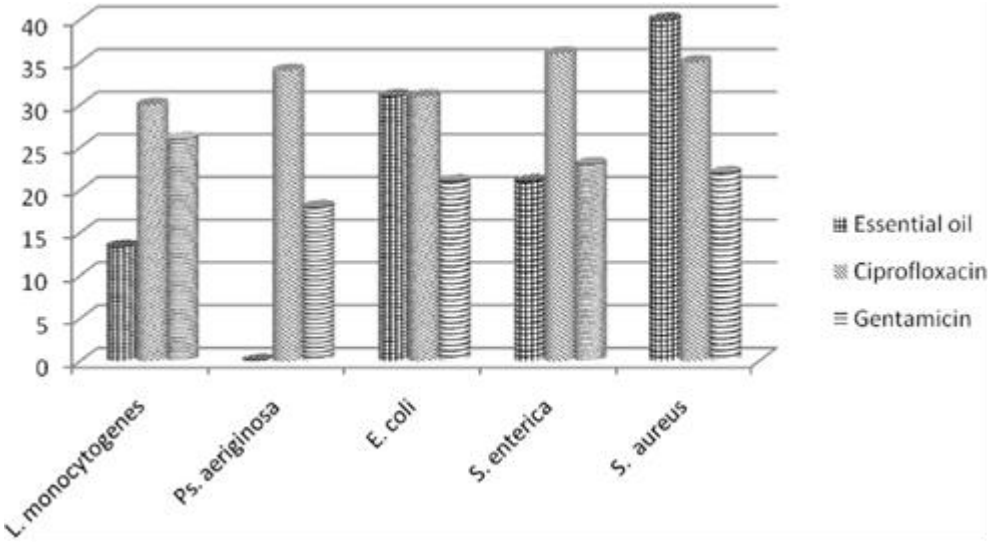

Fig. 4. Inhibition zone of chamomile flowers essential oil and selected antimicrobial drugs on L. monocytogenes, P. aeruginosa, E. coli, S. enterica and S.aureus (in mm)

Although several types of bacteria as well as other antibiotics were chosen as reference, volatile chamomile flowers oil presented strong areas of inhibition in the case of *Staphylococcus aureus* and *Escherichia coli*.

Moreover, Mohsen Kazeni, 2015 analyzed the volatile oil of chamomile flowers by disk-diffusion agar method (Table 4).

Other types of microorganisms were processed as culture media, but subjected to testing in the case of only a single antibiotic, namely Streptomycin.

Table 4

Antibacterial activity of essential oils (1.0 μg/mL) in disk-diffusion agar method, inhibition zones in mm

Microorganisms	**Chamomile %**	**Streptomycin**
Staphylococcus aureus	30	22
Bacillus cereus	36	22
Bacillus subtilis	32	22
Shigella shiga	25	17
Shigella sonnei	19	18
Pseudomonas aeruginosa	19	18
Proteus sp.	16	15

Diameter of inhibition zones (mm) including the diameter of disk (6 mm).

In this paper, the strongest inhibition zone was in the case of *Bacillus cereus*, and other significant levels were reached in the case of *Bacillus subtilis* and *Staphylococcus aureus*.

Compared to the other works, higher values were obtained, because we used other culture media, but also because the antibiotics that were subjected to testing belong to different classes.

The chamomile flowers studied come from different pedo-climatic conditions, which can be a factor that may also influence the study results by itself.

CONCLUSIONS

The presence of terpenes (i.e. bisabolol-oxide, bisabolol, pollen, farnesene) confirms the potential antimicrobial, antifungal, antiseptic, soothing, antispastic characteristics of the volatile oil of *Matricaria chamomilla L*.

The spots of the first sample i.e. *Chamomillae flos* (Talpoş) were slightly paler compared to the second sample i.e. *Chamomillae flos* (Solaris), which suggests that the industrially obtained volatile oil is more concentrated.

Chamomillae flos aetheroleum shows a good antimicrobial activity on the culture media tested.

The centralization of the aforementioned data recommends the administration of volatile chamomile oil, especially in respiratory and digestive infections, both in monotherapy and in combination therapy.

REFERENCES

1. Bone K., Mills S., 2013, Principles and Practice of Phytotherapy. Modern Herbal Medicine, vol. 2, no. 41, pp.950-1056;

2. Krishna M., Mayank A. P., Vipul G., Jinal S., 2012, Pharmacological Properties of Matricaria recutita. vol. 3, pp.348-351;
3. Ljiljana P., Zelijka R., Vesna D., Jelena S., Dragan J., 2016, Chemical Composition, Antioxidant and Antimicrobial Activity of Chamomile Flowers Essential Oil. vol. 19, pp.2017-2028;
4. Mogoşanu G., Popescu L., 2010, Farmacognozie Fitoterapie Ediţia a II-a. Ed. Sitech, pp.31-33; (Pharmacognosis Phytotherapy 2nd Edition, Sitech publishing house, pg. 31-33);
5. Mohsen Kazemi, 2015, Chemical Composition and Antimicrobial Activity of Essential Oil of Matricaria recutita. vol. 18, pp.1784-1792;
6. Nemeth S., 2011, Farmacognozie curs Volumul I. Ed. Universității din Oradea, pp. 46-52; (Lecture of Pharmacognosis, Volume I, Publishing house of the University of Oradea, pp. 46-52);
7. Nemeth T., Ardelean A., Szabo I., Nemeth S., 2000, Analize farmacognostice II. Ed. Universitatea de Vest, pp.27-30; (Pharmacognosis analysis II- Publishing house of the Western University, pp.27-30);
8. Nistreanu A., 2001, Farmacognozie. Chişinău: Tipografia centrală, pp.150-449. (Pharmacognosis. Chişinău: Central typography, pp.150-449);
9. Pallag A., 2015, Botanică farmaceutică, Sistematica, Cormobionta. Ed. Universitatii din Oradea, pp.264; (Pharmaceutical Botany, Systematics, Vascular plant. Publishing house of the University of Oradea, pp.264);
10. Singh O., Khanam Z., Misra N., Srivastava M., 2011, Chamomile An overview. vol. 5, pp.82-95;
11. Szabo I., 2009, Botanică farmaceutică: sistematica plantelor. Ed. Universității din Oradea, pp.7-358; (Pharmaceutical Botany: plants systematics. Publishing house of the University of Oradea, pp.7-358);
12. Tiţă I., 2008, Botanică Farmaceutică. Editia a III-a, Ed.: SITECH, pp.1-12; (Pharmaceutical Botany, 3rd Edition, SITECH publishing house, pp.1-12);
13. Vikas G., Payal M., Parveeen B., Sukhbir L K., Dhirender K., 2010, Pharmacological Potential of Matricaria recutita. vol. 2, no.1, pp.12-16.

Received: November 01, 2019
Revised: December 14, 2019
Accepted and published online: May 31, 2020

Natural Resources and Sustainable Development
Volume 10, Issue 1, 2020
DOI: 10.31924/nrsd.v10i1.040

MATURITY AND STABILITY EVALUATION OF COMPOSTED POULTRY MANURE

Gorliczay Edit*#, Tamás János*, Bárány László**

*University of Debrecen, Faculty of Agricultural and Food Sciences and Environmental Management, Institute of Water and Environmental Management, Böszörményi St., no. 138, Debrecen 4032 Hungary, e-mail: edit.gorliczay@agr.unideb.hu
**Mastergood Ltd. Ipari St., no 9, Kisvárda 4600 Hungary, e-mail: kapcsolat@mastergood.hu

Abstract

Composting is one of the most popular recycling processes for organic waste. Compost is an inherently variable product produced from a wide variety of organic source materials known as feedstocks.

The aim of our research was to examine the process of composting with maturity and stability parameters. The windrow composting experiments were set up in the composting area of the University of Debrecen, Institute for Water and Environmental Management and a mixture of broiler and hen manure was composted by adding zeolite (0, 1, 2, 5, 7 w/w %). The time for composting experiments was 62 days. We continuously measured the main parameters describing the composting processes: moisture content (w/w %), temperature (°C), pH, electrical conductivity (mS/cm), organic matter content (w/ w%).

Based on our results, it can be concluded that the 50 w/w % moisture content is sufficient for composting in the case of the mixtures of substances tested by us. The four stages of composting can be separated by temperature, and the thermophilic phase is longer with increasing zeolite mixing. The value of pH ranged from pH 6.63 to 8.0, with lower pH values at the beginning and neutral at the end of the composting process. Electrical conductivity values decreased at the end of the composting process. Adding a higher percentage of zeolite reduced the content of organic matter, thereby increasing the mineral content.

Overall, the parameters studied by us are suitable for determining the maturity of compost and for describing the composting process.

Key words: composting, manure, maturity, stability, poultry manure

INTRODUCTION

Intensive animal husbandry generates large amounts of waste and by-products that can sometimes harm the environment. Solid manure or slurry is produced in significant quantities from by-products, but in some animal species and housing technology solutions, large amounts of wastewater should be counted. The manure can't used directly, stored and stored before application and matured.

Composting is an environmentally friendly biological process of aerobic thermophilic microbial degradation of wastes and by-products by populations of the various microorganism which leads to a stabilised, mature, deodorised, hygienic product, rich in humic substances, free of pathogens and marketable as organic amendment or fertiliser (Haug, 1993). Composting is an appealing solution for sustainable management of manure

Corresponding author

and it is importance to solve the problem of waste management. The compost quality for land application depends on its maturity and stability (Albrecht et al., 2008). A great number of physical, physico-chemical, chemical and biological methods were used to study the properties of compost (Bernai et al., 1998; Itavaara et al., 2002; Wang et al., 2004; Kovács, Füleky, 2016), such as: C/N ratio, humified organic carbon, cation exchange capacity, microbial respiration, enzyme activities (Chen, 2005; Castaldi et al., 2005; Tang et al., 2006; Tiquia, 2005), gas concentration tests, reflectance tests (Juhász, Hunyadi, 2014).

MATERIAL AND METHOD

The experiments set-ups and the laboratory tests were carried out at the University of Debrecen, Faculty of Agricultural and Food Sciences and Environmental Management, Institute of Water and Environmental Management. The broiler and hen manure source was the deep litter husbandry units of the Baromfi-Coop Ltd. located in Nyírjákó, Hungary. The bulking agent used was zeolite, which was derived from Mád. Main characteristics of initial materials are shown in Table 1.

Table 1

Main characteristics of raw materials

Parameter	Broiler manure	Hen manure	Zeolite
pH_{H2O}	6.91	6.59	8.49
OM (w/w%)[1]	58.81	66.18	1.16
EC (mS/cm)[2]	11.10	12.78	0.65
TN (w/w%)[3]	2.75	2.14	0.08

[1]OM: Organic matter; [2]EC: Electrical conductivity; [3]TN: Total nitrogen.

The windrow composting experiment was 62 days. It was composed of broiler manure (2/3 volume) and hen manure (1/3 volume) (Table 2). Samples were taken from several points of the compost prisms and taken every three days, and the average sample was used to test them.

Table 2

Applied settings of windrow composting

Name of treatments	Mixed raw materials
Control	26.66 kg broiler manure + 13.33 kg hen manure + 0 kg zeolite
1 w/w% zeolite	26.66 kg broiler manure + 13.33 kg hen manure + 0.4 kg zeolite
2 w/w% zeolite	26.66 kg broiler manure + 13.33 kg hen manure + 0.8 kg zeolite
5 w/w% zeolite	26.66 kg broiler manure + 13.33 kg hen manure + 2.0 kg zeolite
7 w/w% zeolite	26.66 kg broiler manure + 13.33 kg hen manure + 2.8 kg zeolite

For the assessment of compost maturity, important parameters including moisture content, temperature, pH, electrical conductivity, total nitrogen (TN) content, organic matter (OM) content were measured during the composting process (62 days).

The temperature measurements of compost prisms were done in situ, with PT 100 temperature meter. Temperature measurements were made at 12 cm depths of the windrow. The "front" point in the windrow longitudinal section corresponds to the 15 cm section, the "center" point corresponds to the windrow's 35 cm section, and the "end" point corresponds to the windrow's 55 cm section.

The moisture content of the fresh samples was determined as weight loss upon drying at 105 ºC in an oven for 24 hours (MSZ-08-0221-1:1979). The pH and electrical conductivity (EC) of the sample were measured using a 1:10 (w/w, compost/water ratio) sample to deionized water extract. Then, the mixture was stirring 24 hours. After this solution was filtered and the pH and electrical conductivity was measured using Hanna Instruments 2550. The organic matter (OM) content was measured to ashing the sample at 550°C (MSZ-08-0012-6:1981, chapter 3.2).

Statistical analysis was performed using R software in an R Studio user environment R Core Team, 2017. Based on the given parameter, ANOVA was used to verify the statistical differences between the samples at a significance level of 5 %. In order to quantify the statistical differences evidenced by one-way ANOVA, we used the LSD mean value comparison test (Mendiburu, 2019).

RESULTS AND DISCUSSION

The main parameters of composting and compost maturity were examined: moisture content, pH, electrical conductivity, temperature.

Moisture content during composting also influences microbial activity, rate of degradation and composition of microbial population. the optimum moisture content of composting is between 40-60 w/w % (Alexa, Dér, 2001).

The moisture content of the experiment is developed steadily over the 9 weeks (~50 w/w %). Moisture content of the 0 week means the moisture content determined when mixed the windrows, because of this time we measured only the broiler manure, hen manure and zeolite moisture content, without added water.

The 7 w/w % zeolite blend follows the same trend as the other smaller zeolite blends, but with a lower moisture content of -5 w/w % and even -10 w/w % for each measurement. Statistical analysis we proved ($p < 0,05$) the significant differences of the compost windrows.

This can be explained by the fact that the zeolite is capable of absorbing large amounts of water, since the small particles have a relatively high specific surface area. It was concluded that the 50 w/w % moisture content of this mixture was sufficient to complete the composting process.

The pH is highly influenced by biodegradation by acting on the activity of the microorganisms involved in the composting process, thereby increasing and decreasing the biodegradation.

The optimum pH during the composting process is between 6 and 8 (Chang, Chen, 2010; Gea et al., 2007; Alburquerque et al., 2006), since the strongly alkaline or acidic pH affects the degradation negatively. For example, composting of manure results in a high amount of ammonia being released at elevated pH (alkaline medium pH > 8) with high nitrogen loss and odor. However, the additive mixture of organic matter also affects the pH of the medium, e.g. the wood chips are acidifying, even the zeolite is alkalizing.

There is no chemical difference between the weeks and the mixes (whether the control prism or additive treated prisms) (Table 3). The pH values are within the range where the fermentation takes place (pH values 6.8 -7.5).

Table 3

Average pH values of the compost treatments

Name of treatments	pH value
Control (week 1)	6,90
Control (week 8)	7,48
Difference between week 1 and week 8	+0,58
1 w/w% zeolite (week 1)	7,00
1 w/w% zeolite (week 8)	7,55
Difference between week 1 and week 8	+0,55
2 w/w% zeolite (week 1)	6,90
2 w/w% zeolite (week 8)	7,31
Difference between week 1 and week 8	+0,41
5 w/w% zeolite (week 1)	6,80
5 w/w% zeolite (week 8)	7,59
Difference between week 1 and week 8	+0,79
7 w/w% zeolite (week 1)	6,80
7 w/w% zeolite (week 8)	7,40
Difference between week 1 and week 8	+0,60

Conductivity also plays an important role in the composting process by indicating the salt content of the compost.

The conductivity value should decrease as the composting process progresses. The increasing tendency of conductivity reduces the suitability of compost for nutrient supply, as it can cause phytotoxicity and inhibit

germination. The conductivity and thus the soluble salt content do not influence the degradation processes, but may limit the use of compost (Tamás, 1990).

In addition, if aerobic dominance is not achieved in the composting process, conductivity increases due to the release of mineral salts and ammonium ions released from the decomposition of organic matter (Gao et al., 2010). The conductivity values decreased with increasing mixing of the zeolite (Table 4).

Table 4

Average electrical conductivity values of the compost treatments

Name of treatments	Electrical conductivity (EC) [mS/cm]
Control (week 1)	6,33
Control (week 8)	7,19
Difference between week 1 and week 8	+0,86
1 w/w% zeolite (week 1)	5,93
1 w/w% zeolite (week 8)	6,04
Difference between week 1 and week 8	+0,11
2 w/w% zeolite (week 1)	5,62
2 w/w% zeolite (week 8)	5,81
Difference between week 1 and week 8	+0,19
5 w/w% zeolite (week 1)	5,08
5 w/w% zeolite (week 8)	5,35
Difference between week 1 and week 8	+0,27
7 w/w% zeolite (week 1)	4,15
7 w/w% zeolite (week 8)	5,53
Difference between week 1 and week 8	+1,38

One of the most common ways to determine compost maturity is to monitor the temperature during the composting process. The temperature of the compost is important not only for its degradation but also for pathogenic microorganisms and parasites. High temperatures (55 °C) kill pathogenic microorganisms and parasites, but if the prism temperature does not reach the correct value, its infectivity can be maintained (De Bertoldi, Vallini Pera, 1983). As a result of prolonged high temperatures, bacterial populations are transformed and various thermophilic microorganisms become more prominent, and bacterial density and activity decrease at temperatures above 60 °C (Miyatake, Iwabuchi, 2005).

The temperature of the control prism is shown in Fig. 1 and temperature of the 7 w/w % zeolite prism shown in Fig. 2.

In the case of the control prism, it can be clearly seen that the temperatures were measured in different parts of the prism different. The highest temperature was measured in the center of the prism. After mixing, the prisms were wetted and heat production was started. Based on these, a

primary phase of composting can be observed on day 1, which is accompanied by a rapid increase in temperature. By day 12, a very intense heat-producing phase was present in the prism, with the highest temperature measured on day 2 (52.8 °C).

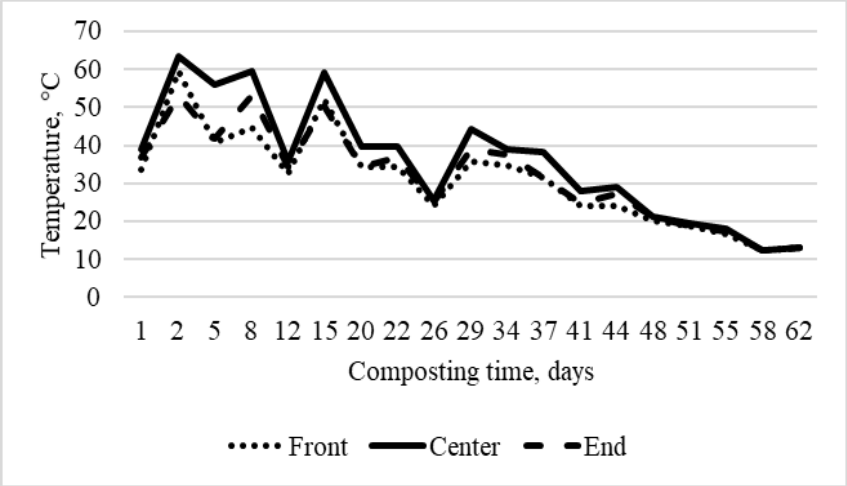

Fig. 1. Measurements of temperature with control compost prism longitudinal section and composting time

The minimum points in the temperature curves represent the points where no moisture content of about 50 w/w % was available, which resulted in a decrease in microbial activity which resulted in a decrease in temperature. By day 62, the temperature of the prism had dropped and raised its external (environment) temperature. This indicated to us that the material had reached the curing stage. Based on the temperature profile of the prism, the composting stages were completed within 62 days.

In the 7 w/w % zeolite treated prism the thermophilic phase lasted longer (up to 22 days) than in the control prism (Fig. 2).

There was no significant difference between the temperature measured in the longitudinal sections in either the control or the 7 w/w % zeolite treated prisms at the 5 % significance level.

This additive can be explained by a favorable impact on the compost raw materials, since the zeolite has improved air supply to the prism, and thus had a positive effect on the development of the temperature. The highest temperature was 58.73 °C and the internal temperature of the prism (58.73-37.10 °C) was well above the outside temperature during the first 22 days.

From these results it can be concluded that by increasing the proportion of additive the length of the thermophilic phase can be increased

and a higher initial temperature can be achieved after adjusting the appropriate (in our case 50 w/w %) humidity level.

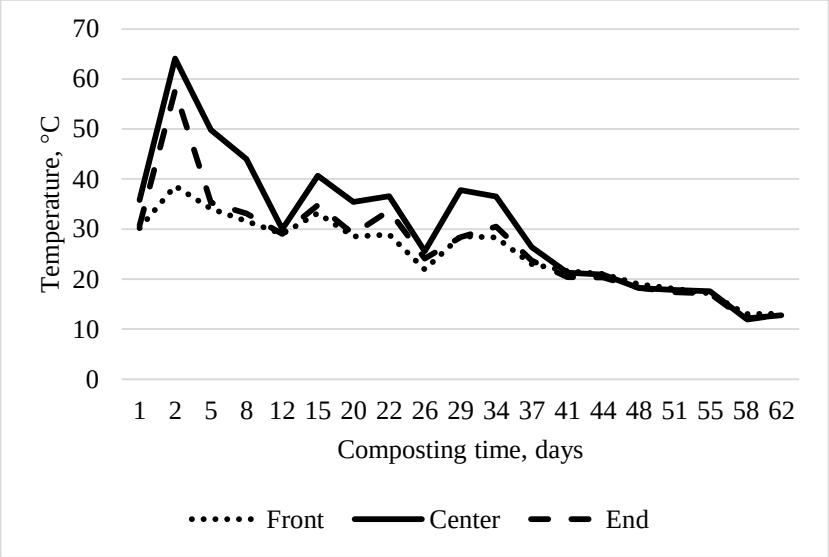

Fig. 2. Measurements of temperature with control compost prism longitudinal section and composting time

About 50 w/w % of the organic matter is completely mineralized during composting. Protein, cellulose and hemicellulose are readily degraded during aerobic fermentation. Many of these compounds produce organic residues called humic substances (Chefetz et al., 1998). There is no ideal organic matter content for raw materials or ready compost. The organic matter content decreases during composting. Typical feedstocks and starter blends contain more than 60 w/w % organic matter and 30-70 w/w % finished compost.

It can be observed that the higher the proportion of zeolite was added to the fertilizer mixture, the smaller was the organic content (Fig. 3).

Both the first and the eighth weeks had the highest organic matter content (over 68 w/w %) in the control. This high organic matter content can be explained by the high organic matter content of the starting materials. The difference in organic matter content between the control and the 7 w/w % zeolite blend is approximately 7 w/w %.

By week 8, a minimal increase in organic matter content was observed, with the exception of 2 w/w % zeolite and 7 w/w % zeolite mixing, with minimal decrease (-0,34 w/w %). The organic matter content should decrease as composting progresses, as Bazrafshan et al., 2016. According to their studies, the organic matter content of the mixture they composted was 66.25 w/w % at the start of composting and decreased to

34.38 w/w % at the end of the process (31.87 w/w % decrease) (after 80 days). During the first 40 days of composting, a maximum reduction in organic matter (24.03 w/w %) was observed, which may be due to high microbial activity and high temperature.

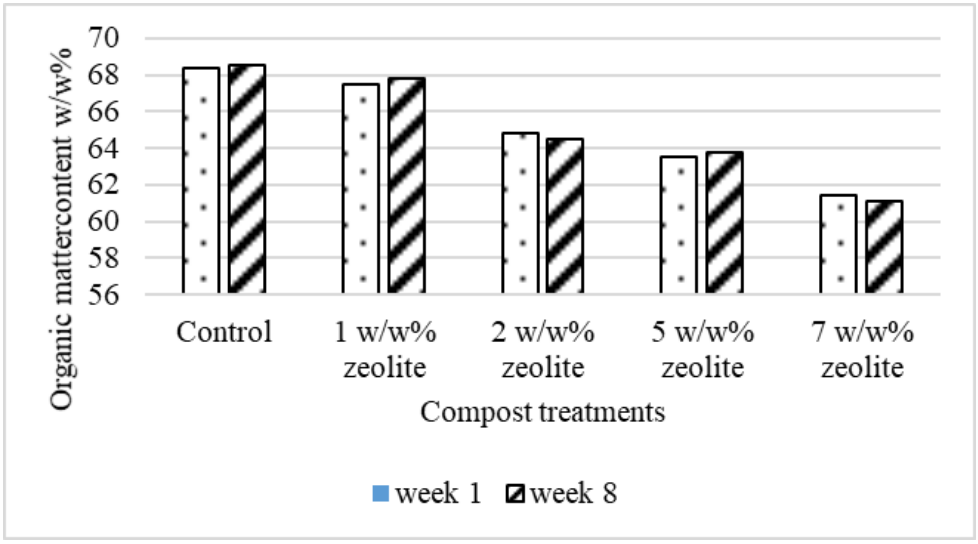

Fig. 3. Organic matter content of compost treatments

Organic degradation did not occur between the first and the eighth week, according to the literature (Bazrafshan et al., 2016), it should have been reduced, which is explained by the fact that the core temperature was very high compared to the small prism size, and therefore the thermophilic organisms had to be replaced by extreme thermophiles. For extreme thermophiles, degradable organic matter was not sufficient, while thermophiles were not available. However, as the proportion of zeolite increased, the rate of organic matter decomposition increased.

CONCLUSIONS

As for the moisture content, the 50 w/w % moisture content of the poultry manure and chicken manure mixture is sufficient to allow the fermentation to take place.

Based on temperature, the four stages of composting can be separated. By increasing the proportion of the additive, the length of the thermophilic phase can be increased, since in the case of the control the intensive heat-producing phase lasted until 12 days, while in the 7 w/w % zeolite treated prism it lasted until 22 days.

The pH values ranged from those in the literature. The conductivity values can be said to be favorable, because when the fermentation is

complete, the electrical conductivity values decrease, which is accompanied by the evaporation of the ammonia and the precipitation of the mineral salts.

Overall, the zeolite does not play a major role, as the fertilizer used has the greatest effect on the organic matter content.

Acknowledgment

I would like to say thanks to Sándor Kun for his dedicated work, and I would like to thank the Baromfi-Coop Ltd. for providing us with the raw materials and for the professional support.

This research was supported by EU grant to Hungary; GINOP 2.2.1.-15-2017-00043.

REFERENCES

1. Albrecth R., Joffre R., Gros R., Le Petit J., Terrom G., Périssol C., 2008, Efficiency of near-infrared spectroscopy to assess and predict the stage of transformation of organic matter in the composting process. Bioresource Technology 99, pp.448-455;
2. Alburquerque J., Gonzálvez J., García D., Cegarra J., 2006, Effects of bulking agent on the composting of "alperujo", the solid by-product of the two-phase centrifugation method for olive oil extraction. Process Biochermistry 41, pp.127-132;
3. Alexa L., Dér S., 2001, Professional composting (in Hungarian: Szakszerű komposztálás). Elmélet és gyakorlat, Profikomp Kft., Gödöllő;
4. Bazrafshan E., Zarei A., Mostafapour F.K., Poormollae N., Mahmoodi S., Zazoul, M.A., 2016, Maturity and Stability Evaluation of Composted Municipal Solid Wastes. Health Scope. 5(1), pp.33-202;
5. Bernai M.P., Paredes C., Sanchez-Monedero M.A., Cegarra J., 1998, Maturity and stability parameters of compost prepared with a wide range organic wastes. Bioresource Technology 63, pp.91-99;
6. Castaldi P., Alberti G., Merella R., Melis P., 2005, Study of the organic matter evolution during municipal solid waste composting aimed at indentifying suitable parameters for the evaluation of compost maturity. Waste Management 25, pp.209-213;
7. Chang J.I., Chen Y.J., 2010, Effects of bulking agents on food waste composting. Bioresource Technology. 101(15), pp.5917-24;
8. Chefetz B., Adani F., Genevini P., Tambone F., Hadar Y., Chen Y., 1998, Humicacid transformation during composting of municipal solid waste. Journal of Environmental Quality 27:, pp.794-800;
9. Chen Y.N., 2005, Nuclear magnetic resonance, infra-red and pyrolysis: Application of spectroscopic methodologies to maturity determination of composts. Compost Science and Utilization 11, pp.152-168;
10. De Bertoldi G., Vallini Pera A., 1983, The Biology Of Composting: A Review. Waste Management & Research 1, pp.157-176;
11. Gao M., Li B., Yu A., Liang F., Yang L., Sun Y., 2010, The effect of aeration rate on forced-aeration composting of chicken manure and sawdust. Bioresource Technology 101, pp.1899-1903;

12. Gea T., Barrena R., Artola A., Sánchez A., 2007, Optimal bulking agent particle size and usage for heat retention and disinfection in domestic wastewater sludge composting. Waste Management 27(9), pp.1108-1116;
13. Haug R.T., 1993, The Practical Handbook of Compost Engineering. Lewis Publishers, pp.615-717;
14. Itavaara M., Karjomaa S., Selin J.F., 2002, Biodegradation of polylactide in aerobic and anaerobic thermophilic conditions. Chemosphere 46, pp.879-885;
15. Juhász Cs., Hunyadi G., 2014, Investigation of aerobic biological waste treatment methods, with special regard to the composting process (in Hungarian: Aerob biológiai hulladékkezelései módszerek vizsgálata, különös tekintettel a komposztálási folyamatra vonatkozóan). Agrártudományi közelmények, 61, pp.33-37;
16. Kovács D., Füleky Gy., 2016, Methods for determining compost maturity – Review (in Hungarian: A komposztérettség meghatározásának módszerei – Szemle). Agrokémia és talajtan, 65, pp.135-160;
17. Mendiburu F., 2019, Agricolae: Statistical Procedures for Agricultural Research. R package version 1.3-0. https://CRAN.R-project.org/package=agricolae;
18. Miyatake F., Iwabuchi K., 2005, Effect of high compost temperature on enzymatic activity and species diversity of culturable bacteria in cattle manure compost. Bioresource technology, 96(16), pp.1821-1825;
19. Tamás J., 1990, Disposal of sewage sludge and its impact on the environment (in Hungarian: Szennyvíziszap elhelyezése és hatása a környezetre). Debreceni Agrártudományi Egyetem. Tudományos Közlemények. Debrecen, pp.1-125;
20. Tang J.C., Maie N., Tada Y., Katayama A., 2006, Characterization of the maturing process of cattle manure compost. Process Biochemistry 41, pp.380-389;
21. Tiquia S.M., 2005, Microbiological parameters as indicators of compost maturity. Journal of Applied Microbiology 99, pp.816-828;
22. Wang P., Changa C.M., Watson M.E., Dick W.A., Chen Y., Hointink H.A J., 2004, Maturity indices for composted dairy and pig manures. Soil Biology and Biochemistry 36, pp.767-776.

Received: October 31, 2019
Revised: January 17, 2020
Accepted and published online: May 31, 2020

Natural Resources and Sustainable Development
Volume 10, Issue 1, 2020
DOI: 10.31924/nrsd.v10i1.041

PHENOLIC COMPOUNDS OF CABERNET SAUVIGNON RED WINE ASSORTMENT FROM DRAGASANI AREA

Stănilă Andreea*#, Diaconeasa Zoriţa*, Stirbu Ioana, Buican Bettina***

*University of Agricultural Sciences and Veterinary Medicine, Faculty of Food Science and Technology, 3-5 Manastur St., 400732, Cluj-Napoca, Romania, e-mail: andreea.stanila@usamvcluj.ro
**Babes Bolyai University, Faculty of Physics, 7-9 Universitatii St., 400084, Cluj-Napoca, Romania

Abstract

The aim of this work is mainly to determine the effect of some pedoclimatic conditions on the phenolics composition of wine originated from Cabernet Sauvignon red grape variety, cultivated in the region of Drăgăşani area (Romania) during 2013-2016. The obtained results revealed that the higher temperatures decrease the quantities of phenolic compounds, especially that of anthocyanins. Also, the more abundant precipitations lead to the decrease of these compounds, constituting a stress factor for their biosynthesis. Total polyphenol concentrations range from 1478 mg GAE/L to 2949 mg GAE/L. Anthocyanins are the most abundant class of polyphenols in wines and among these malvinidin derivatives predominate. Also, a close relationship between phenolic subclasses and antioxidant activity was observed for the wine samples.

Key words: phenolic compounds, anthocyanins, wine, pedoclimatic factors

INTRODUCTION

Phenolic compounds, which are abundant in grape berries and wines, play one of the most important roles in the quality of grape berries and wines (Lesschaeve, Noble, 2005). Polyphenols also exert many favorable effects on human health, such as the inhibition of atherosclerosis, coronary heart disease and various cancer types (Yilmaz, Toledo, 2004). Positive correlations between total phenolics and antioxidant capacity have been reported by Orak, 2007.

According to many authors, antioxidant activity of grape berries and wines results mainly from their phenolics, whereas the phenolic content and composition depend on the grape variety, vineyard location, cultivation system, climate, ageing (Schwarz, et al., 2004). Red wines contain 1500 to 2500 mg/L of total phenolic compounds (Danilewicz, 2011).

Regarding human health, it is shown that polyphenols protect from cardiovascular diseases. Based on in vitro and in vivo studies, a certain amount of everyday wine consumption may prevent various chronic diseases. This is due, in part, to the presence and amount of important antioxidants in red wine. Wine polyphenols, especially resveratrol, anthocyanins, and catechins, are the most effective wine antioxidants (Dartigues et al., 2002).

This study aimed to analyze the differences in the phenolic

Corresponding author

compounds and antioxidant properties of four red wines obtained from grapes *Vitis vinifera* var. Cabernet Sauvignon. The objectives were to evaluate the levels of phenolics compound and antioxidant activities of these samples and provide some useful information for producing high-quality wine.

MATERIAL AND METHOD

The wines were provided from the Şani wine cell, obtained through the classic wine-making technology of the red wine, matured in glass. The samples were produced in 2013, 2014, 2015, 2016 and have five, four, three, respectively two years old at the time of analysis. The samples were symbolized: P1, P2, P3, P4.

1. HPLC–DAD quantification analysis of anthocyanins

Analysis were performed on a Shimadzu HPLC-LC20 AT with Waters 990 PDA detector, Kontron pumps and controller. A Luna Phenomenex C-18 column (5 lm, 25 cm 4.6 mm) was used. The mobile phase used was 4.5 % formic acid in bidistilled water (solvent A) and acetonitrile (solvent B). The gradient elution system started with 10 % B for 9 min. Anthocyanin quantification was done using cyanidin-3-glucoside as standard. Chromatograms were recorded at 520 nm.

2. Determination of total phenolic content

The total phenolic content (TPC) of all the extracts was determined following the Folin–Ciocalteu spectrophotometric method. The absorbance of the samples, standards, and blanks was read at 750 nm using a microplate reader (BioTek Instruments,Winooski, VT, USA). The absorbance of the blank was subtracted from all readings, and a calibration curve was created using the standard. Total phenolic content was calculated as gallic acid equivalents (GAE) based on the gallic acid calibration curve.

The results were expressed as mg of gallic acid equivalents (GAE) per 100 g of fresh weight (FW).

3. Determination of total flavonoid content

The total flavonoid content of the samples was determined according to the aluminium chloride colorimetric method, based on the formation of a complex between flavonoid and aluminium. The absorbance was measured at 720 nm versus water blank was recorded using a spectrophotometer (JASCO V-630 series, International Co., Ltd., Tokyo, Japan).

Total flavonoid content was expressed as mg quercetin equivalents/ 100 g of fresh weight (FW).

4. ABTS radical scavenging assay

This assay is based on the capacity of an antioxidant to scavenge the ABTS radical cation ($ABTS^{+}$) compared to a standard antioxidant (Trolox).

The absorbance of the samples, standards, and blanks was read at 734 nm using a microplate reader (BioTekInstruments, Winooski, VT, USA). A standard curve was prepared using different concentrations of Trolox and the results were expressed as µM Trolox/g sample.

RESULTS AND DISCUSSION

1. Chemical parameters of wines

For a better interpretation of the results, alcoholic degree, total acidity, total and free sulfur dioxide of all wines were determined. The results are presented in Table 1.

Table 1

Chemical parameters of Cabernet Sauvignon wine samples

Type of analysis	P 2013	P2014	P2015	P2016
Alcohol conc., % vol	13.9^{a}	12.9^{c}	13.2^{bc}	13.5^{ab}
Total acidity, g/l	6.94^{a}	6.49^{bc}	5.5^{d}	6.17^{c}
Free SO_2, mg/l	21.06^{d}	28.16^{c}	35.56^{b}	43.52^{a}
Total SO_2, mg/l	40.80^{d}	58.88^{c}	65.75^{b}	96.66^{a}

The values represent the means of three samples, nalyzed individually in triplicate (n=3x3). Different superscript letters (a,b.c,d) n the same row mean significant differences ($p<0.05$) ANOVA „Turkey's Multiple Comparison Test"

2. Comparison on Phenolic Compounds

The total polyphenols (TP), total flavonoids (TFO), and total anthocyanins (TA) and ABTS assay were measured for all the wine samples from the four years and the results are shown in Table 2.

The results confirm a variation in phenolic content among wine samples tested. The amounts of phenolics varied in different wine grape-growing regions, depending on the grape variety, genetic and environmental factors of vine growth (Villaňo et al., 2006).

Table 2

Total amount of phenolic substances of Cabernet Sauvignon wines from different years (2013; 2014; 2015; 2016)

Samples	Total anthocyanins mg ME/L	Total polyphenols mg GAE/L	Total flavonoids mg CTE/L	ABTS µM T/100ml
P1(2013)	194.8 ± 1.9^{c}	1478.1 ± 35.1^{d}	398.9 ± 1.22^{a}	665.85 ± 4.95^{d}
P2(2014)	197.25 ± 2.8^{c}	1649.65 ± 18.5^{c}	335.19 ± 2.20^{b}	743.9 ± 5.6^{c}
P3(2015)	345.7 ± 3.1^{b}	2537.05 ± 47.5^{b}	294.41 ± 3.65^{c}	901 ± 5.75^{b}
P4(2016)	629.15 ± 2.2^{a}	2949.05 ± 24.5^{a}	400.75 ± 1.36^{a}	1140.8 ± 9.60^{a}

Total polyphenols (TP) - mg of gallic acid eq/liter (mg GAE/L) Total flavonoids (TFO) - mg of catechin eq/liter (mg CTE/L); Total anthocyanins (TA) - mg of malvidin-3-*O*-glu eq/ liter (ME mg/L).

The values represent the means of three samples, nalyzed individually in triplicate (n=3x3). Different superscript letters (a,b.c,d) n the same row mean significant differences ($p<0.05$) ANOVA „Turkey's Multiple Comparison Test"

2.1. Quantification of total anthocyanins TA

In Cabernet Sauvignon wines total anthocyanins (TA) contents varied from 19.29 mg ME/100 ml in P1, 19.44 mg ME/100 ml, in P2 - 34.26 mg ME/100 ml, in P3 to 63.14 mg ME /100 ml in P4. These results are summarized in Table 3 and the chromatogram of individual anthocyanins identified in the samples is presented in Fig. 1.

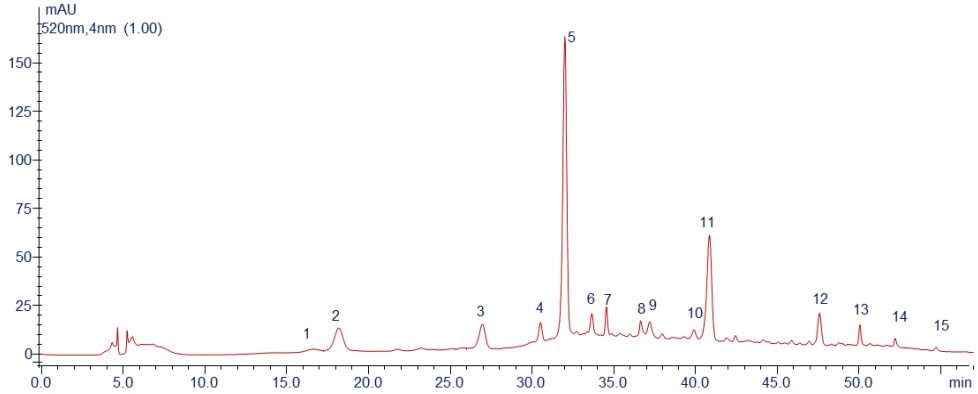

Fig. 1. Chromatogram of individual anthocyanins identified in Cabernet Sauvignon wine

The present research revealed that the contents of TA in Cabernet Sauvignon is dependent on pedoclimatic factors. The mean temperature in July-August months of every years were: 23.90C in 2013; 23.40C in 2014; 22.30C in 2015, respectivelly 21.8 0C in 2016. The precipitations level expressed as an average of the values between three months (August, September, October) of each studied year were: 59.2 mm (2013); 52 mm (2014); 99.2 mm (2015) and 82.7 mm (2016).

Increasing air temperatures, will increase the rate of metabolic processes in the plant, with an associated increase in development and metabolite accumulation (Downey et al., 2003).

The pigment formation and the optimal physiological ripening of grapes for the synthesis of colour and aroma compounds take place between 20° C and 22 °C (Chorti et al., 2010). Other researchers found an increase in the skin tannins and anthocyanin amounts per berry, as well as concentrations with an increased water deficit (Ojeda et al., 2002; Roby, Matthews, 2004).

Our study is consistent with these findings. The content of total anthocyanins increased three time in 2016, the year with the smallest temperature and the most abundant precipitations, which suggest that these climatic conditions could be a stress factor, increasing the anthocyanins

biosynthesis. Regarding the anthocyanins, their concentration decreased significantly during aging, which is consistent with previous studies (Castellari et al., 2002). This reduction for wines was high, 69.25% after four years of aging.

Table 3

Individual anthocyanins quantified in Cabernet Sauvignon wines

Peak	RT (min)	Compound	P1-Conc mg/100 ml	P2-Conc mg/100 ml	P3-Conc mg/100 ml	P4-Con. mg/100 ml
1	16.58	Petunidin 3-*O*-glucoside	0.43	0.41	0.37	0.52
2	18.16	Peonidin 3-*O*-glucoside	0.10	0.12	1.93	4.40
3	26.93	Malvidin 3-*O*-glucoside	0.11	0.12	1.55	3.63
4	30.49	Malvidin 3-*O*-(6-*O*-acetyl)-glucoside-pyruvic acid	0.16	0.11	1.94	2.17
5	31.98	Malvidin 3-*O*-glucoside -ethyl-catechin (1)	11.94	12.67	13.20	24.77
6	33.63	Malvidin 3-*O*-(6-*O*-acetyl) -glucoside-acetaldehyde	0.14	0.15	1.66	3.95
7	34.53	Malvidin 3-O-glucoside-ethyl-catechin (1)	0.69	0.63	1.22	1.77
8	36.62	Malvidin 3-O-glucoside-ethyl-catechin (1)	0.34	0.21	1.49	2.79
9	37.18	Peonidin 3-*O*-(6-*O*-acetyl) -glucoside	0.13	0.07	1.63	3.14
10	39.88	Malvidin 3-*O*-(6-*O*-acetyl) -glucoside	0.13	0.02	1.10	2.07
11	40.82	Malvidin 3-*O*-(6-*O*-caffeoyl) -glucoside	4.22	4.32	5.68	9.95
12	47.55	Malvidin 3-*O*-(6-*O*-*p*-coumaryl) -glucoside-acetaldehyde	0.19	0.20	1.38	2.48
13	50.03	Malvidin 3-*O*-(6-*O*-*cis*-*p*-coumaryl) -glucoside	0.44	0.30	0.68	0.83
14	52.19	Peonidin 3-*O*-(6-*O*-*trans*-*p*-coumaryl) -glucoside	0.20	0.08	0.30	0.54
15	54.70	Malvidin 3-*O*-(6-*O*-*trans*-*p*-coumaryl) -glucoside	0.08	0.04	0.13	0.11
		Total	19.29	19.44	34.26	63.14

2.2. Q*uantification of total flavonoids TFO*

The four sample wines varied in total flavonoids (TFO) ranging from 294.41 to 400.75 mg CTE /L. The sample P4 from 2016 year exhibited the highest values of TFO, whereas the lowest TFO content was detected in the

sample P3 from 2015 year. Based on the present study, we found that climate conditions play an important role in the regulation of biosynthesis of polyphenols in grape, resulting in significantly higher levels in polyphenol contents of grapes grown in vineyards with less precipitation. This is consistent with previous study (Lee et al., 2009). The smallest content in total flavonoids was obtained in 2015, which was abundant in precipitation.

Another important factor in winemaking is the use of SO_2, due to its ability of an effective antioxidant, preventing the activity of the oxidases. From the results obtained, it can be concluded that higher concentrations of phenolic components, were measured in the wines with higher dose of SO_2, since SO_2 prevented the phenolic oxidation and thus, allowed higher extraction of polyphenols.

The storage of wines in bottles had as a result the decrease of total flavonoids, total polyphenols and total anthocyanins. Similar results were obtained by other researchers (Castelari et al., 2002). Polymerization reactions of tannins could lead to a decrease of total phenolics.

2.3. Quantification of total polyphenols TP

The total polyphenols content varied from 1478.1mg GAE/L in 2013 to 1649.65 mg GAE/L in 2014, 2537.05 mg GAE/L in 2015 and 2949 mg GAE/L in 2016. The higher content in P3 and P4 (2537.05 – 2949 mg GAE/L compared with 1478.1 mg GAE/L in 2013 could be related with climatic conditions in years 2015 and 2016, which were the most abundant in precipitations. Also, the SO_2 concentration affect the stabilization of polyphenols.

These values of the main phenolic groups (including TP, TFO, and TA) were within the range reported for some Cabernet Sauvignon wines from other researchers (Jiang, Zhang, 2012; Ma et al., 2014).

2.4. Antioxidant activity - correlations with phenolics compounds

To evaluate the antioxidant levels of each wine samples, the antioxidant capacities exibit by ABTS method differed greatly, related with phenolics components. There is a positive relationship between phenolic compounds and antioxidant activities (Jiang, Zhang, 2012). In generally, as the phenolics contents in wine increased, the antioxidant activities also increased. Antioxidant activities varies from 665.85 µM T/100 ml in 2013, to 743.9 µM T/100 ml in 2014, 901 µM T/100 ml in 2015 and 1140.8 µM T/100 ml in 2016.

Correlation analysis was used to explore the relationships amongst the different antioxidant variables measured for all the wine samples. The total phenols and anthocyanins contents of wine samples exhibited the strongest correlation with antioxidant properties, except the flavonoid compounds, as it could be seen in Table 4 and Fig. 2.

Table 4

Pearson's correlation coefficients of antioxidant capacity, TP, TFO, and TA in Cabernet Sauvignon wine from four different years

	TA	TFO	TP
ABTS	0.9636	0.6537	0.9369

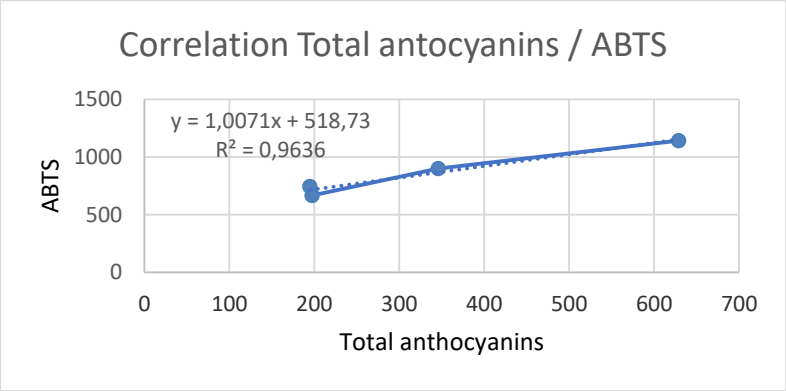

Fig. 2. Correlation between ABTS antioxidant activity and TA content in Cabernet sauvignon wine.

Thus, the antioxidant efficiency of Cabernet Sauvignon wines tested appear to be largely influenced by the total phenols, flavonoids and anthocyanins, these results were consistent with previous reports in the literatures (Kim et al., 2003).

CONCLUSIONS

The results from this study provide informations the contents of phenolic compounds and antioxidant activities in Cabernet Sauvignon wines from the Dragasani region. The amounts of phenolics and antioxidant activity varied considerably in these regional wines, depending on the environmental factors, storage time and SO_2 concentration. Meanwhile, a close relationship between phenolic subclasses and antioxidant activity for all the wine samples were observed. The results suggest that SO_2 affect the content of total phenolics, anthocyanins, flavonoids, increasing their content.

During wine aging, when polymerization of phenolics occurs, slight decrease of total phenolics with intensive decrease of anthocyanins were observed in the wines stored different years in bottles.

REFERENCES

1. Castellari M., Sartini E., Fabiani A., Arfelli G., Amati A., 2002, Analysis of Wine Phenolics by High-Performance Liquid Chromatography Using a Monolithic Type Column. Journal of Chromatography A, 973, pp.221-227;

2. Chorti E., Guidoni S., Ferrandino A., Novello V., 2010, Effect of different cluster sunlight exposure levels on ripening and anthocyanin accumulation in Nebbiolo grapes. Am. J. Enol. Vitic. 61, pp.23-29;
3. Danilewicz J.C., 2011, Mechanism of Autoxidation of Polyphenols and Participation of Sulfite in Wine: Key Role of Iron. American Journal of Enology and Viticulture, 62, pp.319-328;
4. Dartigues J.F., Berr C., Helmer C., Letenneur L., 2002, Epidemiologie de la maladie d'Alzheimer. Medicine/ Sciences, 18, pp.737-743;
5. Downey M.O., Harvey J.S., Robinson S.P., 2003, Analysis of tannins in seeds and skins of Shiraz grapes throughout berry development. Aust. J. Grape Wine Res. 9, pp.15-27;
6. Jiang B., Zhang Z.W., 2012, Comparison on phenolic compounds and antioxidant properties of Cabernet Sauvignon and Merlot wines from four wine grape-growing regions in China. Molecules, 17(8), pp.8804-8821;
7. Kim D.O., Chun O.K., Kim Y.J., Moon H.Y., Lee C.Y., 2003, Quantification of polyphenolics and their antioxidant capacity in fresh plums. J. Agric. Food Chem., 51, pp.6509-6515;
8. Lee J.E., Hwang G.S., Van Den Berg F., Lee C.H., Hong Y.S., 2009, Evidence of vintage effects on grape wines using 1HNMR- based metabolomic study. Analytica Chimica Acta, 648(1), pp.71-76;
9. Lesschaeve I., Noble A.C., 2005, Polyphenols: Factors influencing their sensory properties and their effects on food and beverage preferences. Am. J. Clin. Nutr., 81, pp.330-335;
10. Ma T.T., Sun X.Y., Gao G.T., Wang X.Y., Liu X.Y., Du G.R., Zhan J.C., 2014, Phenolic characterisation and antioxidant capacity of young wines made from different Grapevarieties gwn in Helanshan Donglu wine zone (China). South African Journal of Enology and Viticulture, 35(2), pp.321-331;
11. Ojeda H., Andary C., Kraeva E., Carbonneau A., Deloire A., 2002, Influence of pre- and postvéraison water deficit on synthesis and concentration of skin Phenolic compounds during berry growth of *Vitis vinifera* cv. Syrah. Am. J. Enol. Vitic. 53, pp.261-267;
12. Orak H.H., 2007, Total antioxidant activities, phenolics, anthocyanins, polyphenoloxidase activities of selected red grape cultivars and their correlations. Sci. Hortic., 111, pp.235-241;
13. Roby G., Matthews M.A., 2004, Relative proportions of seed, skin and flesh in ripe berries from Cabernet Sauvignon grapevines grown in a vineyard either well irrigated or under water deficit. Aust. J. Grape Wine Res. 10, pp.74-82;
14. Schwarz M., Hofmann G., Winterhalter P., 2004, Investigations on Anthocyanins in Wines from *Vitis vinifera* cv. Pinotage: Factors Influencing the Formation of Pinotin A and Its Correlation with Wine Age. Journal of Agricultural and Food Chemistry, 52, pp.498-504;
15. Villaňo D., Troncoso M.S., Fernández-Pachón A.M., García Parrilla M.C., 2006, Influence of enological practices on the antioxidant activity of wines. Food Chem., 95, pp.394-404;
16. Yilmaz Y., Toledo R.T., 2004, Health aspects of functional grape seed constituents. Trends Food Sci. Technol., 15, pp.422-433.

Received: October 31, 2019
Revised: February 21, 2020
Accepted and published online: May 31, 2020

Natural Resources and Sustainable Development
Volume 10, Issue 1, 2020
DOI: 10.31924/nrsd.v10i1.042

IDENTIFYING MOTIVATION FOR SHEA NUTS GATHERING IN AN URBAN COMMUNITY FROM GHANA

Owusu-Ansah Nana*# , Asare-Gyebi Kwadwo*

*Gbele Resource Reserve, Post Office Box 35, Tumu, Ghana,
e-mail: naduono74@yahoo.co.uk

Abstract

Fruit bats survey and interviews were conducted to collect data on bat roosting sites and gatherers' motivation for collecting nuts respectively. Three different fruit bat species were identified from four different roosting sites. Income was identified to be the major motivating factor among the five factors that urged the gatherers to collect Shea nuts. Gatherers mentioned more often that bat discarded nuts have short shelf life than any other demotivating factor. There was a statistically significant relationship between demotivating factors and gatherers' discriminatory tendencies against bat discarded nuts (X^2=31.536, Df=5, P=7.342e-6). However, there was no statistically significant relationship between demotivating and motivating factors (X^2= 26.592, Df=20, P=0.1471).

Gatherers without formal education made the largest sales from Shea nuts than the educated. There was statistically significant relationship between educational background and income generated from Shea nuts (X^2= 47.303, Df=27, P= 9.175e-3). The widowed had the highest median income values from Shea nuts although there was no statistically significant relationship between marital status and income generated. All age groups were involved in Shea nuts gathering and the general trend suggested the levels of incomes generated increase with age. There was a statistically significant relationship between gatherers' age and number of children whereas there was no statistically significant relationship between the number of children and income generated.

Key words: demotivation, fruit bat, gathering, motivation, roosting, Shea nuts

INTRODUCTION

Gathering of natural resources for subsistence is not only rooted in the past but still part of rural livelihoods especially those in the developing world (Blench, 2001; Getzner, Islam, 2013; Laube, 2015; Nawrotzki et al., 2012; Moore, 2008). Really, gathering of some natural resources in some instances has served as a raw material base for the manufacture of modern products. Nuts from the Shea tree (*Vitellaria paradoxa)* are one such natural resource that are gathered across the Savanna regions of Africa for its essential economic and other benefits.

Blench, 2001 reported how the Shea trade has lasted for more than millennia across the 18 African countries where the species thrives in the Savanna. The Shea tree has economic, socio-cultural and ecological relevance and these functions have molded the landscape of the people who utilise it (Fontaine et al., 2004). Products derived from the Shea tree span across cosmetics to foods directly prepare from its fruits or as an added supplement. The species medicinal properties come from the leaves, the

Corresponding author

bark and the nuts. For example, the butter from the nuts has healing properties for treating diseases like eczema, sunburns, wounds and fractures (Laube, 2015).

Shea nut is processed into butter either to be used at home or sold at the local markets. However, in most cases kernels are sold at the local markets or to large scale processors for industrial production of butter. The literature has reported how remarkably the Shea trade is solely done by women (Rammohan, 2010). The impression from literature is that the Shea trade serves as a readily income source for the women gatherers in the lean season where little farm work is done. Shea nut processing into butter is tedious. Homemade Shea butter processing begins with fruit collection and shelling off the pulp to the boiling of the nuts. Grinding nuts could either be manual or machine driven. The mashed nuts is then cooked to decant the oil to cool off to get the butter. In all these, the processors' wages do not commensurate with the costs of labour and fuel use in processing the nuts into butter at the subsistence level.

Notwithstanding the Shea tree enormous benefits, there are challenges in realizing its economic potential in Ghana. Some of the challenges are: (1) undefined access rights, (2) transportation difficulties to collection points, (3) inefficient processing methods, (4) inefficient energy sources and (5) difficulties in marketing the products. Access to the Shea tree differs from place to place. For example, in the study area there are no clear rules governing the right of access and thus gatherers can collect nuts from any tree they come across. The right of access is hindered really in urban communities where limited patches of the species stands are available. The limited number of trees in urban communities generate competition for access or simply it wanes the interest in the long held tradition of gathering Shea nuts when it is in season.

The challenges enumerated above could explain the reasons that demotivate people to gather Shea nuts in urban communities. This study assumed that Shea nuts gatherers in an urban community called Tumu in the Upper West Region of Ghana are motivated to collect nuts not only from Shea trees but also nuts discarded by fruit bats. This assumption is appropriate, for the literature points to the notion that collectors develop new strategies to motivate themselves to collect plant resources when conditions change (Schunko et al., 2015).

The purpose of this study was to assess gatherers motivation to collect Shea nuts in an urban community where the commodity is relatively scarce. The objective was to assess if gatherers deliberately add to their collection bat discarded nuts. Thus, increasing bat colonies in the community could be an additional source of Shea nuts and that would also promote bat conservation. The study also aimed to assess demographic factors that

motivate gatherers to increase income generated from gathering Shea nuts in the community.

Four main questions were asked for the study:

1. What species of fruit bats have colonies in the community?
2. What factors motivate gatherers to collect Shea nuts in the community ?
3. How do gatherers motivation and demotivation factors relate in collecting fruit bats discarded nuts ?
4. How do demographic factors of (I) educational background, (II) marital status, (III) age of the gatherer and (IV) number of children motivate gatherers' levels of income generated from Shea nuts ?

Theoretical Perspectives of Gatherers' Motivation

The study was to understand whether the limited access for Shea trees in the urban community motivate the gatherers to include other sources of the nuts into their collection. The theoretical background of this study relates gatherers motivation for collecting Shea nuts under both Shea trees and fruit bats discarded nuts.

The Notion of Motivation

Motivation inspires one to do with a zeal to achieve an end whiles demotivation indicates lack of impetus to perform an activity. There are both internal and external values that motivate or demotivate an individual into performing a task (Bénabou, Tirole, 2003). Motivation is described to have both intrinsic and extrinsic values that span the continuum between 'motivated not to do' to 'motivated to do' (Ryan, Deci, 2000).

Intrinsic motivation promotes inherent tendencies of interest that enjoins one to perform a task. The inherent tendencies of intrinsic motivation is derived from an individual autonomy that enable free choices to be made without being coerced (Singh, 2016). That is individual interests and satisfaction derive from his/her activities are treasured in intrinsic motivation.

Extrinsic motivation however, requires the influences of external values to produce a separable outcome (Ryan, Deci, 2000). Nonetheless, extrinsic motivation can sometimes be inherently induced to promote certain perceived values associated with certain activities and their outcomes. Thus, extrinsic motivation can either be externally driven to avoid sanctions or self-endorsed to gain certain functional values (Yoo et al., 2012).

Shea Nuts Gatherers' Motivation and Fruit Bats Discarded Nuts

Djossa et al., 2008 stated Shea nuts are dispersed mostly by three species of fruit bats found in West Africa. These flying mammals are the The Gambian epauletted fruit bat (*Epomophorus gambianus*), Peters's dwarf epauletted fruit bat (*Micropteropus pusillus*), and Veldkamp's dwarf

epauletted fruit bat (*Nanonycteris veldkampii*). These animals have special pouches in their mouth that can store many nuts which are carried to roosting sites (Kingdon, 1997). The bats eat the fruit pulp and then discard the nuts under their roosting sites.

Shea nuts gatherers could seize the opportunity provided by bats' colonies to augment nuts gathered directly under Shea trees in the community. The advantage is that extra nuts are carried from the feeding grounds of the bats to the community which the women could collect from the roosting sites of the bats. Apart from the gatherers not walking long distances to collect such nuts, it would also reduce the danger of suffering snakebites which is common under Shea trees in the bushes. The Shea fruit is succulent and thus attract rodents and other eaters which leads to snakes laying ambush to prey on the primary consumers.

Rejecting or collecting bat discarded nuts together with those under Shea trees would fit into Yoo et al., 2012 statement that indicated motivation empowers one to reflect and assimilate new ideas to undertake or not to undertake a task. Although Bénabou, Tirole 2003, mentioned intrinsic and extrinsic motivations may sometimes conflict with each other, it would require both components of motivation for gatherers to collect nuts under Shea trees and/or bat discarded nuts.

The above claims could be useful to the gatherers if rallying for such motivation would provide utility outcomes. Moser et al., 2011 stated the quality of a product to consumers is influenced by both its intrinsic and extrinsic evidences provided by the producer/seller of the product. Thus, a combination of opportunities provided by available Shea tree stands and bats roosting sites in the community together with the mind, knowledge, power and skills of the gatherers would be needed to provide motivation for collecting nuts (Assche et al., 2017; Poudel, 2012; Timiș-Gânsac et al., 2018).

In this context, the gatherers have been assumed to be motivated to collect nuts from both traditionally known source (under Shea trees) and other sources (bat discarded nuts) with the new conditions of relatively nuts scarcity in the community. Food, medicine, income, tradition and recreation have been stated as the major motivational factors that encourage people to gather plant resources from the wild. These motivational factors hinge on the needs of the people especially in subsistence situations as pertain in the study area.

MATERIAL AND METHOD

Study Area. Tumu is the district capital of the Sissila East Municipality. The 2010 population and housing census had the town's population as 11,086 as against the total municipal population of 56,528.

Agricultural activities form the major occupation of the people with 84.4 % of the working population. However, there are considerable differences in the economic activities depending on the location. According to the Ghana Statistical Service, 2010, the majority of households (94.9 %) in the rural areas were engaged in agriculture as against 56.9 % for the urban dwellers in the municipality.

There are parklands of Shea trees and assemblage of either planted or natural tree stands of different tree species that have canopies for bat roosting in the town. The dominant tree species that provide bat roosting niches are the neem (*Azadirachta indica*), mahogany (*Khaya senegalensis*) and stands of mangoes (*Mangefera indica*) in the town.

Data collection. Data collection was structured into two sections. The first was to locate clusters of tree stands where fruit bats roost. It was to identify the bat species, estimate their populations as well as the tree species they roost. The second section was to locate women who collect Shea nuts in the community for interviews. Data collection took place in the fruiting season of the Shea tree in the community (beginning 1st June to the 31st August, 2019).

Marking Bat Roosting Sites. A snowballing technique was used to identify roosting sites of fruit bats in the community through key informant approach (Wilcke, 2006). A global position system (GPS) coordinates were taken at the estimated center of each roosting site identified. Four research assistants counted the number of individual bats on a roosting site simultaneously. Counting was done in mid-afternoon (between 12 noon and 1Pm) where bats are mostly docile (Hayman et al., 2012). Care was taken not to arouse the bats whiles counting was going on to allow for sequential counting of all individuals sighted. The figures obtained by each counter was added and the averages calculated to represent the number of individual bats for each site. The species were then identified with the help of field guide.

All Shea nuts seen under each roosting site were collected for three consecutive days during the peak period in July. The nuts were counted to get an idea of possible number of nuts that are carried from feeding grounds by bats. The average number of nuts counted is presented at the results section.

Interviews. A semi structured interview guide was used to collect data on motivating factors for collecting nuts and demotivating factors against bat discarded nuts. The interview questions included incomes generated from Shea nuts and gatherers' demography. Focus group discussion was conducted after interviews were completed to clarify issues.

The community was divided into four units at the central point (the Post Office area). Clusters of Shea tree stands and bat roosting sites in each

unit was earmarked as points to find gatherers for interview. A Shea nut tree clusters in this study is defined to be within human settlement in the community. The earmarked clusters had at least thirty Shea trees with the average breast height girth of 30cm. Nine clusters were identified with two each located in each unit except one unit which had three clusters. The researchers tested the interview guide with five gatherers sampled accidentally at nuts collection points. After correcting errors detected during the test run, one research assistant was assigned to each of the four units to look for gatherers to interview.

The four research assistants visited their assigned clusters between 6 am and 9 am and between 4pm and 6pm weekly to get respondents for interviews. Snowballing sampling technique was also used to locate other gatherers who picked Shea nuts in the community. Each cluster was visited until no new gatherer was identified. No gatherer was interviewed twice but their phone contacts and house numbers were taken. The researchers followed on each respondent weekly to collect the quantity of nuts that had been gathered or sold.

The research assistants would move to the next cluster of Shea trees within their units if there were no gatherers at the time of visit or when interviews were completed in a cluster. Gatherers were asked for their consent before interviews were conducted. Children (girls) who gathered nuts for their mothers were followed to their homes to interview their mothers. Interviews lasted between 15 minutes and 20 minutes. Each research assistant submitted data gathered weekly to the main researchers. This allowed for editing and cleaning of the data on regular basis.

Focus Group Discussion. A focus group discussion was conducted after the nut collection season to clarify issues identified during the interview sessions (Creswell, 1998). Selection of participants was based on representation from each of the four units and also the quantity that a gatherer collected. The three highest gatherers in each unit were selected for the focus group discussion bringing the total to 12. The views expressed by participants enhanced the interview data gathered for analysis.

Data Analysis. Data were analysed with the help of the statistical software-Statistics-open-for-all (SOFA) (Self, 2017). Data have been analysed and presented in descriptive and inferential statistics format. Chi Square statistics was mainly used because data was grouped at the nominal level. The results are presented in tables and charts. Gatherers' incomes were derived from the quantity of Shea nuts gathered after the season and the local market value of a kilogram for the nuts in 2019.

RESULTS AND DISCUSSION

Results presentation begins with fruit bats survey conducted in the community on 2nd June, 2019 after a reconnaissance survey was undertaken on the previous day to locate roosting sites. The subsequent sections present the results from interview and focus group discussions data.

Location of Fruit Bats Colonies in Tumu. Four fruit bat colonies were identified in the community. The general observation was that the preference sites for roosting were on tall trees (above 7 meters) with open canopy vegetation. Hayman et al., 2012 made similar findings for Straw Coloured bat roosting preferences. Table 1 below provides detail description of the identified bat colonies.

Table 1

Identified Bats and Roosting Sites Description in Tumu

Location Description	GPS Coordinates	Identified Bat Species	Average Counts of bats	Roosting Tree Species/ number of nuts counted
Place serves as playground for Draught and *Oware* games. Nine lottery vendor kiosks and a food joint are located in the area. There is no undergrowth.	10. 877 45 N; 001.984 10 W	Dwarf Epauletted Fruit Bat (*Micropteropus pusillus*) *(Kingdon, 1997).*	363	Neem (9 trees) *Azadirachta indica* Average nuts counted=438
In front of the Tumu College of Education Administration Block with no undergrowth.	10.891 87 N; 001.985 59 W	Epauletted Fruit Bat (*Epauletted gambianus*) *(Kingdon, 1997).*	70	Mango (18 trees) *Mangefera indica* Average nuts counted=123
An alley of mango trees leading to staff quarters of the Tumu College of Education with little undergrowth.	10.893 41 N; 001.985 33 W	Epauletted Fruit Bat (*Epauletted gambianus*) *(Kingdon, 1997).*	122	Mango (18 trees) *Mangefera indica* Average nuts counted =243
Located on the Campus of the Kanton Senior High School. Their stay was temporal for less than two months. This species is known to be migratory (Hayman et al., 2012).	10.873218N 001.978953W	*Straw Coloured Fruit Bat (Eidolon helvum) (Kingdom, 1997).*	432	Mahogany (7 trees) *Khaya senegalensis* Average nuts counted = 652

The findings in this study showed mostly, majority of the roosting orientation was towards the leeward side of the trees that pointed towards the western ends of the tree canopies. This finding indicates the bats roosting orientation preferences was to reduce the negative impacts of the early to midday heat and to enjoy sunset low temperatures before flying to feeding sites. This agrees with Ruczynski et al., 2007 report that indicated the level of temperature is a factor in bat roosting preferences. The authors stated high temperatures affect bat thermoregulation activities negatively.

Gatherers' Motivating Factors. All the 81 Shea nuts gatherers identified were interviewed. Respondents were asked to mention one major motivational factor for collecting Shea nuts. The gatherers' motivational factors were grouped into income, food, medicine, tradition and recreation.

Below are the details of the percentage coverage of each motivational factor that urged the gatherers to collect Shea nuts in the community (Fig. 1).

The proportions of income and food constituted more than half of the factors that motivated gatherers to collect Shea nuts in the community. With the exception of tradition and recreation which can be standalone motivational factors, the other three are linked. This was evident during the focus group discussion, it came out that those who mentioned food or medicine did not necessarily used the nuts solely for those purposes but rather the nuts were sold to purchase those items. Laube, 2015 and Moore, 2008 made similar findings where incomes generated from Shea nuts were spent on household items like medicine, soap and was also use to improve household food security. It can be said primarily, much as these motivating factors (particularly tradition and recreation) were intrinsically generated, the interest for getting satisfaction from Shea nuts income was inspired by extrinsically separable outcomes of using the money to buy basic needs.

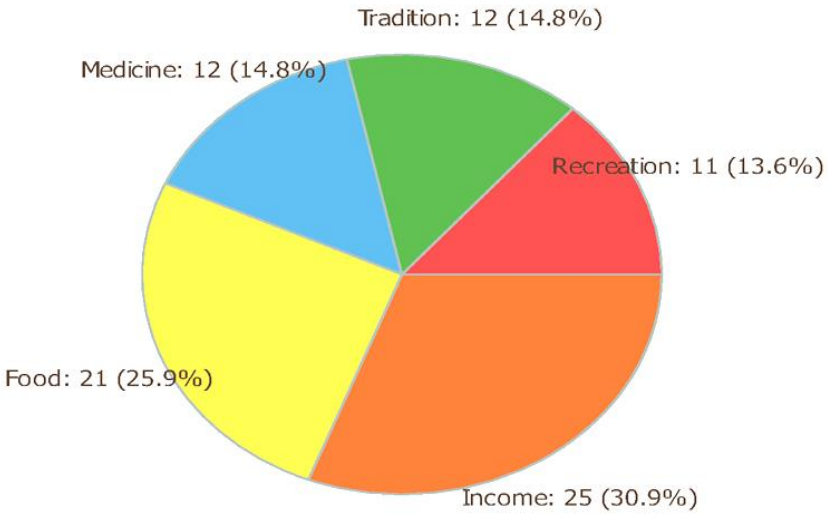

Fig. 1. Gatherers' Motivation for Collecting Shea nuts

Demotivating Factors and Discriminatory Tendencies against Bat Discarded Nuts. Respondents were asked whether they discriminate by gathering only from under Shea trees or they deliberately add bat discarded nuts from their roosting sites. Sixty nine (85.19 %) said they discriminate against gathering bat discarded nuts. Gatherers were asked again to name their major demotivating factor against bat discarded nuts. The results were: Short shelf life (42), do not attract good price (7), uncertainty about the source (6), light in weight (6), do not produce enough oil (9) and could be contaminated (11).

These demotivating factors could negatively affect the Shea nut value chain because they all have adverse impacts on the market value of nuts sold and therefore the level of income that can be generated. For example, Esiegbuya et al., 2014 pointed out healthy Shea nuts have brownish-creamy colour which loses out to blackish and whitish colours when infested with certain fungi strains. The fungi infestation could be what the gatherers alluded to about bat discarded nuts darkening fast and therefore do not attract good price. Obviously, these demotivating factors would not promote a competitive value chain for bat discarded nuts.

Gatherers' demotivating factors and discriminatory tendencies relationship. A statistical question was asked to determine the relationship between demotivating factors and discriminatory tendencies of the gatherers against bat discarded nuts. Below is the details of a Chi Square test of association between demotivating factors and gatherers' discriminatory tendencies against bat discarded nuts (Table 2).

Table 2

Demotivating factors and Discriminatory Patterns of Gatherers against Bat Discarded Nuts

		Do You Discriminate Against Bat Discarded Nuts ?					
		Yes		**No**		**TOTAL**	
		Obs.	**Exp.**	**Obs.**	**Exp.**	**Obs.**	**Exp.**
Demotivating Factors Against Bats' Discarded Nuts	Short Shelf Life (germinates, darkens)	41	35.8	1	6.2	42	42
	Do not attract Good Price	6	6.0	1	1.0	7	7
	Uncertainty about Source	6	5.1	0	0.9	6	6
	Light in Weight	3	5.1	3	0.9	6	6
	Do not have enough Oil	3	7.7	6	1.3	9	9
	Could be Contaminated	10	9.4	1	1.6	11	11
	TOTAL	69	69	12	12	81	81

$X^2 = 31.536$, Df = 5, P = 7.342e-6

The results showed there was a statistically significant relationship $X^2 = 31.536$, Df=5, P=7.342e-6 between the two variables at 1 %. Although 14.81 % of the gatherers said they did not discriminate against bat discarded nuts, they still had demotivating factors against bat discarded nuts. For example, three and six of the gatherers who did not discriminate believed bat discarded nuts were light in weight and do not yield enough oil respectively. The gatherers who do not discriminate against bat discarded nuts said although they do discriminate, they do not also deliberately search for them but would add them to their collection when they come across.

Although gatherers' demotivating factors against bat discarded nuts could be debated, Djossa et al., 2008 findings support some of their assertions. For example, the researchers mentioned bats normally choose seeds that are smaller in size but with a good pulp to enable them carry the

nuts for longer distances to roosting sites. In reference to the above, the gatherers would be right to state bat discarded nuts are light in weight and rightly yield less oil. Again, most often gatherers who produce homemade Shea butters do not readily process nuts gathered for oil, but rather store them until after the farming season. Findings confirmed bat discarded nuts germination successes improve more than non-bat processed nuts and this supports the gatherers' claims that bat discarded nuts germinate quickly.

Ryan, Deci, 2000 mentioned extrinsic motivation could be inherently or externally induced to promote certain perceived values associated with certain activities and their outcomes. The authors' statement is reflected in the demotivating factors of the gatherers. It could be stated for example, the gatherers applied an inherently self-endorsed extrinsic motivation on demotivating factors of "uncertainty about the source" and "could be contaminated" against bat discarded nuts to gain some sentimental values. Again, it could be said the rest of the demotivating factors were externally induced to avoid losing certain utility values. Actually, the externally induced extrinsic motivation formed the majority of the demotivating factors.

It stands to reason that the gatherers have certain knowledge, skill, mind and power about Shea nuts value chain that informed their demotivation against bat discarded nuts. The above assertion relates to Moser et al., 2011, statement that indicated every product's intrinsic and extrinsic values are what is portrayed by the producer or the seller to attract buyers. Thus, it is not surprising that the gatherers exhibited these demotivating factors against bat discarded nuts which obviously they believed will negatively affect the utility outcomes of the nuts they collect - the income.

Motivating and demotivating factors against bat discarded nuts relationship. The study found out there was no statistically significant differences between motivating and demotivating factors against bat discarded nuts $X^2 = 26.592$, Df = 20, P = 0.1471) at 5 %. This suggests although demotivating factors such as short shelf life of bat discarded nuts dominated gatherers responses, the general motivating factors for gathering Shea nuts overrode the concerns about the source of the nuts. In other words, most gatherers (85.19 %) did not pay attention to bat discarded nuts but rather concentrated on the traditionally known source-- only under Shea trees.

Details of the Chi Square test between motivating factors for gathering Shea nuts and demotivating factors' relationship against bats' discarded nuts is shown below (Table 3).

Demographic Factors and Motivation for Generating Income from Shea Nuts. The study assessed demographic factors of: (I)

educational background, (II) marital status, (III) age of the gatherer and (IV) number of children relationship with gatherers' motivation for generating income from Shea nuts. An estimated income of each gatherer was conducted based on the number of kilograms of nuts gathered and sold. The assessment was based on the market value of the nuts at the end of the gathering season for 2019. This is exclusive of homemade butter sold or used in the homes because it was difficult to get figures.

Shea nuts are sold in small quantities to middlemen who act as agents for the large scale processors. A measuring can is used to measure the nuts for saleable units and averagely it takes about 30 cans to make a bag load of between 82 kg and 90 kg. The largest sales (656 Kg of eight bags) made by a gatherer in this study amounted to one thousand and two hundred Ghana Cedis (GHS 1,200.00) and the least sale was (82 kg of one bag) amounted to one hundred and fifty Ghana Cedis (GHS 150.00). The monetary values equivalency respectively in United States dollars was two hundred and fifty dollars ($ 250) and thirty one dollars and twenty five cents ($ 31.25), (exchange rate at $1≡ GHS 4.8 at August, 2019).

Table 3

Motivating and Demotivating Factors against Bats' Discarded Nuts Relationship

		Motivation for Collecting Shea Nuts											
		Income		**Food**		**Medicine**		**Tradition**		**Recreation**		**TOTAL**	
		Ob.	**Ex.**	**Ob.**	**Ex.**	**Ob.**	**Ex.**	**Ob.**	**Ex.**	**Ob.**	**Ex.**	**Os.**	**Ep.**
Demotivating Factors Against Bats' Discarded Nuts	Short Shelf life (germinates and darkens fast)	6	13.0	15	10.9	9	6.2	5	6.2	7	5.7	42	42
	Will not attract Good price	4	2.2	1	1.8	0	1.0	1	1.0	1	1.0	7	7
	Uncertainty about Source	3	1.9	1	1.6	1	0.9	0	0.9	1	0.8	6	6
	Light in Weight	2	1.9	1	1.6	2	0.9	1	0.9	0	0.8	6	6
	Do not yield enough oil	4	2.8	2	2.3	0	1.3	1	1.3	2	1.2	9	9
	Could be contaminated	6	3.4	1	2.9	0	1.6	4	1.6	0	1.5	11	11
	TOTAL	25	25	21	21	12	12	12	12	11	11	81	81

$X^2 = 26.592$, Df = 20, P = 0.1471

Educational level and income generation relationship. Figure 2 clearly indicates that those with no or little formal education generated higher levels of income than those with higher education from Shea nuts. For example, the plot for tertiary education did not show in the figure because there were less than four entries. Although there were income generation disparities within each group, the median values of GHS 900, GHS 600 and GHS 450 recorded for none, Primary/Junior and Senior

Secondary levels respectively showed a general variability among the different groups.

There was a statistically significant relationship between educational background and income generated from Shea nuts in a Chi Square test (X^2 = 47.303, Df = 27, P = 9.175e-3) at 5 %. The result for the different educational background groups' proportions involve in Shea nuts gathering is not different from previous studies. Laube, 2015 made similar findings where gatherers with no educational background formed the majority at above 70 %.

The argument could be made that those with low levels of education see incomes from Shea nuts not only as stopgap, but rather a venerable income generating source to complement petty trading and farming. These arguments are based on literature that suggest Shea nut gatherers' passion to generate income is to provide complementary sources of earnings derive from diverse livelihood activities. Again, it could be stated those with higher education may have less time to engage in Shea nut gathering because they could be engaged in formal work. Thus, it could be said it is not because of disinterests or the tradition has waned among the educated to gather Shea nuts. For example, Laube, 2015 stated the traditional knowledge of Shea nut processing had not died down among the female population in northern Ghana, except that Shea butter can now easily be purchased at the local markets.

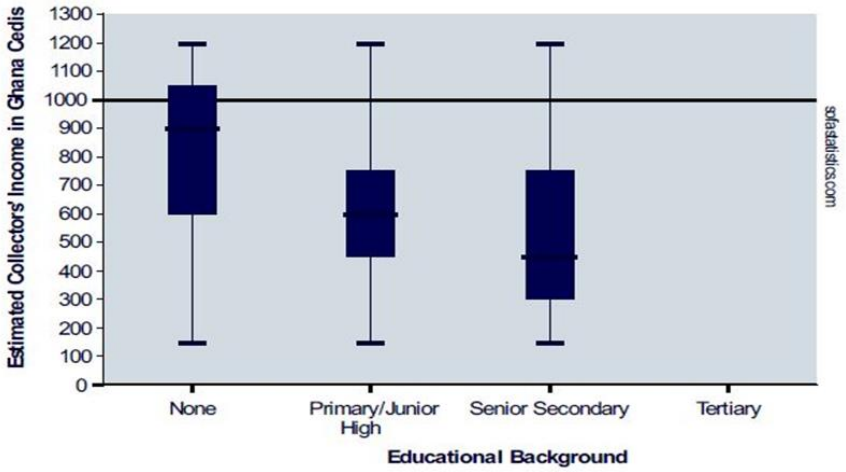

Fig. 2. Income level versus Education level

Marital status and income generation relationship. The median values for incomes generated from Shea nuts based on marital status were from the highest to the lowest: Widowed (GHS 900), followed by the married (GHS 750) and both the unmarried before and the divorced had

their median values at GHS 600. The figures showed variability within and among the different marital status groups (Fig. 3). Even the married, whom it is assumed to have economic support from their husbands had the second highest income levels, this is an indication of how women from the study area are regarded to be the main actors of providing food for their households.

There was no statistically significant relationship between marital status and the level of income generated from Shea nuts in Chi Square test of association $X^2 = 16.094$, Df = 15, P = 0.3758) at 5 %. The results indicate the motivation for Shea nut gathering goes beyond the gatherers' marital status in society. Shea nut is probably one of the major resources in Ghana that provides some financial independence to the poor rural women in that part of the country. Laube, 2015 for example stated traditionally, women are not allowed to own land in northern Ghana but rely on the benevolence of their husbands to cultivate crops. Therefore generating income from Shea nuts which is used to support households especially during the lean season comes in handy. This is buttressed by the results from this study which showed the widowed were motivated to generate more income than the rests of the groups because they may have little or no other income generating sources as their husbands are no more.

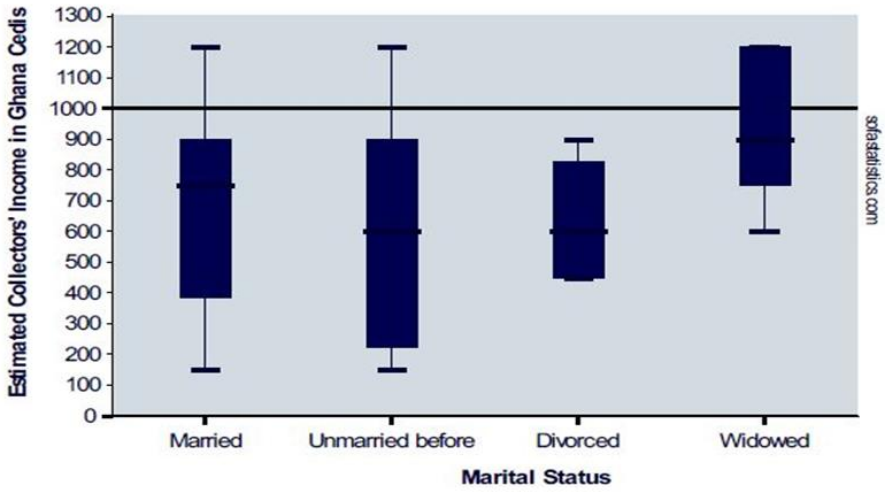

Fig. 3. Income Level versus Marital status

Gatherers' age groups and income generation relationship. The median values for incomes generated from Shea nuts for the different age groups indicated the lowest was for the 21 to 30 age group with GHS 450 to the highest of GHS 975 for the above 60 age group. The general trend showed the level of income generation from Shea nuts increased with

increasing age. Below are the details for gatherers' age and income generation from Shea nuts (Fig. 4).

From Fig. 4, it is rather the elderly that gathered more to generate higher income than the younger gatherers. This finding contrast Carette et al., 2009 report where the elderly rather gathered less than the young. The reason for this contrasting findings could be attributed to the gatherers not walking longer distances to gather Shea nuts in this study, but rather gathering was concentrated in the community. Laube, 2015 assertion that elderly women have greater access and control to Shea trees than the younger counterparts could also be a factor that enabled the elderly to collect more nuts in this study.

There was no statistically significant relationship between gatherers' age group and the level of income generated from Shea nuts in Chi Square test of association $X^2 = 54.325$, Df = 45, P = 0.1628) at 5 %. This indicates age is not a barrier to gathering Shea nuts in the community and this confirms Laube, 2015 findings that showed all age groups engage in Shea nuts gathering.

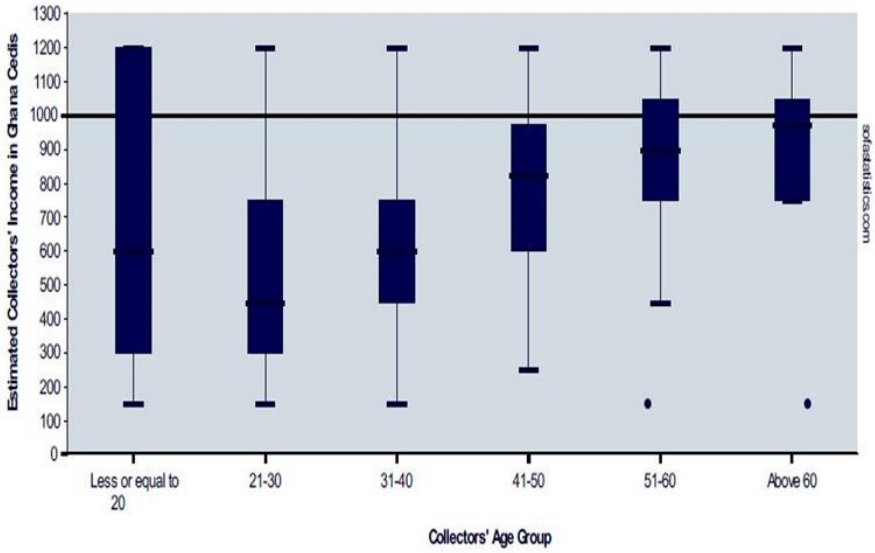

Fig. 4. Income versus Age group

Gatherers' age, income generation and number of children relationship. There was statistically significant relationship between number of children and gatherers' age $X^2 = 54.212$, Df = 30, P = 4.354e-3 at 5 %. It could be argued that as gatherers aged, they have more children who depend on them for support and that motivate them to generate more income from Shea nuts. It could also mean an older gatherer would have more hands to support to increase nuts gathering.

The least number of children for a gatherer was one and the highest was seven. The income range between the least and the highest number of children a gatherer had was GHS 450 and GHS 825 respectively. That notwithstanding, there was no statistically significant relationship between the number of children and incomes generated from Shea nuts in a Chi Square test of association ($X^2 = 50.212$, Df = 54, P = 0.6213) at 5 %.

CONCLUSIONS

This study applied a survey technique to locate bat roosting sites for identification and census. Three different bat species were identified from four roosting sites in the community. The flying mammals identified were Dwarf Epauletted Fruit Bat (*Micropteropus pusillus*), Epauletted Fruit Bat (*Epauletted gambianus*) and Straw Coloured Fruit Bat (*Eidolon helvum*). Hundreds of peeled Shea nuts carried from feeding grounds by bats were seen under each roosting site.

This study assumed that Shea nuts gatherers in an urban community are motivated to collect nuts not only from Shea trees and that they do not discriminate against nuts discarded by fruit bats. Interviews were conducted to gather data on gatherers' motivating factors for collecting Shea nuts and demotivating factors against bat discarded nuts. The findings showed however, that the majority of the gatherers (85.19 %) discriminate against bat discarded nuts.

Five motivating factors were identified to urge the gatherers to collect Shea nuts in the community. They were income, food, medicine, tradition and recreation. Gatherers responses suggested income was the major motivational factor that urged them to collect nuts.

Six demotivating factors were identified and the major among them was that bat discarded nuts have short shelf life. There was a statistically significant relationship between demotivating factors and gatherers' discriminatory tendencies against bat discarded nuts in Chi Square test. However, there was no statistically significant relationship between demotivating and motivating factors in a Chi Square test mainly because gatherers do not pay particular attention to bat discarded nuts.

The largest sales made from Shea nuts by a gatherer was equivalent to $250 and the least was $ 31.25 at the end of the 2019 gathering season. Gatherers with no education made the largest sales from Shea nuts than the educated. There was statistically significant relationship between educational background and income generated from Shea nuts in a Chi Square test. Although there was no statistically significant relationship between marital status and income generated from Shea nuts, the widowed had the highest median values for incomes generated from Shea nuts. These

results indicate Shea nuts is a major resource that provides readily source of income to vulnerable women in northern Ghana.

The findings showed gatherers were made up of all ages with the general trend suggesting the levels of incomes generated increase with age although there was no statistically significant relationship between the two variables. However, there was a statistically significant relationship between gatherers' age and number of children whereas there was no statistically significant relationship between the number of children and income generated from Shea nuts. These results suggest as gatherers aged, they have many children who need to be supported thus, requiring more resources to cater for them or probably more hands would have been developed to support in the gathering enterprise.

The findings of this study indicate Shea nut gatherers had both intrinsic and extrinsic motivation for gathering. The gatherers also had both intrinsically and extrinsically inspired demotivation against bat discarded nuts. Income was the major motivating factor for collecting Shea nuts and it was the main reason behind demotivating factors against bat discarded nuts which was to prevent a devaluation of the Shea nuts value chain.

This study was conducted in only one urban community and the number of gatherers sampled were limited. It is therefore recommended that the research be expanded to cover other urban communities in the Shea nuts belt to properly understand gatherers motivation and its relationship with bat discarded nuts which could support bat conservation and Shea nuts dispersal.

REFERENCES

1. Assche K.V., Beunen R., Duineveld M., Gruezmacher M., 2017, Power/knowledge and natural resource management: Foucaultian foundations in the analysis of adaptive governance. Journal of Environmental Policy & Planning, vol. 19, no.3, pp.308-322, DOI:10.1080/1523908X.2017.1338560;
2. Bénabou R., Tirole J., 2003, Intrinsic and extrinsic motivation. Review of Economic Studies, vol. 70, pp.489-520;
3. Blench R., 2001, Trees on the march: The dispersal of economic trees in the prehistory of West - Central Africa. SAFA Conference, Cambridge, United Kingdom;
4. Carette C., Malotaux M., Leeuwen M.V., Tolkamp M., 2009, Shea nut and butter in Ghana: Opportunities and constraints for local processing. Wageningen University, Wageningen;
5. Creswell J.W., 1998, Qualitative inquiry and research design: Choosing among five traditions. Thousand Oaks, CA: Sage;
6. Djossa B.A, Fahr J., Kalko E.K.V., Sinsin B.A., 2008, Fruit selection and effects of seed handling by flying foxes on germination rates of Shea trees, a key resource in northern Benin, West Africa. ECOTROPICA, vol. 14, pp.37-48;
7. Esiegbuya D.O., Osagie J.I., Okungbowa F.I., Ekhorutomwen E.O., 2014, Fungi associated with the postharvest fungal deterioration of Shea nuts and kernels.

International Journal of Agriculture and Forestry, vol. 4, no.5, pp.373-379, DOI: 10.5923/j.ijaf.20140405.05;
8. Fontaine C., Lovett P.N., Sanou H., Maley J., Bouvet J.M., 2004, Genetic diversity of the Shea tree (Vitellaria paradoxa C.F. Gaertn), detected by RAPD and chloroplast microsatellite markers. Heredity, vol. 93, pp.639-648, www.nature.com/hdy;
9. Getzner M., Islam M.S., 2013, Natural resources, livelihoods, and reserve management: A case study from sundarbans mangrove forests, Bangladesh. Int. J. Sus. Dev. Plann. vol. 8, No. 1, pp.75-87, DOI: 10.2495/SDP-V8-N1-75-87;
10. Hayman D.T.S., McCrea R., Restif O., Suu-Ire R., Fooks A.R., Wood J.L.N., Cunningham A.A., Rowcliffe J.M., 2012, Demography of straw colored fruit bats in Ghana. J Mammal, vol. 93, no.5, pp.1393-1404. DOI:10.1644/11-MAMM-A-270.1;
11. Kingdon J., 1997, The kingdon field guide to African mammals. Princeton University Press, New Jersey, ISBN-10:0-691-11692-X;
12. Laube W., 2015, Global Shea nut commodity chains and poverty eradication in northern Ghana. UDS International Journal of Development [UDSIJD] Vol. 2, No. 1, http://www.udsijd.org;
13. Moore S., 2008, The role of Vitellaria Paradoxa in poverty reduction and food security in the Upper East region of Ghana. Earth & E-nvironment, Vol.3, pp.209-245;
14. Moser R., Raffaelli R., Thilmany-McFadden D., 2011, Consumer preferences for fruit and vegetables with credence based attributes: A review. International Food and Agribusiness Management Review, vol. 14, no.2;
15. Nawrotzki R.J., Hunter L.M., Dickinson T.W., 2012, Rural livelihoods and access to natural capital: Differences between migrants and non-migrants in Madagascar. Demogr Res., vol. 26, DOI: 10.4054/DemRes.2012.26.24;
16. Poudel K.P., 2012, Resource management: A geographical perspective. Researchgate. DOI: 10.3126/ttp.v11i0.11526;
17. Rammohan S., 2010, The Shea value chain reinforcement initiative in Ghana. Stanford Global Supply Chain Management Forum, Stanford Graduate School of Business, www.starShea.com;
18. Ryan R.M., Deci E.L., 2000, Intrinsic and extrinsic motivations: Classic definitions and new directions. Contemporary Education Psychology 25, pp.54-67;
19. Schunko C., Grasser S., Vogl C.R., 2015, Explaining the resurgent popularity of the wild: Motivations for wild plant gathering in the Biosphere Reserve Grosses Walsertal, Austria. Journal of Ethnobiology and Ethnomedicine, vol. 11, no.55, DOI 10.1186/s13002-015-0032-4;
20. Self G., 2017, Lab manual SOFA: Statistics open for all. Paton-Simpson & Associates Ltd. http://www.sofastatistics.com;
21. Singh R., 2016, The impact of intrinsic and extrinsic motivators on employee engagement in information organizations. J. of Education for Library and Information Science, vol. 57, no. 2, doi:10.12783/issn.2328-2967/57/2/11;
22. Timiș-Gânsac V., Enescu C.M., Dincă L., Oneț A., 2018, The management of non-wood forest products in Bihor county. Natural Resources and Sustainable Development, Vol. 8, no.1, DOI: 10.31924/nrsd.v8i1.004;
23. Wilcke M.M., 2006, Hermeneutic phenomenology as a research method of social work. Currents, vol.1, no. 1, pp.1-10. Retrieved from: http://fsw.ucalgary.ca/currents_prod_v1/articles/wilcke_v1_n1.htm;
24. Yoo S.J., Han S.H., Huang W., 2012, The roles of intrinsic motivators and extrinsic motivators in promoting e-learning in the workplace: A case from South

Korea. Computers in Human Behavior, vol. 28, pp.942–950, doi:10.1016/j.chb.2011.12.015;
25. ***, 2010, Ghana Statistical Service, Population and housing census. Accra, Ghana.

Received: March 02, 2020
Revised: March 25, 2020
Accepted and published online: May 31, 2020

Natural Resources and Sustainable Development
Volume 10, Issue 1, 2020
DOI: 10.31924/nrsd.v10i1.043

FUTURE SMART FOOD CROPS IN NEPAL: A NECESSITY FOR FUTURE FOOD AND NUTRITIONAL SECURITY

Shrestha Jiban*#, Shrestha Renuka, Joshi Bal Krishna***, Subedi Subash******

*Nepal Agricultural Research Council (NARC), Agriculture Botany Division, Khumaltar, Lalitpur, Nepal, e-mail: jibshrestha@gmail.com
**Agronomy Division, NARC, Khumaltar, Lalitpur, Nepal
***Genebank, Nepal Agricultural Research Council, Khumaltar, Lalitpur, Nepal
****National Maize Research Program, NARC, Rampur, Chitwan, Nepal

Abstract

Neglected and Underutilized Species (NUS) are major source of food and nutrition in rural areas of Nepal. These crops play an important role in food, nutrition as well as economic security of poor people who have limited access to major food crops. Majority of NUS are considered as Future Smart Food (FSF) crops. The FSF crops were referred as poor people's crops, third order crops and marginal crops and attracted very little attention in agriculture research and development in past years. Nowadays with increasing awareness in the importance of local commodities, many formerly neglected crops have now become globally significant and got space as a Future Smart Food crops because of their multidimensional uses and importance. Tartary buckwheat, proso millet, foxtail millet, naked barley, sorghum, grasspea, amaranthus, fababean and ricebean, taro, yam, drumstick, wood apple, indian gooseberry, linseed and nepali butter tree are FSF crops found in Nepal. This paper highlighted the some of FSF crops found in Nepal along with their nutritional importance. The works on conservation, research and promotion of FSF species lead to exploration of new staple crops, motivate people to consume them in a sustainable manner and reduce the malnutrition.

Key words: Agrobiodiversity, neglected crops, Future Smart Food (FSF) crops, nutrition value

INTRODUCTION

The neglected and underutilized species (NUS) are species of which any crop varieties that have not been released and registered. NUS are of secondary priority in term of research and development. These species have important role in the sustaining farming system, human nutrition, food security and socioeconomic importance (Joshi et al., 2019). They are not commercially cultivated and also not included in formal seed system but these species may be grown for short period of time i.e. 5 years (Joshi et al., 2019). The scientific information regarding NUS are not sufficient and very little attention was paid or which were entirely ignored by agricultural researchers, plant breeders and policymakers.These crops were neglected by public and private sectors for research and development (Joshi et al., 2019).

Because of their wider importance and scope, NUS crops have become now future smart crops. Future Smart Foods (FSF) can fill this gap because they generally do not require high inputs and can be grown on marginal and degraded lands hence contributing to increased agricultural production, crop diversification and environmental sustainability (Li et al.,

Corresponding author

2018). In turn, food and nutritional security will be improved. Future smart food is NUS that have high potential for food, nutrition security and high adaptability (Li et al., 2018). Among the 484 cultivated indigenous crop species in Nepal, a research team identified more than 200 species under NUS (Joshi et al., 2019). Some of crop species are considered as FSF are listed in Table 1. Smart food crops are healthy foods and rich in micronutrients (Joshi et al., 2019). The FSF crops are most resilient and best survive in the harsh environments, therefore, they are referred as climate-smart crops (Li et al., 2018). To know about the details of future smart food crops found in Nepal along with their nutritional importance, this study has been carried out. The current review encompassed the importance of NUS and FSF crops along with conservation of new crops.

Some FSF crop species in Nepal (Fig. 1):

Tartary Buckwheat (*Fagopyrum tataricum Geartn*). In Nepal, buckwheat is a sixth staple food crop after rice, wheat, maize, finger millet, and barley. It is considered as poor man's crop and is an alternate cereal that represents an important food supply in remote places of Himalayas. Both species of buckwheat species namely *Fagopyrum esculentum Moench* and *F. tataricum Geartn* are grown in Nepal. In colder areas Tataricum type is more common where common buckwheat cannot be cultivated (Upreti, 1995). Common buckwheat (*Fagopyrum esculentum*) is grown throughout the country, whereas bitter buckwheat (*Fagopyrum tataricum*) is grown in the hilly area of Nepal. Hill Crops Research Program (HCRP), Dolakha, Nepal has 495 accessions of buckwheat that includes common and tataricum type from local and exotic sources (Upreti, 1995).

Relatively wide adaptability has been observed in *tataricum* type than in common buckwheat. Grain and other tissues of buckwheat contain many nutraceutical components and rich in vitamins, especially B groups (Fabjan et al., 2003).

The amino acid composition of buckwheat proteins is well balanced and has a high biological value, although protein digestibility is relatively low (Liu et al., 2001). The microelements such as Zn, Cu, Mn and Se can be achieved from buckwheat grains (Stibilj et al., 2004) and microelements: K, Na, Ca, Mg (Wei et al., 2003). Rutin, catechins and other polyphenols contents and their significant antioxidant value affects the dietary value (Wanatabe, 1998). Buckwheat grain is a rich source of TDF (total dietary fiber), soluble dietary fiber (SDF), and is used in the prevention of obesity and diabetes (Brennan, 2005).

Buckwheat protein is rich in arginine and lysine, which constituent about (13.36 %) (Watanabe, 1998; Christa, Soral-Smietana, 2008). The amino acid composition of buckwheat proteins is of a high biological value

and is well balanced (Kato et al., 2001). Buckwheat product is an important source of retrograded starch (Christa, Soral-Smietana, 2008).

Table 1

List of future smart food crop species in Nepal

SN	English Name	Nepali Name	Scientific Name
1	***Cereals/ pseudo cereals***		
1	Tartary Buckwheat	Tite Phapar	*Fagopyrum tataricum* (L.) Gaertn.
2	Sorghum	Junelo	*Sorghum bicolor* (L.) Moench
3	Foxtail Millet	Kaguno	*Setaria italica* (L.) P.Beauv.
4	Proso Millet	Chino	*Panicum miliaceum* L.
5	Foxtail Amaranth	Jhule Latte	*Amaranthus caudatus* L.
6	Blood/ Red Amaranth	Rato Latte	*Amaranthus cruentus* L.
7	Pearl Millet	Baajra	*Pennisetum glaucum* (L.) R.Br.
2	***Root and tubers***		
1	Taro	Pindalu	*Colocasia esculenta* (L.) Schott
2	Greater Yam, White Yam	Tarul, GharTarul	*Dioscorea alata* L.
3	Deltoid Yam	Vhyakur	*Dioscorea nepalensis*
4	Tapioca, Cassava	SimalTarul	*Manihotes culenta* Crantz
3	***Pulses***		
1	Rice bean	Mashyang	*Vigna umbellata* Thunb.
2	Horse gram	Gahat	*Macrotyloma uniflorum* (Lam.) Verdc.
3	Grass pea	Khesari	*Lathyrus sativus* L.
4	***Small pea, Field pea***	Saano Keraau	*Pisum sativum* L. var. arvense L.
4.1	*Fruit vegetables*		
1	Chayote	Iskush	*Sechiumedule* (Jacq.) Sw.
2	Balsam Apple	Barella	*Momordica balsamina* L.
3	Drumstick	Sahinjan/Sital Chini	*Moringa oleifera* Lam.
4	Ash Gourd, Wax Gourd	Kubhindo	*Benincasa hispida* (Thunb.) Cogn.
4.2	*Leafy vegetables*		
1	Lamb's Quarter	Bethe	*Chenopodium album* L.
2	Water Cress	Sim Saag	*Nasturtium officinale* R.Br.
3	Green Amaranth	Lunde	*Amaranthus gracilis* Desf.
4.3	*Fruits*		
1	Wood Apple, Bael Tree	Bel	*Aegle marmelos* (L.) Correa
2	Nepalese Hog Plum	Lapsi	*Choerospondia saxillaris* (Roxb.)
3	Pummelo, Shaddock	Bhogate	*Citrus grandis* (L.) Osbeck
4	Indian Gooseberry	Amalaa	*Emblica officinalis* Gaertn.
5	Custard Apple	Sariphaa, Sitaaphal	*Annona squamosa* L.
6	Rough Lemon	Jyamir	*Citrus junos* Siebold ex Tanaka
7	Tamarind, Indian Date	Imli	*Tamarindus indica* L.
5	***Oilseeds***		
1	Linseed	Aalaash	*Linum usitatissimum* L.
2	Nepali Butter Tree	Chiuri, Mahuwa	*Bassia latifolia* Roxb.
3	Himalayan Cherry	Dhatelo	*Prinsepia utilis* Royle
6	***Spices***		
1	Perilla	Silaam	*Perilla frutescens* (L.) Britton
2	Nepal Pepper	Timur	*Zanthoxylum armatum* DC.
3	Caraway, Ajowan, Ammi	Jowano	*Trachyspermum ammi* (L.) Sprague
4	Black Cumin	Himaali Jiraa	*Bunium persicum* (Boiss.) B. Fedtsch.

(Source: Joshi, Shrestha, 2018)

It also contains some healing component and biologically active properties, such as flavonoids and flavon, condensed thanin, phenolic acid, phytosterols and fagopyrins in grain and hulls. Flavonoids are phytonutrients which act as antioxidants and having chelating properties (Bojnanska et al., 2009).

Fig. 1. Some Future Smart Food (FSF) crop species in Nepal

Proso millet (*Panicum miliaceum* L.). Proso millet (*Panicum miliaceum L.*) is one of the oldest cereal grains cultivated in the north-western part of Nepal which can be grown up to 3500 m in elevation and has one of the lowest water requirements of any cereal, makes it an

incredibly resilient crop (Joshi et al., 2019). It is cultivated in Mugu, Dolpa, Humla, Jumla, Kalikot, Bajura and Jajarkot. Grains are rich in minerals and vitamins. It is poor in calcium but the seeds contain a high amount of phosphorus. Grain is rich source of starch, trace elements, dietary fibre and vitamins. Seeds also contain component with healing benefits which decrease the level of low density lipoprotein cholesterol in blood and injury to the liver. Phenolic components like antioxidants and beta glucans are also present. Proso millets are also rich in micronutrients such as niacin, B-complex vitamins, Vitamin B6, and folic acid (Hulse et al., 1980; Pathak, 2013). It is completely gluten-free and is packed with a variety of essential minerals, potassium in particular, which contributes to nervous system health. Current research suggests it may also be an alternative to corn in the production of biofuels, leading to a potential future role in the green-energy industry (Joshi et al., 2019).

Foxtail millet (*Setaria italica* L.). Foxtail millet (*Setaria italica* L.) is the second most widely planted species among millets in the world and the most important millet in East Asia (Kumari et al., 2011; Ning et al., 2015). It is also known as Italian millet, German millet or Hay millet but locally known as Kaguno in Nepal. Major foxtail millet growing districts in Nepal are Mugu, Kalikot, Humla, Jumla, Bajhang, Bajura, Dolpa, Lamjung, Gorkha, Ramechhap and Kavre where crop is grown sole as well as mixed with finger millet, proso millet, beans, amaranths, sorghum, etc. Nepal is one of the centres of diversity of foxtail millet and has high genetic diversity of this crop (MoFSC, 2002), however, very little research has been conducted and its status is still unexplored. Foxtail millet features a variety of uses, from being cooked and eaten like rice, ground into a hearty porridge or used to brew alcoholic beverages. A recent study indicates that foxtail millet can lead to a significant fall in blood glucose, making it a useful food to help manage and prevent diabetes (Joshi et al., 2019). Foxtail millet grain contains 12.3 % protein, 4.3 % fat, 60.9 % carbohydrates, 14 % dietary fibre and 3.3 % minerals (Saha et al., 2016; Saud, 2010). Foxtail millet (Kaguno) is the third important crop among group of millets with wide range of utility in Nepal. Foxtail millet is valued by mountain farmers for its nutritional content and health promoting properties, ability to grow under low external input conditions and tolerance to extreme environmental stress, particularly drought.

Naked barley (*Hordeum vulgare* L.). Naked barley (*Hordeum vulgare* L.) is a traditional, culturally important, climate-resilient and highly nutritious winter cereal crop of the high mountainous region of Nepal. The unique geographical distribution pattern of naked barley in the higher altitudes (>2500 masl) implies its tremendous food value and wide utility in the high mountains. In Nepal, it is grown at elevations up to 3800 m, higher

than any other place in the world. Naked barley is an excellent source of whole grains and complex carbohydrates, whose health benefits include lowering cholesterol levels and the risk of type-2 diabetes. Traditionally, Buddhist monks have consumed barley as a nutritious breakfast food that helps the body conserve energy in cold weather (Joshi et al., 2019). Furthermore, it does not require additional processing, contrary to hulled barley which has tightly adhered grain husks. It is rich in soluble ß-glucans content, which acts as an inhibitor of cholesterol synthesis and thus is salubrious for heart patients (Behall et al., 2004; Bhatty, 1999; Gill et al., 2002).

Sorghum (*Sorghum bicolor* L.). Sorghum (*Sorghum bicolor* L.) is cultivated across Mid hill and across Tarai in small area. Sorghum is one of the four major food grains of the world. Millions of African people depend on sorghum as a staple food. In recent years, this crop has been used as bio-fuel in developed countries. It is originated in central Africa, near Ethiopia or Sudan. Local varieties are very tall plant usually that grows up to a height of 4 m and late maturing. It is the third important crop among the food grains of India but less important in Nepal. It is cultivated in terrace bunds and used for food and fodder. Diversity within Nepalese sorghum accessions is not very high. Sorghum is a powerhouse in terms of nutrients. Sorghum is rich in vitamins like niacin, riboflavin, and thiamin, as well as high levels of magnesium, iron, copper, calcium, phosphorous, and potassium, as well as nearly half of the daily, required intake of protein and a very significant amount of dietary fiber (48 % of the recommended intake).

Grasspea (*Lathyrus sativus* L.). Grasspea (*Lathyrus sativus* L.) is one of the hardiest but most underutilized crops for adaptation to fragile agro-ecosystems, because of its ability to survive under extreme climatic conditions such as drought, water stagnation and heat stress. It is grown mainly for eating purposes in India, Bangladesh, Nepal, Pakistan and Ethiopia, and for feed and fodder purposes in other countries. Grasspea grains are a good protein supplement (24-31 %) to the cereal-based diet of poor people in areas of its major production. Globally, the area under grass pea cultivation is estimated at 1.50 million ha, with annual production of 1.20 million tonnes (Beliga et al., 2011). The crop has not attained much progress, due to the limited research on genetic and genomic resources available for grasspea in the gene banks of world. Grasspea seeds are known to have a neurotoxin known as β-*N*-oxalyl-L-α, β-diaminopropionic acid (β-ODAP). Its overconsumption as a staple food in an unbalanced diet for an extended period of 3-4 months can cause spastic paralysis is of the legs in human beings. Therefore, β-ODAP needs to be reduced through genetic means to a safe level for human consumption.

Amaranth (*Amaranthus caudatus* L.). Amaranth (*Amaranthus caudatus* L.) is considered one of the old crops, especially in South America, Asia and Africa, and is believed to be native in Central and South America. Crude calcium, iron, magnesium, potassium and zinc fibers, vitamins C, B6 and A are rich in amaranth. In Nepal, the crop is consumed as grain in Karnali and high hills, and green vegetables in mid hills and terai. Nevertheless, the farming community rarely uses astonishing for the targeted cultivation as green vegetables. The situation is getting worse because researchers pay less attention to fascination. Amaranth is consumed as nutritious cereal in high mountain communities and as iron-rich leafy vegetables in the rest of the country. Amaranth is a gluten-free grain and is an excellent source of protein. It is an excellent source of amino acids for lysine, which is rare in plant nutrients. Amaranth grains are associated with purity in Nepal and are used as food that can be consumed even during religious fasting.

Fababean (*Vicia faba* L.). Fababean (*Vicia faba* L.) or broad bean (local name Bakula) is the minor grain legume. Large seeded type is commonly grown in Kathmandu Valley and adjoining districts as a kitchen garden whereas small seeded (green or black color testa) types are grown as a field crop or in a home garden. Large pods consumed mostly as green vegetable and dry seed as roasted bean and small seed usually splited and consumed as soup.

Rice bean (*Vigna umbellata* Thunb). Rice bean (*Vigna umbellata* Thunb) locally known as *Mashyang, Siltung, Jhilinge, Gura*s is one of the neglected and under-utilized summer grain legumes cultivated mainly in the hilly areas of Nepal as mixed cropped with maize with no additional inputs and care. A great variation in seed color has been observed in landraces were observed and research has initiated since 2006 to develop high yielding short duration cultivars.

Conservation of future smart food (FSF) crops

The neglected and underutilized species (NUS), now known as future smart food crop species are characterized by many values (Shrestha, Dhillion, 2003). Since ancient times, they have been one of the most important sources for food and medicines in western Nepal, where access to modern facilities is limited (Kunwar, Bussmann, 2008). As a result, these plants may have the potential to support local livelihoods, particularly in the replacement or reinforcement of high-value plant species with high exploitation (Aryal et al., 2009). In addition, FSF species often appear in marginal habitats. Although the importance of these plants to the Nepalese existence has long been recorded in the economy and culture, the potential to use these plants is not well understood, perhaps due to lack of awareness, research capability, market, transportation and communication. Land use

and habitat change, over-exploitation, deforestation and climate change further aggravate the situation. FSF crop species are often poorly managed due to the low interest of local communities. Further research is needed through state-owned and community institutions, along with sustainable management, along with the plants, identity, documentation and appropriate use of these plants. There could be many social, economic, environmental, agronomic and political drawbacks of NUS and FSF crops. The failure of national and local governments to prioritize the conservation and use of NUS, lack of funds for ex situ conservation, lack of adequate facilities and electricity supplies to maintain ex situ collections, failure of governments to support scientific research on NUS, lack of characterization, breeding and evaluation information, absence of legal frameworks, policies, projects, national programmes and strategies and lack of integration between conservation and use programmes are some remarkable challenges of NUS and FSF crops (Padulosi, 1999; IPGRI, 2002; Padulosi et al., 2013). Similarly low competitiveness, limited germplasm available, lack of research and well-documented technical information on genetic diversity, growth stages and life cycle of NUS, including agronomy and breeding systems, lack of information on their susceptibility to diseases, insect pests and parasitic weeds of economic importance, lack of national policy for supporting research and development for improving production, loss of indigenous knowledge and documentation of national recipes, lack of interest from producers, lack of interest in the private sector, lack of markets and commercialization and insufficient demand of consumers outside traditional niche markets are some major drawbacks for the promotion of NUS and FSF crops.

CONCLUSIONS

Farmers are unwilling to grow underutilized neglected crops because of low yield, low return, poor market value, unaware about their nutritional and environmental value. Underutilized neglected crops are ‘underexploited’ and under-researched crops. Promoting local underutilized plant species is one alternative for conservation of agro-biodiversity and it will prove successful in improving the food sufficiency and economic well being of poor farmers of Nepal and proved them as smart crops in future. These underutilized and neglected species can play a crucial role in the food security, income generation and diversify food culture of the rural poor and become future smart food crops. Also conservation of these crops is one of the best options for genetic resources conservation, which is the main asset of marginality and poor community living in the remote parts of the country. The development and implementation of research and development programs to improve these crops is essential. Moreover, effective policy

frameworks to popularize these crops among city dwellers are other strategic options. Therefore, it is important to make arrangements to develop and popularize these crops among the people. Provision of marketing facilities, necessary inputs, storage and processing facilities will help them to keep on growing these crops in their own farms.

REFERENCES

1. Aryal K.P., Berg A., Ogle B., 2009, Uncultivated Plants and Livelihood Support: A Case Study from Chepang People of Nepal. Journal of Ethnobotany Research and Applications, vol.7, pp.409-422;
2. Behall K.M., Scholfield D.J., Hallfrisch J., 2004, Diets containing barley significantly reduce lipids in mildly hypercholesterolemic men and women. American Journal of Clinical Nutrition, vol. 80, pp.185–93, DOI: https://doi.org/10.1093/ajcn/80.5.1185;
3. Beliga M.S., Shivashankara A.R., Haniadka R., Dsouza J., Bhat, H., 2011, Phytochemistry, nutritional and pharmacological properties of *Artocarpus heterophyllus* Lam (jackfruit): A review. Food Research International, vol. 44, No.7, pp.1800-1811, DOI: https://doi.org/10.1016/j.foodres.2011.02.035;
4. Bhatty R.S., 1999, The potential of hull-less barley. Cereal Chemistry, vol.76, pp.589–99, DOI: https://doi.org/10.1094/CCHEM.1999.76.5.589;
5. Bojňanská T., Frančáková H., Chlebo P., Vollmannová, A., 2009, Rutin content in buckwheat enriched bread and influence of its consumption on plasma total antioxidant status. Czech Journal of Food Sciences, vol. 27, pp.236-240;
6. Brennan C.S., 2005, Dietary fibre, glycaemic response and diabetes. Molecular Nutrition and Food Research, vol. 49, pp.560–570, DOI: https://doi.org/10.1002/mnfr.200500025;
7. Christa K., Soral-Śmietana M., 2008, Buckwheat grains and buckwheat products–nutritional and prophylactic value of their components–a review. Czech Journal of Food Sciences, vol.26, pp.153-162;
8. Fabjan N., Rode J., Košir I.J., Zhang Z., Kreft I., 2003, Tatary buckwheat (*Fagopyrum tartaricum* Gaertn.) as a source of dietary rutin and quercetin. Journal of Agricultural and Food Chemistry, vol.51, pp.6452-6455, DOI: https://doi.org/10.1021/jf034543e;
9. Gill S., Vasanthan T., Ooraikul B., Rossnagel B., 2002, Wheat bread quality as influenced by the substitution of waxy and regular barley flours in their native and extruded forms. Journal of Cereal Science, vol.36, pp.19-237, DOI: https://doi.org/10.1006/jcrs.2001.0458;
10. Hulse J.H., Laing E.M., Pearson O.E., 1980, Sorghum and the Millets: Their Composition and Nutritive Value. London: Academic Press, pp.187-193;
11. IPGRI, 2002, Neglected and underutilized plant species: strategic action plan of IPGRI. International Plant Genetic Resources Institute, Rome;
12. Joshi B.K., Shrestha R., 2018, Nepal. In Future Smart Food - Rediscovering Hidden Treasures of Neglected and Underutilized Species for Zero Hunger in Asia, edited by X. Li and K. H. M. Siddique, pp.161-178. Bangkok: FAO. Accessed 15 September 2019. http://www.fao.org/documents/card/en/c/I8907EN/;
13. Joshi B.K., Shrestha R., Gautam I.P., Poudel A.P., Gotame T.P., 2019, Neglected and Underutilized Species (NUS), and Future Smart Food (FSF) in Nepal.

National Agriculture Genetic Resources Center (NAGRC, National Genebank), NARC, Khumaltar, Kathmandu, Nepal;
14. Kato N., Kayashita J., Tomotake H., 2001, Nutritional and physiological functions of buckwheat protein. Recent Research Development Nutrition, vol. 4, pp.113-119;
15. Kumari R., Dikshit N., Sharma D., Bhat K.V., 2011, Analysis of molecular genetic diversity in a representative collection of foxtail millet [*Setaria italic* (L.) P. Beauv.] from different agro-ecological regions of India. Physiology and Molecular Biology of Plants, vol. 17, Issue 4, pp.363-374, DOI: https://doi.org/10.1007/s12298-011-0085-3;
16. Kunwar R.M., Bussmann R.W., 2008, Ethnobotany in the Nepal Himalaya. Journal of Ethnobiology and Ethnomedicine, vol. 4, pp.24, DOI: https://doi.org/10.1186/1746-4269-4-24;
17. Li X., Siddique K., Akinnifesi F., Callens K., Broca S., Noorani A., ...Chowdhury AK., 2018, Future smart food- Rediscovering hidden treasures of neglected and underutilized species for zero hunger in Asia. Bangkok: Food and Agriculture Organisation of the United Nations;
18. Liu Z., Ishikawa W., Huang X., Tomotake H., Watanabe H., Kato N., 2001, Buckwheat protein product suppresses 1,2-dimethylohydrazine-induced colon carcinogenesis in rats by reducing cell proliferation. Journal of Nutrition, vol. 131, pp.1850-1853, DOI: https://doi.org/10.1093/jn/131.6.1850;
19. MoFSC, 2002, Nepal Biodiversity Strategy. Ministry of Forests and Soil Conservation, Nepal;
20. Nakayama H., Namai H., Okuno K., 1999, Geographical variation of the alleles at the two prolamin loci, Pro1 and Pro2, in foxtail millet, *Setariaitalica* (L.) P. Beauv. Genes & Genetic Systems, vol. 74, pp.293-297, DOI: https://doi.org/10.1266/ggs.74.293;
21. Ning N., Yuan X., Dong S., Wen Y., Gao Z., Guo M., Guo, P., 2015, Grain yield and quality of foxtail millet (*Setariaitalica* L.) in response to tribenuron-methyl. PLoS ONE, vol. 10, No. 11, pp.1-12, DOI: http://dx.doi.org/10.1371/journal.pone. 0142557;
22. Padulosi S., 1999, Criteria for priority setting in initiatives dealing with underutilized crops in Europe. pp.236-247 in Implementation of the Global Plan of Action in Europe – Conservation and Sustainable Utilization of Plant Genetic Resources for Food and Agriculture. T. Gass, F. Frese, E. Begemann and E. Lipman, eds., *Proceedings of the European Symposium*, 30 June-3 July 1998, Braunschweig, Germany. International Plant Genetic Resources Institute, Rome p.396;
23. Padulosi S., Bala Ravi S., Rojas W., Valdivia R., Jager M., Polar V., Gotor E., Mal B., 2013, Experiences and lessons learned in the framework of a global UN effort in support of neglected and underutilized species. Acta Horticulturae, vol. 979, pp.517-53, DOI: https://doi.org/10.17660/ActaHortic.2013.979.56;
24. Pathak H.C., 2013, Role of Millets in Nutritional Security of India. New Delhi: National Academy of Agricultural Sciences, pp.1-16;
25. Saha D., Gowda M.V.C., Arya L., Verma M., Bansal K.C., 2016, Genetic and genomic resources of small millets. Critical reviews in Plant Sciences, vol. 35, pp.56-79, DOI: http://dx.doi.org/10.1080/07352689.2016.1147907;
26. Saud N.B., 2010, Crops of Nepal and their sustainable farming (in Nepali): Nepalka balinali ra tinko digo kheti). Lalitpur, Nepal: Sajha Prakashan, Pulchok, pp.223-227;

27. Shrestha P.M., Dhillion S.S., 2003, Medicinal plant diversity and use in the highlands of Dolakha District, Nepal. Journal of Ethnopharmacology, vol. 86, pp.81-96, DOI: https://doi.org/10.1016/S0378-8741(03)00051-5;
28. Stibilj V., Kreft I., Smrkolj P., Osvald, J., 2004, Enhanced selenium content in buckwheat (*Fagopyrum esculentum* Moench) and pumpkin (*Cucurbita pepo* L.) seeds by foliar fertilization. European Food Research and Technology, 219, pp.142-144, DOI: https://doi.org/10.1007/s00217-004-0927-0;
29. Uprety R.P., 1995, Buckwheat Overviews, in Nepal: Scope and Cultivation Strategy Practices, Research. Current Advances in Buckwheat Research, 35, pp.277-284;
30. Wanatabe M., 1998, Catechins as antioxidant from buckwheat (*Fagopyrum esculentum* Moench) groats. Journal of Agricultural and Food Chemistry, vol. 46, pp.839-845, DOI: https://doi.org/10.1021/jf9707546.

Received: March 08, 2020
Revised: March 25, 2020
Accepted and published online: May 31, 2020

Natural Resources and Sustainable Development | **Volume 10, Issue 1, 2020**
DOI: 10.31924/nrsd.v10i1.044

ANALYSIS OF NUTRITIONAL PARAMETERS OF BIOGAS SLURRY

Kiss Nikolett Éva*#, Tamás János*, Gorliczay Edit*, Gálya Bernadett*, Nagy Attila*, Jóvér János, Riczu Péter*****

*University of Debrecen, Faculty of Agricultural and Food Sciences and Environmental Management, Institute of Water and Environmental Management, Debrecen, Hungary,
e-mail: kiss.nikoletteva@agr.unideb.hu
**Zal-Agro Corporated Company, Türje
***KITE Zrt., Hungary

Abstract

Large amount of waste and by-products generated during livestock processes requires urgent treatment and disposal. The energy recovery of wastes and by-products can be a solution for the problem, since the biogas production is an obvious way of recovery. As a by-product of biogas production biogas slurry is produced and it is to be suitable for nutrient supply.

The samples of the biogas slurry originate from the Nyírbátor Regional Biogas Plant. The plant is used for the disposal and recovery of plant residues, manure of cattle and poultry, poultry slaughterhouses and other animal wastes. The organic matter from the fermenter is separated. After separation, the dilute phase is transferred to the manure storage and the solid phase is transferred to a drying plant or composting plant. Aims of the study were the analysis of filtering efficiency of the separator, comparison of properties of the pre-separator and the separated fermentation residue, since the company wants to spread the biogas slurry to arable land and pasture in a frame of complex precision irrigation system. For this reason, the sampling points were planned to set both before and after separator processes. Samples were taken twelve times between February and June 2018. Among other properties, the dry matter content of the biogas slurry, C and N content, element content, pH, conductivity, biological and chemical oxygen demand were measured.

Based on the element content and the N content, the biogas slurry is suitable for nutrient supply. The average dry matter content values of the samples show that the result of the separation process the dry matter content is significantly reduced ($P<0.05$). The salt content was very high in the samples both before and after separation. In order to prevent environmental stress, it is recommended to reduce the salt content before applying the biogas slurry.

Key words: biogas slurry, nutritional parameters, separator, precision irrigation

INTRODUCTION

Due to their environmental impact, non-recyclable secondary products formed during animal husbandry processes, such as untreated manure or slaughterhouse waste, are a major problem for the livestock sector. There are two forms of by-product recovery, material recovery and energy recovery. In the latter case, anaerobic fermentation produces biogas from a large amount of slurry, litter manure and slaughterhouse waste. The anaerobic fermentation process is suitable for the disposal of bio-waste and for the production of "green energy" (Mézes et al., 2007; Tamás, Kovács, 2008; Mézes, Tamás, 2015). The stages of anaerobic fermentation are naturally inseparable, since the microbiological activities are based on each

Corresponding author

other. The four stages of anaerobic fermentation are as follows (Gijzen, 1987; Bitton, 1994; Angenent, Wrenn, 2008; Wilkie, 2008):

1. Hydrolysis. Conversion of polymers into monomers (sugars, amino and fatty acids).

2. Acidogenesis. Conversion of the monomers into alcohols, ammonia, carbon dioxide, hydrogen gas and volatile fatty acids.

3. Acetogenesis. Conversion of alcohols and volatile fatty acids into acetate, carbon dioxide and hydrogen by acetogenic bacteria.

4. Methanogenesis. Conversion of acetate, carbon dioxide and hydrogen by methanogenic bacteria into methane and carbon dioxide.

Biogas production can produce 50 % or even 75 % of methane, which can be used as heat and/or electricity. Biogas production highly depends on the raw materials used (Table 1).

Table 1

Biogas production for various manures and other feedstocks (Surendra et al., 2013)

Feedstock	Biogas production (m^3/ton dry solids)
Cattle manure	200-300
Pig manure	250-500
Chicken manure	310
Sheep manure	300-400
Human excreta (night soil)	380
Vegetable wastes	400
Grass lawn cuttings	700-800
Rice straw	550-620
Maize silage	600-700
Maize straw	400-1000
Kitchen waste	400-1000

Two products are produced during the fermentation process: the methane gas, which is suitable for energy production and the biogas slurry suitable for fertilization, the fermentation broth. Szegi, 1967 and Bíró, Pacsuta, 2002, emphasize in their publication that fermented material is capable of regenerating soil fertility, increasing agricultural production and replacing fertilizers (Szőllősi et al., 2008).

The composition of the biogas slurry is influenced by the raw materials used for biogas production and the digestion technology (Monnet, 2003).

Fermentation reduces the carbon content in the slurry, but not the nitrogen content and other nutrients. Thus, the resulting material is rich in macro-, micro-nutrients, trace elements and organic compounds (Holm-Nielsen et al., 1997; Ishikawa et al., 2006; Alam, 2006).

The samples of the biogas slurry originate from the Nyírbátor Regional Biogas Plant. The plant is used for the disposal and recovery of

plant residues, manure of cattle and poultry, poultry slaughterhouses and other animal wastes. Since to biogas production uses mixed raw materials, a combination of mesophilic and thermophilic fermenter is used for more perfect organic matter decomposition. The raw materials are pumped in every four hours into mesophilic fermentors (32-38 °C) and then into thermophilic digesters (55-60 °C). The organic material from the thermophilic fermentor is stored in containers, where it is being cooled down to 35-38 °C and its decomposing continues, then by gravity it goes into a tank. With pump, the biogas slurry is transported to the separators, where the dilute phase is transferred to the manure storage and the solid phase goes to a drying or a composting plant.

The fermentors produce 20 000 – 25 000 m^3/day of biogas with a methane content of 60-65 %, which is used for electricity generation and heating. The fermentation residue of biogas production at the factory is 100000 t biofertilizer or biogas slurry, which is utilized for irrigation for nutrient supply. In order to ensure sustainable and environmentally friendly management and to maintain biogas production, it is essential to study the nutritional parameters and safe disposition of the slurry.

The aim of our research was to analyze the filtering efficiency of the separator and to compare the properties of the pre-separator and the separated dilute phase.

MATERIAL AND METHOD

The sampling points were located before (pre-separator samples) and after the separator (separated samples). Samples were taken twelve times between February and June 2018.

The analysis of the nutrient parameters (pH, EC, TDS, COD, BOD, dry matter content and sedimentation, micronutrient and nutrient content) was carried out at the University of Debrecen, Faculty of Agriculture, Food Science and Environmental Management, by the Water and Environmental Management Institute and other tests (C, N content, C/N ratio, Kjeldahl N content) was carried out by the microbiological laboratory of Gastor Foods Kft. The tests were performed in 3 replicates for statistical evaluation.

Evolution of C content and N forms of the biogas slurry

The pre-separator and the separated slurry samples were first dried at 105 °C, then grind to a small grain size and finally the samples were sieved for homogeneity. The C and N contents of the prepared samples were analyzed with the Vario EL Elementar universal elemental analyzer, which is also suitable for the analysis of H, S and O elements.

To measure the recoverable N content of the biogas slurry Kjeldahl N content was also determined in three steps: digestion (in a Kjeldahl flask),

distillation (in a Wagner-Parnas apparatus) and then titration. As a first step, the nitrogen content of the slurry was converted to ammonium sulfate by sulfuric acid digestion. The sulfuric acid solution was basified in a Wagner-Parnas apparatus, the liberated ammonia is distilled and trapping in boric acid. The final step was the titration with hydrochloric acid. In this way, the amount of bound ammonia was obtained, and from this the nitrogen content of the protein sample could be calculated.

The nitrite and nitrate contents of the samples were measured with Photometer PF-12 Plus. Before measurement biogas slurry samples were sedimented for 3 minutes using a Rotofix 32A centrifuge, then diluted 100-fold and finally the required Visocolor ECO reagents were added to the samples.

Element content of biogas slurry

The biogas slurry samples were dried at the temperature of 105 °C until reaching the constant weight, shredded and the particle fraction below 2 mm was placed in a sampling bag. The elemental content of the samples were determined with Niton XLt 700 field X-ray spectrometer.

Dry matter content and determination of the amount of sediment

One liter of the pre-separator and the separated samples were weighed into measuring cylinders in three replicates. Samples were taken daily at 10, 20 and 30 cm depths using a pipette for 5 days. The wet weight of fresh samples was weighed and then dried in drying oven at 105 °C for 24 hours. After drying the dry sample weight was also measured. The dry matter content was calculated to determine the amount of sediment using the following formula:

$$\text{Dry matter content (\%)} = \frac{\text{wet weight} - \text{dried weight}}{\text{dried weight}} * 100$$

Measurement of pH, electrical conductivity (EC) and total dissolved solids (TDS)

The biogas slurry and deionized water were mixed in a ratio of 1:9 and shaken for 24 hours. The pH, EC and TDS of the samples were measured with a HANNA HI 2550 combined pH, ORP EC, TDS, NaCl meter.

Evolution of Biological Oxygen Demand (BOD)

BOD refers to the amount of oxygen needed to decompose biodegradable organic matter in water, thus suggesting the organic nutrient load to water. During the measurement, 43.5 ml of the fermentation broth sample was weighed into the BOI bottles. A magnetic stirrer was placed in

the bottles, and a rubber basket collar was placed on the neck of the bottle, in which 2 NaOH granules were placed. The bottle was sealed with the OxiTop probe, started the measurement, and placed in a thermostat cabinet at 20 °C for 5 days.

Measurement of Chemical Oxygen Demand (COD)

Since the COD value is related to the organic matter content, it is a very important point in the analysis of slurry. The measurement was carried out according to ISO 15075: 2002 as follows: 2.0 ml of a 100-fold dilution of the biogas slurry was weighed into test tubes which is containing sulfuric acid (80-98 %), potassium dichromate (0.28-0.56 %) and mercury (II) sulfate (0.74-1.50 %). The test tube was placed in a thermoblock at 148 °C for 2 hours after sealing and shaking. After the sample had cooled to room temperature, we began the measurement with the PF-12 Plus photometer.

Statistical analysis

Statistical analysis of the data was performed using R software in R Studio user environment.

The normal distribution of the data was examined by the Shapiro-Wilk test. If the data were found to be normal, the Duncan test was applied to quantify statistical differences at a 5 % significance level ($p = 0.05$). In some cases, the normality was not fulfilled for the groups, in which case the Kruskal-Wallis test was applied.

RESULTS AND DISCUSSION

Evolution of C content and N forms of the biogas slurry

The C and N contents of the samples were analyzed with the Vario EL Elementar universal elemental analyzer (Table 2).

Table 2

C and N content, C:N ratio of the samples

	Pre-separator samples	Separated samples
C content (mg/l)	19851.35[a]	9595.48[b]
N content (mg/l)	1846.86[a]	1004.17[b]
C:N ratio (%)	12.03[a]	9.5[b]

The C and N content of the biogas slurry and thus the C:N ratio decreased as a result of the separator, of which significantly decreased value could be detected.

The Kjeldahl's N content has also been defined to map accurately the usable N content (Table 3).

Table 3

Kjeldahl N content

	Pre-separator samples (mg/l)	Separated samples (mg/l)
Kjeldahl N content	4326.66[a]	3860[b]

The N content determined by the Kjeldahl method was higher than the N content measured by the elemental analyzer. This is due to the two methods of sample preparation, since the CNS elemental analyzer requires a solid sample, whereas the Kjeldahl N content was determined from the dilute phase. The difference is due to the nitrite and nitrate nitrogen content in the dilute phase. The Kjeldahl method also showed a significant decrease in the nitrogen content.

Since the nitrite and nitrate contents can not be detected in the Kjeldahl nitrogen determination, they were subjected for photometric measurements using Visocolor ECO tests.

Of the two parameters, only the nitrate content decreased, but no significant difference could be detected (Table 4).

Table 4

Nitrite and nitrate content of biogas slurry

	Pre-separator samples	Separated samples
NO_2 (mg/l)	22.69[a]	22.75[a]
NO_3 (mg/l)	2445.9[a]	1895[a]

The sum of the N content measured with the elemental analyzer and the photometrically determined nitrite and nitrate content is close to the Kjeldahl N content.

Element content of biogas slurry

For the Rb, Cu and Zn elements, some increase was observed as a result of the separation, while the amount of the other elements decreased after the separator (Table 5).

Table 5

Element content of biogas slurry

	Rb	Cu	Zn	Sc	Mn	Fe	S	Cl	Ca	K
Pre-separator simples (mg/kg)	0.8[a]	9.2[a]	15.1[a]	29.1[a]	31.2[a]	111.8[a]	304.8[a]	485.5[a]	2172.7[a]	2983.8[a]
Separated simples (mg/kg)	1.0[b]	9.3[a]	15.8[a]	12.0[b]	20.6[b]	98.3[a]	167.6[b]	452.4[a]	974.3[b]	2678.3[b]

Significant difference was found for Rb, Mn, Sc, Ca, K and S elements. Despite the change due to separation, the amount of micro- and macro-nutrients in the biogas slurry does not exclude agricultural use.

Dry matter content and determination of the amount of sediment

The dry matter content was checked daily. Pre-separator and separated samples were sampled at 10, 20 and 30 cm depths for 5 days. After measuring the wet and dry mass, the dry matter content was calculated. The results are presented by the following figures (Fig. 1, Fig. 2).

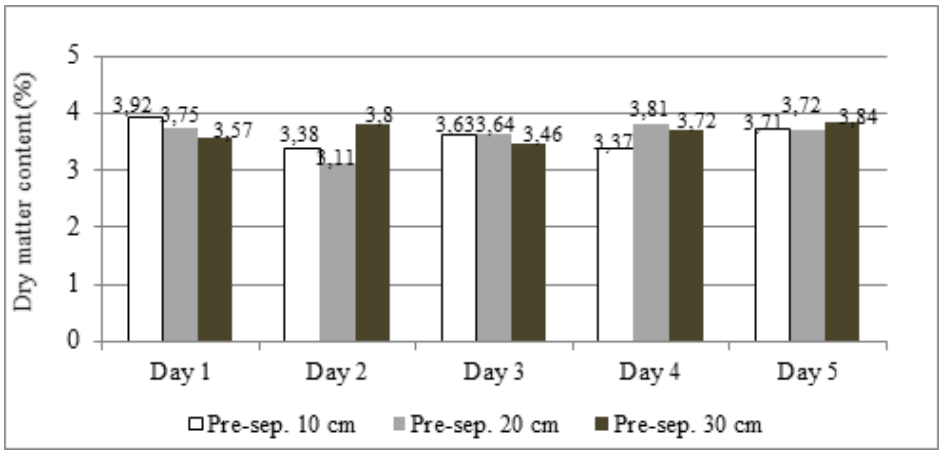

Fig. 1. Dry matter content of pre-separator samples

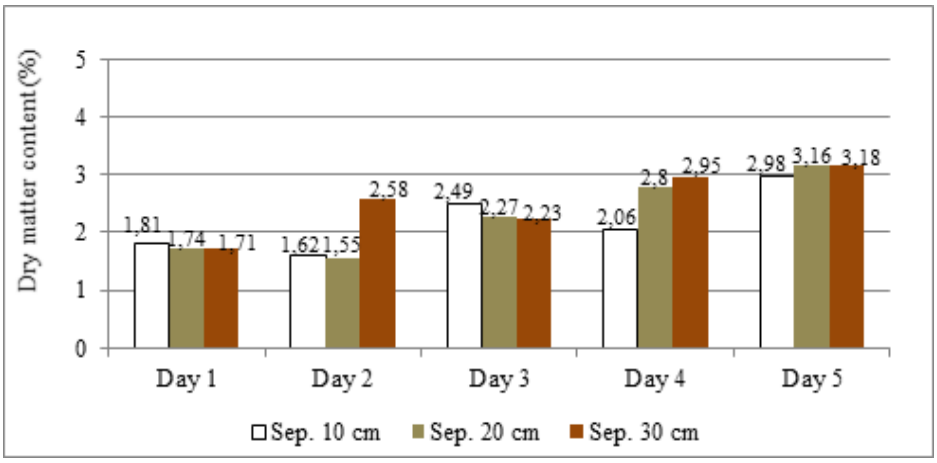

Fig. 2. Dry matter content of separated samples

In the pre-separator samples the dry matter content ranged from 3.11 to 3.92 % and from 1.55 to 3.18 % in the separated samples. The values decreased significantly due to separation, however the biogas slurry still contains a significant amount of floating material which must be removed in case of rainy irrigation.

Measurement of pH, electrical conductivity (EC) and total dissolved solids (TDS)

The pH of the biogas slurry, both before and after the separator, ranges from 8.2 to 8.4, so it is slightly alkaline. No significant difference was observed in the effect of the separator (Table 6).

Table 6

The pH, electrical conductivity and total dissolved solids of the biogas slurry

	Pre-separator samples	Separated samples
pH	8.33[a]	8.45[b]
EC (mS/cm)	19.79[a]	21.17[b]
TDS (mg/l)	9940.56[a]	10727.78[b]

During the measurements, the biogas slurry both before and after the separator, had very high salinity based on electrical conductivity (EC). According to Stefanovits et al., 1999, no salinization occurs if the irrigation water should not exceed 500 mg/l, which corresponds to 0.78 mS/cm. Accordingly, the salt concentration of the biogas slurry is very high and should be reduced in order to prevent environmental loading.

The total dissolved solid (TDS) content showed a slight increase due to separation (Table 6).

Evolution of Biological Oxygen Demand (BOD)

Biological oxygen demand was measured using a five-day incubation period.

A continuous growth in biological oxygen demand was traceable both before and after the separator. The biological oxygen demand of the separated biogas slurry was lower all the time, but no significant difference ($p = 0.05$) was observed (Fig. 3).

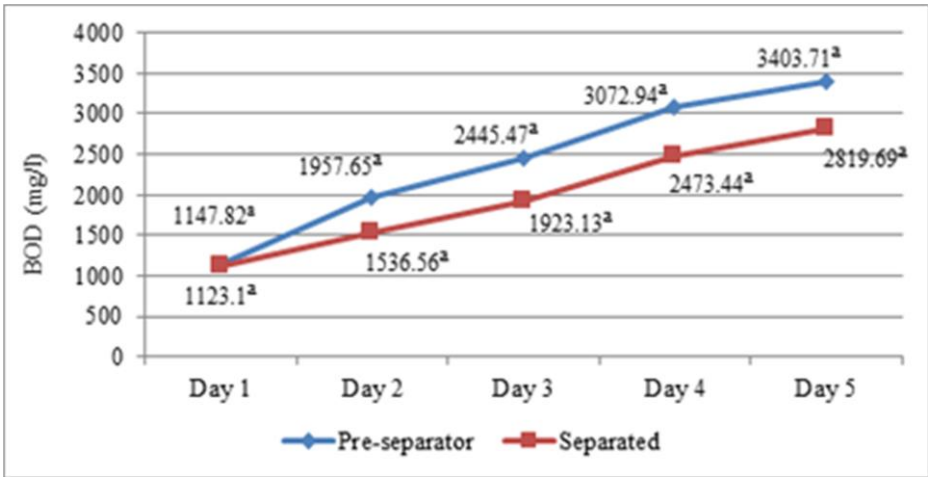

Fig. 3. Evolution of biological oxygen demand in the biogas slurry

Measurement of Chemical Oxygen Demand (COD)

According to other authors the chemical oxygen demand generally shows a downward trend in the effect of the separator. This is reported by Gamze, Göksel, 2003, who have experienced a 32 % reduction in some cases and up to 50 % in other cases as a result of separation.

During the study the average oxygen demand was 53737 mg/l in pre-separator samples and 52273.33 mg/l in the separated samples (Table 7).

Table 7

Evolution of chemical oxygen demand due to the separator

	Pre-separator simple	Separated simple
COD (mg/l)	53737[a]	52273.33[a]

Based on this, in our case the decreasing tendency was the effect of the separator, which was 2.7 % based on the average COD values. However, we could not detect a significant change.

CONCLUSIONS

Based on our results, it can be concluded that the decrease in C, N and other elemental contents due to separation does not exclude agricultural utilization.

However, utilization by irrigation may be difficult because significant amounts of suspended solids remain in the slurry despite separation. In addition, the biogas slurry has a very high salt content, which has not been reduced despite the separation, so it can be a burden on the environment.

The further studies are mainly aimed at reducing high suspended solids and also high salt concentrations.

Acknowledgment

This research was supported by EFOP-3.6.2-16-2017-00001 project (Research of complex rural economic and sustainable development, elaboration of its service networks in the Carpathian basin).

REFERENCES

1. Alam S., 2006, Production of organic manure in Bangladesh. Bangladesh Livestock Research Institute's Report, Savar, Dhaka, Bangladesh;
2. Angenent L.T., Wrenn B.A., 2008, Optimizing mixed-culture bioprocessing to convert wastes into bioenergy. In: J. Wall (Ed.), Bioenergy. ASM Press, Washington, pp.179-194;
3. Bíró B., Pacsuta A.J., 2002, Újgenerációs szemlélet és lehetőségek a talajbiológiai aktivitás és a talajtermékenység irányított fokozására. Gyakorlati Agrofórum. 13, pp.72-74;

4. Bitton G., 1994, Anaerobic digestion of wastewater and sludge. Wastewater Microbiology, Wiley-liss. New York, pp.229-245;
5. Gamze G.D., Göksel N.D., 2003, Effect of initial COD concentration, nutrient addition, temperature and microbial acclimation on anaerobic treatability of broiler and cattle manure. Bioresource Technology, Volume 93, pp.109-117;
6. Gijzen H.J., 1987, Anaerobic digestion of cellulosic waste by rumen a rumen-derived process. University of Nijmegen, The Netherlands;
7. Holm-Nielsen J.B., Halberg N., Hutingford S., Al Seadi T., 1997, Joint biogas plant. Agricultural Advantages – circulation of N, P and K. Report Made for the Danish Energy Agency, Revised and Emendted Edition, August 1997;
8. Ishikawa S., Hoshiba S., Hinata T., Hishinuma T., Morita S., 2006, Evaluation of a biogas plant from life cycle assessment (LCA). International Congress Series, 1293, pp.230-233;
9. Mézes L., Bíró T., Tamás J., Petis M., 2007, The examination of poultry feather digestility for biogas production. Acta Agraria Debreceniensis, 26, pp.113-118;
10. Mézes L, Tamás J., 2015, Feather Waste Recycling for Biogas Production, Waste and Biomass Valorization 5:(6) pp.899-911;
11. Monnet F., 2003, An Introduction to Anaerobic Digestion of Organic Wastes. Final Report Biogasmax. Remade. Scotland;
12. Stefanovits P., Filep Gy., Füleky, Gy., 1999, Talajtan. – Mezőgazda Kiadó. Budapest;
13. Surendra K.C., Takara D., Jasinski J., Khanal S.K., 2013, Household anaerobic digester for bioenergy production in developing countries: opportunities and challenges. Environmental Technology 34(13-14), pp.1671-1689;
14. Szegi J., 1967, Nitrogénkötő mikroorganizmusok jelentősége a talaj termékenysége szempontjából. Agrokémia és Talajtan. 16, pp.477-486;
15. Szőllősi N., Mézes L., Bíró Gy., Petis M., 2008, Evaluation of landuse, based on recycling of liquid biogas by-product. Növénytermelés, 60, pp.459-462;
16. Tamás J., Kovács E., 2008, Environmental technology. University of Debrecen, Centre for Agricultural and Applied Economic Sciences;
17. Wilkie A.C., 2008, Biomethane from biomass, biowaste and biofuels. In: J. Wall (Ed.), Bioenergy. ASM Press, Washington, pp.195-205.

Received: October 31, 2019
Revised: April 02, 2020
Accepted and published online: May 31, 2020

Natural Resources and Sustainable Development
Volume 10, Issue 1, 2020
DOI: 10.31924/nrsd.v10i1.045

THE INFLUENCE OF DESERTIFICATION FACTORS IN THE REPUBLIC OF MOLDOVA AND THE TASKS TO COMBAT IT

Cojocaru Olesea*#, Bacean Ion*

*State Agrarian University of Moldova, Agronomy Faculty, Department of Agroecology and Soil Science, 50 Mircesti, MD-2049, Chisinau, Republic of Moldova,
e-mail: o.cojocaru@uasm.md

Abstract

Environmental protection is a problem of global importance, which must become a national priority, because it directly concerns the living conditions and the health of the population, the achievement of economic interests, as well as the capacities of sustainable development of the society. Desertification is considered one of the main global economic problems, in particular because of the reciprocal link between land degradation and food production. Desertification, land degradation and droughts are a danger to human food security, reducing agricultural production and even destroying homes. According to the evaluation of the United Nations Environment Program due to the desertification process, over 40 million ha were severely affected. Every year over 900 million people are subjected to the negative influence of desertification processes. In the Republic of Moldova, soil degradation and desertification processes are conditioned by both natural conditions and anthropogenic factors. Among the natural conditions are the climatic phenomena (torrential rains, frequent periods of drought and drought, strong winds), the rugged relief, the lithogenesis and the composition of the rocks from the earth's surface. Currently, on the territory of the Republic about 40 % of the agricultural lands have soils eroded of different degree: weakly eroded - 23.2 %, moderately eroded - 11.7 and strongly eroded - 4.9 %. Each year the surface of the eroded land increases by an average of 0.9 %, and the annual losses of fertile soil are estimated at 26 million tons. The balance of humus is profoundly deficient, the reserves of humus decrease annually by about 1 t/ha, the nutrients by 180 - 200 kg/ha. The damage caused to the national economy by the loss of production through soil degradation amounts to about 3.1 billion lei (251 million USD) annually. The degradation of the soil cover and the drying of the climate during the spring-summer period lead to the intensification and extension of the desertification processes of the lands.

Key words: environmental protection, chernozem, desertification, natural and anthropogenic factors, soil degradation processes

INTRODUCTION

Human influence on the environment is becoming more and more violent, and the consequences of intervention in the laws of natural processes are increasingly harmful. From the current processes conditioned by the anthropic activity, a special role belongs to the desertification. By definition, desertification is a complex process of land degradation in arid, semi-arid and sub-humid-dry areas due to climate change and non-human activities. Desertification affects the natural areas and soils of Moldova in different ways (Andrieș, 2005; Cerbari, 2000). Taking into account the need to address this new problem, the Parliament of the Republic of Moldova on December 24, 1998 adopted the Decision no. 257-XIV regarding the

Corresponding author

accession of the Republic of Moldova to the UN Convention for combating desertification in countries severely affected by drought and desertification.

In accordance with this Decision, the Government of the Republic of Moldova obliged the Ministry of Environment and Territory Planning, the State Service "Hidrometeo" and the National Institute of Ecology to elaborate the National Action Program for Combating Desertification in the Republic of Moldova. This Program was approved by the Government Decision of the Republic of Moldova no. 367 of April 13, 2000. The purpose of the mentioned Program was to identify the factors contributing to desertification and the practical measures needed to combat desertification and reduce the effects of drought in the Republic of Moldova. With the support of the international community, a systematization of information on degraded lands was undertaken in 1998-2000. Based on this assessment, maps of degraded-eroded areas and drought-exposed areas were published (Andrieș et al., 2008; Andrieș and Filipciuc, 2012). In the curricula for university courses in the field of agriculture and environmental protection, aspects regarding sustainable land management and combating desertification were introduced. The country also benefited from technical and financial assistance for the elaboration of the National Action Program for Combating Desertification and the National Report on the Implementation of the Convention.

The Republic of Moldova is located in the South-East part of Europe and occupies most of the territory between the Dniester and Prut rivers as well as a narrow strip on the left bank of the Dniester. In the West it is neighboring with Romania, and in the North, East and South - with Ukraine. Moldova has a special geographical position, being at the connection of three natural areas. The climatic conditions are characterized by instability - the dry periods happen to the period with heavy rains (Daradur et al., 1996; Constantinov and Nedealcov, 2008). The torrential character of the rains and the fragmented relief under conditions of maximum use of the soil layer condition the intense erosion. The eroded soil, ravines and landslides significantly reduces productivity of the land fund. The main natural wealth of our country are the soils (Ursu, 2011). At present agriculture occupies a significant place in the national economy of the country, its contribution in the volume of GDP being about 18 %.

Together with the agricultural raw material processing industry, the agrarian sector contributes about 32 % to the creation of GDP and with almost 65 % in the total volume of exports, in agriculture being involved more than 40.5 % of the occupied population of the country. In the rural area, about 54 % of the population of the republic operates (World Bank, 2017). Therefore, efficient and rational land use is a prerequisite for a prosperous economy and for ensuring the well-being of the population. The

intensive exploitation of agricultural land and the use of environmentally harmful technologies have led to a considerable reduction in productivity and have had a destructive impact on the soil. The state of the soil is essential for the development of an export oriented agriculture and sustainable food industry (Шабанова et al., 2000). At present, however, the productivity of agricultural soils is declining, which threatens the development of the agro-industrial sector and affects the national economy as a whole (Tărîţă et al., 2013).

MATERIAL AND METHOD

In accordance with this Decision of the Parliament it was elaborated and approved by the Government Decision no. 367 of April 13, 2000 "the national action program for combating desertification in the Republic of Moldova". The nominated program provides: determining the factors that contribute to the intensification of the desertification; elaboration and implementation of practical measures on combating desertification and mitigating drought consequences; maintaining the fertility of the lands that are affected by the desertification processes. According to the National Action Program in front of the line ministries and the bodies of the local public administration, concrete tasks and strict deadlines have been put in place, because the situation is quite acute. The accomplishment of the indicated actions will allow the organization in the Republic of the Integrated Ecological Monitoring System (including the monitoring of the desertification processes). Within the National Action Program are presented in detail the basic directions, the realization of which will contribute to the liquidation of shortcomings in the field of agriculture, urbanization, industry, energy and transport, significant importance for the prevention or diminution of desertification processes.

Combating desertification is a component part of the rational use of soil resources in drought-stricken regions in order to develop society in the long term (Ursu, 2000). Among the most important activities aimed at combating desertification processes in the Republic of Moldova are the following:

- improvement of the favorable legislative framework for the protection, improvement and sustainable use of soil resources, its connection to the European one;
- creation of the information system of the soil quality status;
- structuring and reconstructing the landscaping by extending forests, meadows and meadows, wetlands;
- implementation of phyto-ameliorative, silvotehnic and hydrotechnical measures to minimize soil erosion and stabilize landslides;

- increasing soil fertility by forming a balanced or positive balance of humus and nutrients in the soil by applying fertilizers;

- approaching a state policy in the field of soil resource management;

- consolidation of agricultural lands taking into account the relief, the structure of the soil cover, the correlation between natural and anthropic systems;

- organizing the monitoring of desertification and land cadastre;

- the restoration and extension of large and small irrigation;

- the rational use, the ecological protection and reconstruction of the grassland vegetation, the implementation of the controlled pasture;

- development and implementation of pilot projects to combat desertification at field level;

- strengthening of the financial assistance mechanisms;

- scientific assurance of actions to combat soil degradation and desertification;

- creation of a system of training, information and awareness of the population regarding the problems related to soil degradation and desertification.

RESULTS AND DISCUSSION

The lack of modern information and technologies, especially the limited access of the rural population to the information on the efficient use of the land, leads to the use of inadequate cultivation technologies and to the neglect of deserts. The reduced application of mineral or organic fertilizers has caused the reduction of humus and nutrients in the soil. Other factors, such as the reduced use of pesticides, land salinization, deep plowing and illegal logging of agricultural lands, have contributed to the erosion.

Desertification is land degradation in arid, semi-arid and dry sub-humid zones, caused by various factors, including climate change and human activities, resulting in a decrease or destruction of the biological potential of the soil, which can lead to desert conditions.

***Climatic factors as intensifiers of desertification*.** In accordance with the UNEP international classification of arid territories, the territory of Moldova for the most part belongs to the humid - sub-humid zones, in the South-Eastern regions - to semi-arid. The average annual rainfall is about 490-620 mm. The greatest amount of precipitation is observed in the North-Western part of the republic and on the slopes of the Central Moldavian Upland, the least (490-520 mm) in the South-Eastern and southern regions of Moldova. About 10 % of the territory of the Republic of Moldova is subjected to intense drought every 2-3 years, 50 % - once every 10-12 years. It should be emphasized that in connection with global and regional climate

changes, this phenomenon tends to increase and intensify (Stancu, 2000; Коробов et al., 2004).

Meso- and microclimate. Considering the hypsometry of the territory, the laws of structural, climatic, geomorphological changes and vegetation, 11 agroclimatic regions with different types of mesoclimates are distinguished in the country. A variety of mesorelief and vegetation has a significant impact on the change in the main agroclimatic indicators of heat and humidity.

The climate of Moldova is temperate continental and is characterized by mild, short-lived and low-snowy winters and long warm summers with low rainfall. Phenomena of drought and the changing nature of the weather constitute a negative aspect of the climate in the region. Located in southeastern Europe, in an area with insufficient humidity, in the territory of the Republic of Moldova a positive radiation balance is recorded for 11 months a year. Duration is 3806 hours. Moldova is called "solar" because the duration of insolation in the country varies from 1940 to 2180 hours. In winter, the air temperature is unstable. Frequent thaws and frost-free days have a negative effect on crops, and often resume vegetation (Constantinov et al., 2008; Daradur et al., 1996; Лалыкин et al., 2004).

The coldest month of the year is January with an average temperature of -2.5 ... -5.5 °C. With the penetration of Arctic air from the north and a delay in anticyclones, the air temperature may drop to -28 °C and in the south of the republic (in the north - to -36 °C). The average monthly soil temperature at the depth of the arable layer (20 cm) is generally positive in the winter or around 0 ^{o}C, however, in the absence of a stable snow cover, the soil can freeze up to 100 cm. During the winter, 100-140 mm of precipitation falls; this is 20 % of the annual norm. In most cases, precipitation falls in the form of snow and rain, and their intensity is small.

Snow cover appears in late November or early December; its height is negligible. Only in 10 % of winters does the snow cover reach 0.5 m in the northern regions and 20-30 cm in the southern and central ones. Summer is dry and hot. The hottest month is July, the average air temperature can reach 37-40 °C, and on the soil surface - 62-66 °C. In the warm period of the year, during 60-95 days, the air temperature rises to 25 °C and above, and only 10 days a year, the air temperature is above 30 °C. The total duration of air temperature is above 25 °C and varies from 300 to 600 hours. The absence of precipitation over a long period of time against the background of high temperatures leads to the occurrence of the drought phenomenon, which is observed once every 6-7 years in the central part of the republic, and 3-4 times in the southern part during this period. According to the modern concept, desertification factors have a climatic and anthropogenic nature (Ursu, 2000).

Anthropogenic factors as intensifiers of desertification. In the natural and economic conditions of the Republic of Moldova, the factor of intensification of the desertification process is agriculture, since agricultural lands occupy on average 75.5 % of the total territory of the country, and 81 % in the southeastern part (Andrieș et al., 2008).

Arable land: the negative aspect and the main factor in the intensification of desertification is the large area of arable land, including horticultural and viticulture, which on average in the republic is 64.4 %, and in the whole country varies from 85.1 % (in the north) to 93.1 % (in the south east).

High plowing of the territory of the republic (Fig. 1) will lead to an intensification of desertification processes: surface and linear erosion, deflation, landslides, which will lead to increased disturbance of the ecological balance.

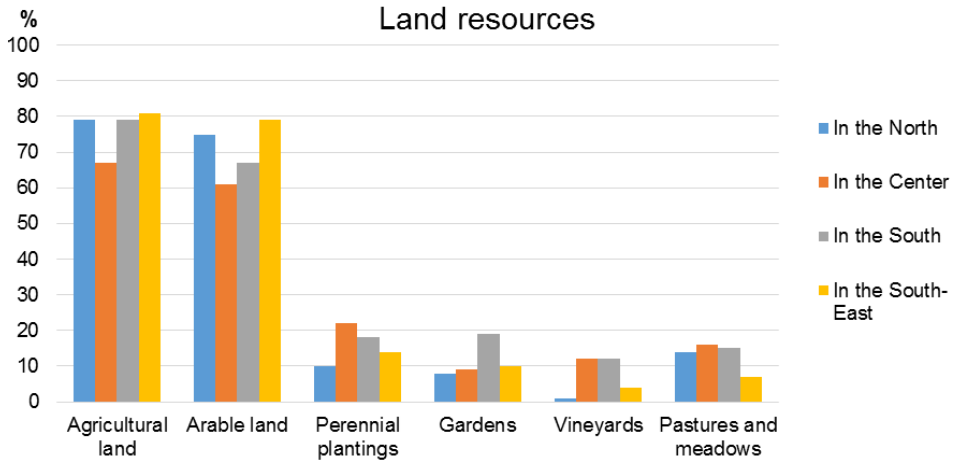

Fig. 1. Territorial use of land resources

Decrease in soil fertility. Neglect of modern environmental farming principles has led to a decrease in soil fertility. It has been established that over the past 100 years, 2.8 tons of nitrogen, 0.8 tons of phosphorus and 6.1 t/ha of potassium were extracted and exported from the soil together with the crop, a total of 9.1 t/ha. About 20 million tons of nutrients were exported from all agricultural land, including 4.8 million tons of nitrogen, 1.7 million tons of phosphorus and 13.8 million tons of potassium. Throughout the history of agriculture in Moldova, only during the period of intensive chemicalization (20 years, 1970 - 1990), a positive balance of nutrients in the soil was created. Currently, about 80 % of the total area is characterized by a very low level of nitrification (below 10 mg/100 g of soil) and 59 % of the total area is characterized by a very low (21 %) and low (38 %) content of mobile phosphorus. Over the past 5-6 years, only 8-110 kg/ha of nutrients

are introduced into the soil annually (Тюрин, 1965). Together with the crop, about 200-220 kg/ha of nutrients are extracted and exported from the soil. Thus, the balance of nutrients in agriculture is deeply negative - minus 190-210 kg/ha.

According to the regulations, the return of nutrients to the soil by applying fertilizers in optimal doses provides an increase in yield by 35-40 % and vice versa. Large annual losses of humus in the process of denitrification, a deeply negative balance of nutrients in agriculture lead to the depletion of chernozems, once so fertile, estimated by the founder of genetic soil science V.V. Dokuchaev as "First-class". Not compensation of losses of organic substances and a decrease in nutrients every year will undoubtedly lead to a decrease in fertility, to a significant change in the volume and quality of the crop, especially wheat (Ursu, 2011).

Managerial and technological implications. Currently, there is no scientific justification for field crops, horticulture, viticulture, vegetable growing and livestock farming in accordance with local pedoecological conditions and the existing landscape. Crop rotation is not observed, including anti-erosion, which provides for the necessary ratio of row crops, spikes, and leguminous crops, perennial grasses. Geographically limited systems: minimal tillage, the use of organic fertilizers originating from all possible resources, the introduction of integrated plant protection management. The areas of growing peas (3.9 times), soybeans (16.2 times), and sunflower (1.4 times) decreased significantly. The average annual global cereal production over the past 10 years amounted to 2584 thousand tons, or 500-700 tons less than planned (World Bank et al., 2003). The sharp decline in the yield of cereals, as well as sugar beets, tobacco and other crops is explained to a large extent by a sharp decrease in the doses of fertilizers introduced into the soil, failure to comply with timely agrotechnical measures to control weeds, pests and diseases, and to delay harvesting. The indicated managerial and technological aspects and the absence of a long-term strategy impede the transition of current agriculture to sustainable agriculture, which will effectively combat the desertification process.

The consequences of irrigated agriculture. In the Republic of Moldova, irrigated lands occupy 308,700 ha, or 0.07 ha per capita, while in the world irrigated land per capita is only 0.05 ha. Contrary to many convincing examples of increasing the effective fertility of irrigated lands by 1.5-2 times, the productivity of irrigated lands in the Republic of Moldova is low. The increase in productivity of such lands is due to water quality and irrigation regime, indicators of soil properties, features of crop rotation and agricultural technology used, as well as management system. The ill-conceived use of irrigated areas causes soil degradation and is a

factor in the intensification of dehydration and desertification processes. Irrigated agricultural land in an area of 12.8 thousand ha (4 %) is in poor meliorative condition, including 8.54 thousand ha (6 %) with an increased level of groundwater, 1.5 thousand ha are saline, 2.8 thousand ha are salt marshes and have an unacceptable level of subsurface water. Since most of the irrigated lands are represented by chernozems, they are easily vulnerable to degradation under irrigation conditions. Irrigation of chernozems even with the unsalted waters of the Prut and Dniester causes weak and moderate structural differences, forms a crust, reduces the overall porosity, aeration, and decalcification of soils. Mineralized waters with a total salt content of more than 1 g/l, and especially 2 g/l with an alkaline reaction, after a few years of use cause salinization of chernozems and a significant decrease in their productivity (Sandu et al., 2013; Sandu et al., 2016). In order to increase the productivity of irrigated lands, as well as expand the possibilities to combat drought and mitigate the negative effects of desertification. It is necessary to implement a number of organizational and technological measures outlined in Section II.

The use of pastures. Pastures in the country occupy 369.6 thousand hectares, or 10.9 %, and meadows - 2.4 thousand hectares, or 0.1 % of agricultural land. In the Northern, Central, and Southern pedoclimatic zones, pastures occupy 14.4–16.4 % of agricultural land and only in the Southeastern semi-arid zone do they make up 6.9 % of agricultural land. The increase in the number of cattle and sheep in the private sector, the lack of land regulation, and the location of pastures on the slopes led to the process of overuse of pastures. Irrational use of pastures without scientific justification leads to their degradation. As a result of increased impact on pastures, there is a successive change of two stages of degradation - destruction of the vegetation cover and destruction of the surface soil layer. If in the North the degradation of meadows as a factor in the intensification of the desertification process is delayed at the first stage, in the Southern and Southeastern zones the degradation of meadows covers both stages (Ursu, 2011).

The process of intensive degradation of meadows takes place especially in the Vulcanesti sector of Cahul city and in Tighina city. Studies have shown that overuse of pastures leads to a decrease in the biodiversity of pastures and their biological pollution with low-quality plant species (elderberry, nettle, lettuce, wormwood, etc.). Soil degradation leads to a decrease in the degree of anti-erosion stability, most pastures are highly eroded. Along with this, they are all significantly damaged by landslide processes. Within the geomorphological region of Reut - Ciuluc, pastures are subject to salinization and solonetzization processes. In this context, the integrated application of measures for the protection and ecological

restoration of pasture vegetation is necessary (Postolache, 1995; Medyanic, Mihailescu, 1992; Tărîţă et al., 2013).

Violation of territorial ecological balance. Anthropogenic activity caused a serious violation of the ecological balance in the republic. Natural and natural-anthropogenic ecosystems (forests, including forest strips, meadows, pastures, swamps, water systems) make up 17 %, which corresponds to a low level of territorial ecological balance (10-20 %). The southeastern semi-arid zone is characterized by the most unfavorable situation with a very low level of natural-anthropogenic systems (< 10 %) and a very large share of arable land (> 80 %). The available 325.4 thousand ha of forests are unevenly distributed (Fig. 2). Of the total area: 60 % fall on the central zone (afforestation rate is 13.5 %), about 26 % fall on the northern zone (7.2 % afforestation), and the southern zone, which is especially prone to drought, is characterized by water scarcity and soil erosion, only 16 % (afforestation - 6.7, i.e. 2 times lower compared to the central zone).

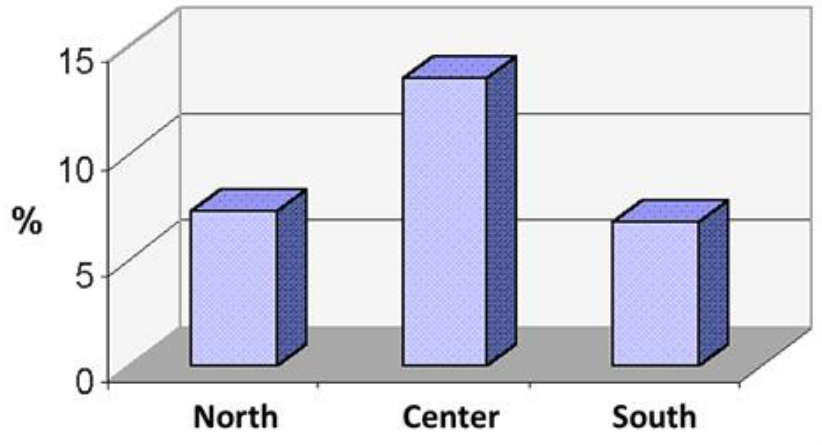

Fig. 2. Degree of afforestation in different zones of Moldova

Increasing the territorial ecological balance will make it possible to transfer modern agriculture to sustainable and landscape. In some regions, afforestation of lands not used for agriculture will significantly reduce the degree of soil erosion, especially in the south of Moldova, protect lands that are constantly threatened by landslides, and reduce the negative effects of arid climate.

Soil erosion and landslides. Soil erosion and landslides are the most important desertification agent, especially to speed up the process. A third of agricultural land susceptible to erosion is prone to accelerated development of the desertification process (Fig. 3).

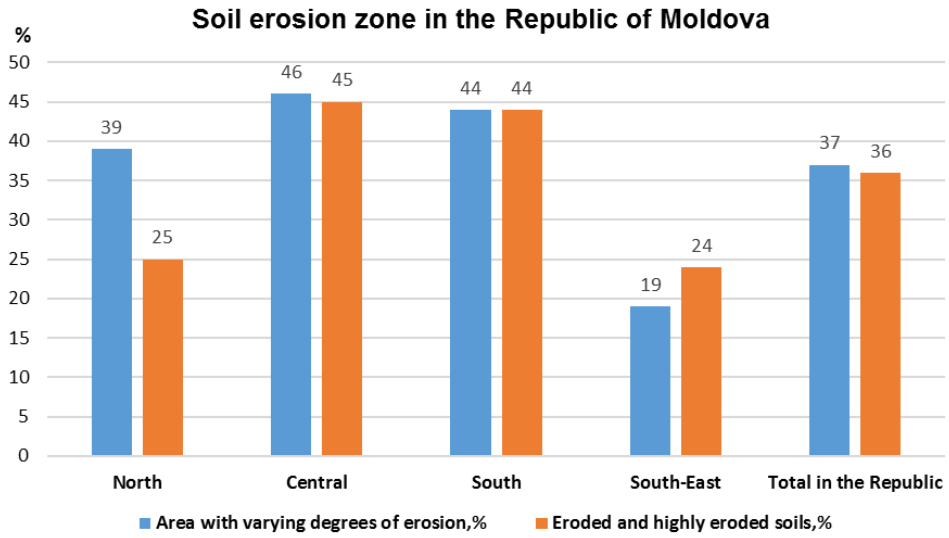

Fig. 3. Eroded agricultural land

Agricultural land in the center and south of the country is significantly damaged by erosion (Andrieș et al., 2012; Капчеля, 1990). The annual loss of fertile soil on all agricultural lands caused by erosion is 26 million tons, including: humus - 700 thousand tons, nitrogen - 50 thousand tons, phosphorus - 34 thousand tons, potassium - 597 thousand tons. These losses cause a significant reduction in crop yields. Indirect losses expressed in agricultural products are stable values that repeat from year to year. Currently, agricultural products annually lost due to soil erosion amount to 525 thousand tons of nutrient units on arable land and 57 thousand tons of fruits and grapes on orchard-viticulture lands, which amounts to annual losses of 221,365 thousand US dollars.

Indirectly, damage due to erosion is also reflected in other areas of human activity: siltation of lakes and other water basins, contamination of lowland and groundwater soils with pesticides and mineral fertilizers washed away from slopes, destruction of communication lines, hydraulic structures and buildings, and social facilities etc. The combination of the complex physical and geographical conditions of intensive farming on the slopes led to the development of linear erosion - from surface erosion to entire systems of ravines on area 8 800 ha, which is estimated at an annual loss of $ 7,622 thousand. The degree of intensification of soil erosion is also increasing due to landslides on the slopes, which completely destroyed the soil cover on an area of 24.1 thousand ha, causing annual damage in the amount of 8432 thousand US dollars. The National Program provides measures for land improvement, to prevent landslides and to fight with them.

Soil deflation. Dust storms are one of the main effects of soil deflation, wind erosion. In a short period of time, massive layers of crushed soil can move, which form precipitation and fall asleep crops, causing their death. According to the main climatic indicators indicating the potential conditions for the occurrence of dust storms, the territory of the republic belongs to the active zone, which is divided into regions with various degrees of manifestation of dust storms. The northern part of the Prut and Dniester valleys, as well as the Central Moldovan Plateau are regions with a low degree of dust storms, the steppe territories, the southern and southeastern border territories are regions with strong dust storms, and the rest of the country is the Balti steppe and the southern outskirts of Codri - with a moderate degree of storms. In the central and southern parts of the republic, dust storms are observed almost annually, in the northern regions - once every 3-5 years. The number of days with dust storms on average in the republic is 2-10 days a year and cannot be taken into account when developing and implementing measures to combat desertification.

Soil salinization. The intensity of soil salinization is determined by the degree of salinity (excessive content of soluble salts) and the level of alkalinity (maximum content of unstable sodium) of different horizons, taking into account the depth of their occurrence. Salinization of soils is associated with the accumulation of soluble compounds by evaporation of subsurface water in an arid climate, especially in the Balti steppe, in the Center and in the South of Moldova. In the conditions of the forest-steppe of the North of Moldova (hydrothermal coefficient > 0.7), saline soils are practically absent or have very limited ranges. The areas of automorphic solonetzes and a complex of solonetzic soils (most of the chernozems) formed in the framework of elluvial landscapes (interfluve, slopes) exceed 25 thousand ha. The areas of saline and solonetzic extra-elluvial hydromorphic soils in the lowlands are about 20 thousand ha, and saline elluvial (floodplains of the Dniester, Prut, small rivers) exceed 99 thousand ha. Since all agricultural lands have a comprehensive soil cover structure, it can be concluded that in the center and in the South of Moldova there is a risk of secondary salinization with all the negative consequences. The action plan provides specific measures to combat soil salinization and salinization.

The consequences of desertification.

Changes in soil properties - the analysis of factors, conditions and desertification agents confirmed the possibility of developing this process throughout the Republic of Moldova, especially in the Southern and South-Eastern pedoclimatic zones. First of all, physical degradation of soils takes place in these zones (crust formation, compaction, structure destruction, and porosity decrease). In the case of soils with heavy loamy and clay granulometric composition, high density (1.46 - 1.60 g/cm^3) and a moderate

degree of shrinkage, the frequency of unsatisfactory estimates of the total porosity is 40 – 60 %. For loamy soils, the frequency of unsatisfactory estimates of total porosity in this segment of compaction is 30 – 40 %. At higher density values, heavy loamy soils and light clays constantly have unsatisfactory porosity values. Even in the case of soils with loamy granulometric composition, the frequency of unsatisfactory values is 70 – 80 %. Consequently, the aridity of the soil and soil cover is accelerating. At the highest levels of soil organization (profile, horizon), aridity is due to the differentiation of the physical and hydrophysical profiles and its compaction and results in a decrease in water permeability. At lower levels of functioning of the soil system (aggregate, microaggregate, elementary particle), the aridity of the soil is due to a significant increase in the forces that hold water in the soil, as a result of compaction of the aggregates. It has been established that over the past 90 years, the humus content has halved (from 5 – 7 % to 3.0 - 3.5 %), or by 70 t/ha. Thus, about 147 tons of humus was lost from all agricultural areas. At present, the humus balance in agriculture is deeply negative (-1.5 t/ha), and its annual losses amount to 3.3 million tons. The annual losses due to erosion are about 0.6 million tons, only 3.9 million tons. The annual rate of humus mineralization is 0.02 %. According to the Agrochemical Service, 40.6 % of agricultural land is characterized by very low or low humus content (below 2 %). In the past 8 – 10 years, the amount of organic fertilizers used in agriculture has decreased from 5 – 6 to 0.8 – 0.9 t/ha. In the future (after 50 years), if an appropriate set of measures is not taken, the humus content will decrease from 3.0 - 3.5 % to 2.0 - 2.5 %. The area of agricultural land with humus content in the soil below 2 % will also increase. As a result, soil productivity will decrease by 30 – 40 %. On the outskirts of Central Codri and in the southern regions, the process of dehumification in ordinary and carbonate chernozems has intensified significantly (Ursu, 2000). The degree of manifestation of this process varies from medium to strong. It should also be noted that these soils are not very resistant to salinization. The decrease in resistance to solitonization is due to a decrease in humus reserves, the ability to retain cations, decalcification of the absorbing complex of the soil, an increase in the role of magnesia cations, a change in the carbonate regime, etc. Thus, in the process of desertification, the risk of saltification, therefore, a decrease in the productive potential of soils is significantly increased.

Change in the level of mineralization of water. Mineralization of subsoil water is associated with the hydro regime of rivers and the level of pollution. The water quality of the Dniester River, according to the standards, belongs to the second class - “moderate pollution”, in the lower zone - to the third class - “polluted”. The waters of the Prut River contain organic matter in increased volumes and inorganic in reduced ones, which

provokes high chemical oxygen consumption and a relatively low amount of dissolved oxygen. According to the standards, the water at the confluence of the Prut River and the Danube River belongs to the third class of quality - "polluted", and in the area of the Valea Mare settlement, the fourth class is "much polluted". The underground water in the floodplains of small rivers is heavily contaminated with nitrates due to the irrational use of nitrogenous fertilizers, dumping of manure from livestock complexes, garbage and other waste located on the ground without a protective layer, etc. In some places, the subsoil waters are heavily contaminated with oil products (Marculesti). About 50 % of the population does not have access to quality drinking water. The main risk factor that has a serious impact on public health in connection with water consumption is a high level of nitrates. Being the most common and most famous toxic substance in the subsoil waters of Moldova, they lead to the occurrence of metgemoglobulinemii, also known as nitrate intoxication, in concentrations above 50 mg/l. More often affected children under three years of age, especially artificially fed. The proportion of samples with a detected excess of the maximum permissible nitrate concentrations in central and local sources in 2005 was 50 %, and in local sources - 68.8 %, respectively, an increase is characteristic of all areas where the detected concentrations also increased - 500-1200 mg/l. Regarding the quality of groundwater to provide drinking water to the urban population through a centralized system (the proportion of groundwater is 50 – 60 %), more than a third of the sources do not meet the quality standards for chemical indicators. The main problems are the high fluorine content (2 - 18 mg/l) in the counties of Balti, Ungheni, Lapusna, Tighina, Chisinau, TAO Gagauzia; ammonia (2 - 10 mg/l) in all zones, often in the Center of the Republic; strontium (7 - 15 mg/l) - in the districts of Orhei and Chisinau; hydrogen sulfide (3 - 20 mg/l) - in the districts of Ungheni, Lapusna, Tighina, Chisinau, TAO Gagauzia; iron (1 - 2.5 mg/l) - in the districts of Balti, Edinet, Cahul (Vulcanesti village).

Changes in the plant world. Vegetation is a biological indicator of desertification. In the composition of vegetation, the ratio of xerophyte and mesophyte species changes. Xerophytization takes place by completing the vegetation cover with cereals (*Bolboscnoemus maritimus, Guncus genardii, Beckmannia aurici formus, Alopecurus arundinaceus*). Due to accelerated anthropogenic salinity, halophytization of vegetation develops (*Salicornia europaea, Halimione werrucifera, Lepidium latifolium,* etc.). An important indicator is the design density of natural vegetation and agrophytocenoses. The density of natural phytocenoses under conditions of desertification and aridity is sharply reduced due to excessive pasture areas and intense droughts. The design density of crops decreases from the north of Moldova with a temperate climate to the South and South-East of Moldova with a dry

sub-humid and even arid climate. If in the northern and central parts the maximum design density of corn for grain is 87 – 85 %, winter wheat – 79 %, sunflower – 99 %, tobacco – 97 %, in the conditions of the South of Moldova the estimate of the design density of vegetation decreases to 76, 68, 92, respectively and 95 %.

Depending on the nature of the design density, vegetation in various ways protects the soil from the harmful effects of rain during the rainy season:

- perennial herbs used in the second and subsequent years, and perennial plants can protect the soil throughout the entire warm period of the year (April-October);
- cereal crops (except corn), peas, winter crops and a mixture of spring herbs can protect the soil at the beginning of the rainy season (April-May);
- perennial herbs for use in the first year, corn, sunflower, tobacco protect the soil during the rainy season (July-August);
- sugar and fodder beets, cabbage and other late vegetable crops protect the soil after an active period of rains (September-October).

An important indicator of desertification is the biological productivity of soil and land, which implies the yield of phytomass and economic production per unit area, taking into account all crops that make up the structure of sown areas. In accordance with the biological productivity assessment scale, the northern zone is characterized by a very high level of biological productivity (more than 5.6 t/ha), the central zone is characterized by a high level (5 - 5.5 t/ha) and the southern and southeastern zone, where desertification factors are most intense, - low level of biological productivity (4.0 - 4.5 t/ha).

CONCLUSIONS

The Republic of Moldova acceded to the United Nations Convention to Combat Desertification on December 24, 1998.

The main intensifiers of desertification are climatic (sub-humid and semi-arid zones) and anthropogenic (unreasoned agriculture, irrigation of agriculture, overuse of pastures) factors. An important role belongs to the meso- and microclimate.

Desertification agents on the territory of the Republic of Moldova are:

- violation of local ecological balance, soil erosion, wind erosion, salinization (solonchaks and solonetzes) of soils;
- the consequences of the processes of drought and desertification consist in the development of trends in the deterioration of soil properties, including their degradation (dehumification and compaction);

- increase in the level of mineralization and water pollution, which is accompanied by a negative impact on human health and the plant world (reduction, herophilization, halophytization);

- the socio-economic crisis and the negative consequences of the processes of aridity and desertification on the territory of the republic require the immediate implementation of the strategy and tactical theses of the Program of Action to Combat Desertification.

REFERENCES

1. Andrieș S., 2005, Starea de calitate a solului: măsuri de protecţie, ameliorare şi sporirea fertilităţii. În: Lucrările conferinţei republicane ştiinţifico-practice „Protecţia solului". Chişinău, pp.47-51;
2. Andrieș S., Cerbari V., Rusu A., Lungu V., Donos A., Filipciuc V., Leah N., Dobrovolschii Gr., Boaghe Lilia, 2008, Condiţiile naturale și antropice de degradare a solului și procedee tehnologice de minimalizare a consecinţelor factorilor ecopedologici nefavorabili. În: Diminuarea impactului factorilor pedoclimatici extremali asupra plantelor de cultură. Chișinău, pp.41-92;
3. Andrieș S., Filipciuc V., 2012, Eroziunea solului: starea actuală, consecinţele și măsurile de minimalizare. În: Agricultura Moldovei, nr.5-6, Chișinău, pp.12-17;
4. Cerbari V., 2000, Sistemul informaţional privind calitatea învelişului de sol al Republicii Moldova (Banca de date). Pontos, Chişinău, pp.15-48, ISBN: 9975-938-24-8;
5. Constantinov T., Nedealcov M., 2008, "Evaluarea fenomenelor climatice nefavorabile". În: "Republica Moldova. Hazardurile naturale regionale", Chișinău, pp.57-68;
6. Daradur M., Nedealcova M., Smirnova V., 1996, Regional climate of Moldova: tendencies and regularities of its changes. Cracow, pp.299-333;
7. Hotărârea Guvernului nr. 367 din 13.04.2000 cu privire la aprobarea Programului Naţional de Acţiuni pentru Combaterea Deşertificării;
8. Шабанова Г.А., Витко К.Р., Постолаке Г.Г., 2000, Уязвимость, устойчивость и адаптация к изменению климата природных экосистем Республики Молдова. В: Глобальные и региональные изменения климата и их природные и социально-экономические последствия. Москва. ГЕОС. стр.148-156;
9. Капчеля А.М., 1990, История формирования оползнеопасных территорий. В: Оползнеопасные территории Молдавии и их рациональное использование. Кишинев, «Штиинца», стр.43-50;
10. Коробов Р.М., Николенко А., 2004, Новые проекции антропогенного изменения климата Молдовы в XXI столетии. В: Климат Молдовы в XXI веке: проекции изменений, воздействий, откликов. Кишинэу, стр.54-97;
11. Medyanic S., Mihailescu C., 1992, The Paleogeographical Stages of Moldova's Flora Development. Chishinau, pp.35-74;
12. Postolache Gh., 1995, Vegetaţia Republicii Moldova. Chisinău, Ştiinţa. pp.82-140;
13. Raportul III Naţional privind implementarea Convenţiei Naţiunilor Unite pentru Combaterea Deşertificării în Republica Moldova, 2007, (The 3rd National Report on the Implementation of the United Nations Convention to Combat Desertification in Republic of Moldova) /coord.: Ilie Boian et al., Ch.: (F.E.P. "Tipografia Centrală"), 88 p., ISBN 978-9975-923-72-9;

14. Sandu M., Tarita A., Lozan R., Gladchi V., Duca Gh., Turcan S., Mosanu E., Prepelita Af., 2013, The water springs - sources for water supply and irrigation in the Nistru river basin. In: Chemistry Journal of Moldova. No 2(8), Chisinau, pp.42-50, ISSN 1857-1727;
15. Sandu M., Tarita A., Lozan R., Zgircu N., Mosanu E., Goreacioc T., Zlotea Al., Comarnitchi A., Sidoren I., Turcan S., Tarita A., 2016, Ecological potential of surface waters in natural scientific reserve "Lower Prut". In: Chemistry Journal of Moldova. General, Industrial and Ecological Chemistry, Chisinau, 11(1), pp.21-26;
16. Stancu V., 2000, Studiu privind impactul schimbărilor climatice asupra răspândirii ascaridozei. Schimbarea climei: cercetări, studii, soluţii (culegere de lucrări). Chişinău, pp.108-110;
17. Tărîţă A., Lozan R., Sandu M., Stegărescu V., Cozari T., 2013, Evoluţia calităţii factorilor de mediu in ariile naturale protejate de stat (monumente naturale hidrologice). In: Buletinul Academiei de Ştiinţe a Moldovei. Ştiinţele vieţii. Numărul 1(319), Chișinău, pp.21-32, ISSN 1857-064X;
18. Тюрин И.В., 1965, Органическое вещество почвы и его роль в плодородии. М.: «Наука», стр.41-42;
19. Ursu A., 2000, Degradarea solurilor și deșertificarea. Chișinău, pp.11-14;
20. Ursu A., 2011, Solurile Moldovei. Chișinău, 323 p.;
21. World Bank, 2017, Rural Productivity in Moldova – Managing Natural Vulnerability;
22. World Bank et al., 2003, Poverty and Climate Change: Reducing the Vulnerability of the Poor through Adaptation;
23. Лалыкин Н.В., Сыродоев, И.Г., 2004, Некоторые подходы к оценке воздействий изменения и изменчивости климата на водные ресурсы. В: Климат в Молдове в XXI веке: проекции изменений, воздействий, откликов. Кишинэу, стр.176-212;
24. http://www.meteo.md
25. http://www.rural.md

Received: November 27, 2019
Revised: April 08, 2020
Accepted and published online: May 31, 2020

Natural Resources and Sustainable Development
Volume 10, Issue 1, 2020
DOI: 10.31924/nrsd.v10i1.046

A NOTE ON EXTENDING DOMAIN FOR CHARACTERISTIC NUMBER IN THE CASE OF WIND TURBINES

Dubău Călin*, Cătaș Adriana#**

*University of Oradea, Faculty of Environmental Protection, 26 Gen. Magheru St., 410048, Oradea, Romania
**University of Oradea, Department of Mathematics and Computer Science, 1 University St., 410087, Oradea, Romania, e-mail: acatas@gmail.com

Abstract

Within the aeroelectric units, wind turbines represent the component that ensures the conversion of the kinetic energy of the wind, into mechanical energy that can be used in the turbine shaft. This is achieved by the interaction between the airflow and the rotor pallet. Within the parameters involved in the performance of the wind machine, an important role is played by a specific form of the characteristic function, namely the speed or rapidity. The paper aims to investigate the extension of the range of this characteristic number in order to increase turbine performance. It starts from a certain approximation for the desired curve and determines an extended domain for the characteristic number, using a mathematical model. The mathematical model is constructed based on characteristic curve and it is proposed for output power of the wind turbine. The present study highlights the importance of knowing certain parameters variation of wine turbine.

Key words: characteristic number, operating curves, wind turbines

INTRODUCTION

The reduction of the traditional sources of energy (coal, oil, natural gas, etc.) as well as their increase cost is the classic motivation for the development of renewable sources, alongside environmental protection by reducing the emission of greenhouse gases, which now becomes an equally important motivation. The technical objectives pursued consist in maximizing the energy utilized and minimizing the costs through adequate technical solutions, high reliability and good maintenance (Gyulai, Bej, 2000; Gyulai et al., 2000).

The technical solutions with reduced complexity have proved to be competitive on the modern markets. In the last years a major interest in renewable energy resources has been observed. Many researchers have had to deal with optimizations process in wind turbine field (Giguere, Selig, 2000; Jureczko et al., 2005; Costea et al., 2011). We also recall the papers: Benini, Toffolo, 2002; Xudong et al., 2009; Dubău, Cătaș, 2013.

For example, the types of hydraulic turbines are ordered based on the kinematic similarity criteria, through several forms of the characteristic functions, namely the characteristic angular velocity (dimensionless), the characteristic speed and the specific speed. However, in the case of wind turbines, a more simple specific form of characteristic function is used. This

Corresponding author

is defined as the ratio of the peripheral velocity of the blade tip to the wind speed: $\lambda = \frac{u_R}{v}$, where u_R is the peripheral velocity of the blade tip: $u_R = \omega R$ and v is the wind speed. With it, the aerodynamic characteristics of the wind turbines can be ordered. This characteristic number is often called speed or „rapidity". The rapidity of the wind turbines is far superior to the fastest hydraulic turbines. It is therefore very important to study these areas of the characteristic number.

Wind turbine is composed mainly of a rotator fixed on a support shaft, comprising a hub and a moving blade consisting of one or more blades. Active body of aeolian turbines, which made the quantity of converted energy is the blade (Bej, 2003). The achieving of aerodynamic performances, kinematics and energy curves of the aeolian turbines depend on the choice of certain geometry. In developing of turbine blade geometry are used improved contours (airfoil) chosen and positioned so that obtained performances for certain site-specific conditions, to be optimal. The moment of interaction between pallets assembly and fluid flow comes from the lifted aerodynamic forces and resistance produced by the outline profiles. Achieving of acceptable aerodynamic efficiency requires the use of aerodynamic performance (Gyulai, 2000 b).

MATERIAL AND METHOD

The efficiency and the performance of the wind turbine can be investigated through mathematical models and also verified by experimental measurements.

There are various types of wind turbines. Between various types of wind turbines the rapid axial horizontal wind turbines (Dubău, 2007) are the most development ones. Many studies are also elaborated taking in consideration the turbines with vertical axes (Gyulai et al., 2000; Gyulai, 2000 a). Such a study was presented by the second author in the paper (Dubău, 2009).

Energy performance representation that produces a wind turbine, as a whole operating area, is materialized by the characteristic curves that are operating in the optimization process. They are of two types namely: operating (exploitation) curves, respectively one dimensional curves of the type of turbine (Dubău, 2005).

The optimization of the blade geometry consists in the successive modification of the initial geometry in order to obtain characteristic curves close to those formulated as "desirability curves". The elaboration of the first geometry most of the time draws on information obtained by systematizing the previous experience accumulated in the field of wind

energy recovery and it is due to the ingenuity and experience of the designer.

The need to design such an initial geometry consists in reducing the number of iterative stages in the optimization process. In this sense it is useful to have a first geometry that comes closest to the final solution. Within the optimization process, the adjustments that are made on it are fine adjustments and not background adjustments.

In order to find the dimensions of the turbine we have to write the expression of the power written in the installation point

$$P_I \cong C_{P_I} \cdot \rho \cdot \frac{v_I^3}{2} \cdot \frac{\pi D^2}{4}; \qquad [1.]$$

from which we establish the form of the diameter

$$D \cong \sqrt{\frac{8 \cdot P_I}{C_{P_I} \cdot \rho \cdot v_I^3 \cdot \pi}}; \qquad [2.]$$

The above relation is approximated being neglected the diameter of the turbine hub.

For the speed of the turbine (RPM) the computation relation is:

$$n = \frac{30}{\pi} \cdot \omega = \frac{60}{\pi} \cdot \frac{u_R}{D}; \qquad [3.]$$

From the mechanical resistance conditions, the peripheral velocity of the blade tip is limited to the value of 80 m/s. Researches withinsome Danish companies regarding the secondary phenomena at the end of the pallet depending on the speed and its shape, recommends limiting the value for the tangential speed at the end of the pallet below 60 m, due to noise considerations.

The evaluation of the speed v_T is established by the below relations:

$$v_{T_a} \cong \frac{v_N + v_{3_a}}{2} = v_N \left(\frac{1 + k_{v_{3a}}}{2} \right); v_{T_a} \cong k_{v_T} \cdot v_N; k_{v_{3a}} = \frac{v_{3a}}{v_N}; \qquad [4.]$$

where: v_{3a} is the axial component of current speed in the output section of the rotor. The coefficient $k_{v_{3a}}$ is estimated around the value 0.9 such that

$$k_{v_T} \cong 0.95, \quad v_{T_a} \cong 0.95 \cdot v_N .$$

This value is accepted as a constant for the entire palette $v_{T_a} = f(r) = ct.$

RESULTS AND DISCUSSION

In order to establish the “desirability curve”, as case study, we have analyzed some reference curves of several tested wind turbines and also confirmed as performing ones. These wind turbines were designed by leading companies in the field. The analyzed exploitation curve are measurement curve, all these previous specified turbines are currently in use

in air power plants, which are located in various places in the world. For an accurate comparison of their performance, the curves should be transposed into dimensionless forms $C_{P_{el}} = f(\lambda)$ through the following relation, using the power of the turbine (P_{el}):

$$C_P = \frac{P_{el}}{\rho \cdot \frac{v^3}{2} \cdot S} = \frac{P_{el}}{\frac{\pi}{8} \cdot \rho \cdot v^3 \cdot \pi \cdot D^2 \left[1 - \left(\frac{d}{D}\right)^2\right]}, \qquad [5.]$$

where we have used the following notations:

S - the area swept by the turbine,
D - the diameter of the turbine,
P - power turbine, ρ mass density of air(kg/m^3),
v - wind speed (m/s),
d - hub diameter,
u_R - peripheral speed at the top of the pallet,
C_p - power coefficient.

The characteristic number, namely rapidity of the turbine, is defined by the relation $\lambda = u_R / R$, where n is the speed turbine (RPM). The characteristic number associated to the turbine optimal point is denoted by λ_0 and it is called the turbine rapidity. This number characterizes the type of turbine and it represents, together with the position axis turbines, the main criteria for the characterization of the turbines. The usual field of wind turbines is $\lambda_0 = 1 \div 12$ and the turbines corresponding to the interval $\lambda_0 = 1 \div 4$ are considered "slow" in the rest of the field the turbines are considered "fast". We accepted for computation a value of 1,23 kg/m^3 mass density of air.

It will be convenient to recall here some relations in order to find the appropriate operating (exploitation) curves. With λ the current value of the rapidity we can write

$$C_{PWT} = C_{M_0} \cdot \lambda + a \cdot \lambda^{\alpha} - b \cdot \lambda^{\beta} \qquad [6.]$$

The study of this curve, using experimental results from literature, implies the evaluation of dependence of the constants on type of turbine.

$$\begin{aligned} a &= f(\lambda_0); b = f(\lambda_0); \\ \alpha &= f(\lambda_0); \beta = f(\lambda_0). \end{aligned} \qquad [7.]$$

We will use different values of the rapidity, for the constants computation, which depends on the type turbine.

Starting from an exploitation curve of third approximation $P_{ts}^3 = f(v)$, obtained with a mathematical simulation on the computer as in Cătas et al., 2018, we will establish an extension domain of characteristic number. The used data are posted below (Table 1).

Table 1

"Desirability" exploitation curve of order three

v	P^3_{arb}	λ	C^3_{Parb}	v	P^3_{arb}	λ	C^3_{Parb}
6	55.7	9.2	0.618	16	325.1	3.4	0.190
8	148.9	6.9	0.697	18	325	3.05	0.133
10	253.3	5.5	0.607	20	322	2.7	0.096
11	305	5.0	0.549	22	320	2.5	0.072
12	325.5	4.6	0.451	23	316	2.4	0.062
14	325.3	3.9	0.284	24	308	2.3	0.053

Starting from the relation $C_P = P_{el} / \left\{ \frac{\pi}{8} \cdot \rho \cdot v^3 \cdot \pi \cdot D^2 \left[1 - \left(\frac{d}{D} \right)^2 \right] \right\}$ and considering all the data presented above, in dimensionless plan, the "desirability exploitation curve" has the plotted allure (Fig. 1).

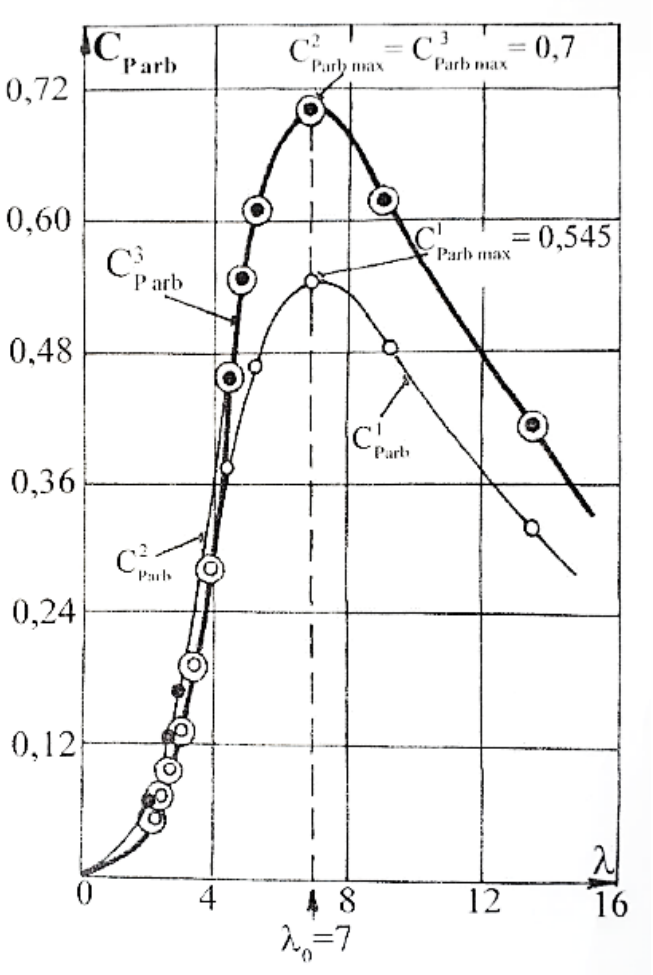

Fig. 1. Dimensionless curve of third order

For this analysis: D = 30 m, n = 35 rot / min, $C_{Fab.max}$ = 0.7, v = 8.2 m/s.

This curve can be theoretically ensured by a turbine having the diameter D = 30 m with the rapidity $\lambda_0 = 7$. The geometry of the pallets realizes the energy transfer both through the kinetic and the static component in a proportion expressed by the value of the degree of reaction $\overline{R} = 0.76$.

The determination of this geometry takes place in several successive stages of optimization starting from an initial geometry (first geometry or „compromise" geometry). In the analyzed concrete case, the conditions for the installation point and the optimal operating point at which the first geometry is calculated are:

– at the installation point:

$$P_i = 325.5kW,\ v_i = 12m/s,\ C_P^i = 0.451; \quad [8.]$$

– at the optimal operating point:

$$P_o = 157.5kW,\ v_o = 8.14m/s,\ C_P^o = C_{P_{\max}} = 0.7; \quad [9.]$$

The present study refers to a curve having the characteristic number (rapidity) $\lambda_0 = 7$. In order to extend the domain of the characteristic number the authors propose a curve that has λ/λ_0 as abscissa and $C_P/C_{P_{\max}}$ as ordinate axis. The curve thus determinate has the numerical coordinates given in the next table (Table 2).

Table 2

Third approximation for "desirability exploitation curve"

λ/λ_0	$C_P/C_{P_{\max}}$	λ/λ_0	$C_P/C_{P_{\max}}$
1.31	0.883	0.486	0.271
0.986	0.996	0.536	0.190
0.786	0.867	0.385	0.137
0.714	0.784	0.357	0.103
0.657	0.644	0.343	0.088
0.557	0.406	0.328	0.076

We have drawn below the allure of this curve (Fig. 2).

From this curve can be customized orientated curves for certain values of λ_0 and $C_{P_{\max}}$. The curve has to be adjusted by supplementary control of the exploitation curve.

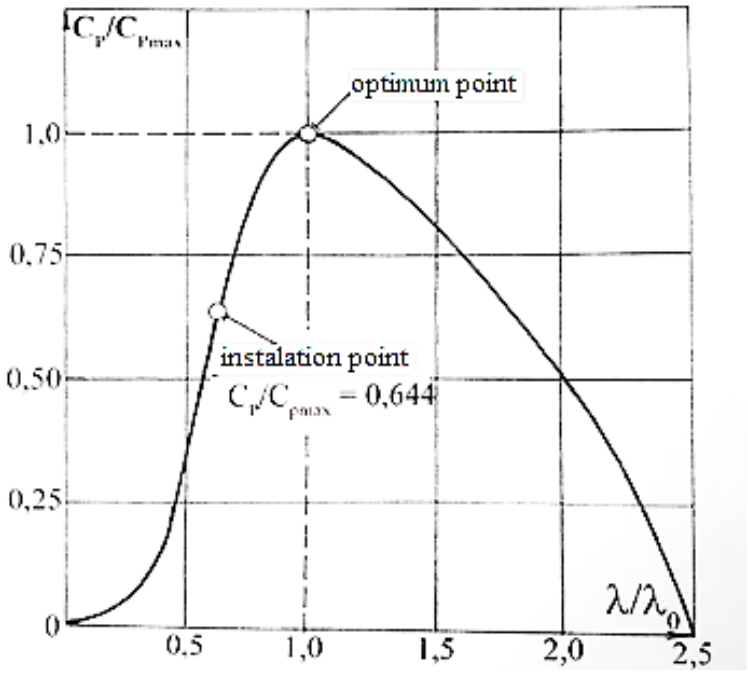

Fig. 2. Exploitation curve in extended domain

CONCLUSIONS

Obtaining the optimal wind blade geometry can improve the overall turbine performance. As we can saw in the paper it is much more advantageous to work with the (λ/λ_0 , $C_P/C_{P_{max}}$) coordinates.

In order to obtain optimization of the aeolian turbines with horizontal axis, by following a certain algorithm, we succeed to obtain those aerodynamic outlines which determine a certain desire functional feature for various applications.

Finding the final approximation of the exploitation curves follows the maximization of the extracted energy for exploitation.

REFERENCES

1. Bej A., 2003, Wind Turbines. Timişoara Polytechnic Press, ISBN 973-625-098-9, Romania;
2. Benini E., Toffolo A., 2002, Optimal design of horizontal axis wind turbines using blade element theory and evolutionary computation. Journal of Solar Energy Engineering: Transactions of the Asme 124(4): pp.357-363;
3. Cătaş A., Dubău C., Borşa E., 2018, Optimization method of wind turbine blades geometry. 17th International Technical-Scientific Conference on Modern Technologies for the 3rd Millennium, Location: Oradea, ROMANIA, MARCH 22-23, Published: 2018, ISBN 978-88-87729-49-8, pp.139-142;

4. Costea M., Vladu E., Tar K., 2011, Wind turbine modeling in MATLAB SIMULINK. Natural Resources and Sustainable Development, vol.1, pp.113-120;
5. Dubău C., 2005, Modern methods regarding the determination of the functioning characteristic curve for a pipe-line network. Analele Universității din Oradea, Fascicula Construcții și Instalații Hidroedilitare, ISSN 1454-4067, vol.VIII;
6. Dubău C., 2007, The Utilization of Micro-Wind Assemblies within Complex Systems. Timişoara Polytechnic Press, ISBN 978-973-625-408-6, Timişoara (In romanian, Ph. D. thesis);
7. Dubău C., 2009, Comparative study regarding the energy of turbines with vertical and horizontal axis. Annals of DAAAM International Vienna & Proceedings, ISSN: 1726-9679, January 1, pp.1819;
8. Dubău C., Cătaș A., 2013, Analytical approximations in modeling of power wind turbines. Natural Resources and Sustainable Development, vol.3, pp.335-340;
9. Giguere P., Selig M.S., 2000, Blade geometry optimization for the design of wind turbine rotors. Proceedings of AIAA/ASME Wind Energy Symposium, Reno, NV;
10. Gyulai F., 2000 (a), Contributions on horizontal axis wind turbine theory. Proceedings of the 5th International Conference on Hydraulic Machinery and Hydrodynamic, Oct. 2000, Timişoara, Romania;
11. Gyulai F., 2000 (b), Vocational Training in Sustainable Energy – Course Wind Systems;
12. Gyulai F., Bej A., 2000, State of Wind Turbines in the End of 20th Century and Proposals for Romanian Options. Buletinul Ştiinţific al Universităţii „Politehnica„ Timişoara, Romania, Tom 45(59), ISSN 1224-6077;
13. Gyulai F., Bej A., Hentea T., 2000, Contribution to aerodynamic optimization of horizontal axis wind turbines for mountain sites. ENERGEX'2000, Proceedings of the 8th International Energy Forum and the Conference of the International Energy Foundation, Las Vegas, USA;
14. Jureczko M., Pawlak M., Mezyk A., 2005, Optimization of wind turbine blades. Journal of Materials Processing Technology, 167(2–3): pp.463-471;
15. Xudong W., Shen W.Z., Zhu W.J., Sorensen J.N., Jin C., 2009, Shape optimization of wind turbine blades. Wind energy, 12, pp.781-803, DOI: 10.1002/we.335.

Received: November 09, 2019
Revised: April 27, 2020
Accepted and published online: May 31, 2020

Natural Resources and Sustainable Development
Volume 10, Issue 1, 2020
DOI: 10.31924/nrsd.v10i1.047

CAN WE IDENTIFY MANNA ASH (*FRAXINUS ORNUS L.)* "SMART FORESTS" IN BANATULUI MOUNTAINS?

Dincă Lucian*#, Vechiu Emilia*, Oneț Aurelia**

*"Marin Dracea" National Institute for Research and Development in Forestry, 13 Cloșca St., Brasov, Romania, e-mail: dinka.lucian@gmail.com
**University of Oradea, Faculty of Environmental Protection,, 26 Gen. Magheru St., 410048, Oradea, Romania

Abstract

Smart forests can be identified based on forest management plans if 15 stand, landscape or stational characteristics are taken into account. A total number of 34 smart stands were identified after these characteristics were graded based on the studied area and the manna ash's ecological requests. These stands are located in Dognecei, Aninei and Locvei Mountains, at altitudes between 225 m and 780 m, on South expositions and on fields with inclinations between 7° and 50°. These forests have relatively young ages (specific to manna ash) even though the presence of forests with extremely old ages was also identified. They belong to some stands located in strict conservation areas such as national parks (very well represented in Banatului Mountains) or in production areas. The characteristic soils are eutric cambisol or rendzic leptosol, while hill common beech stands are located on skeletal or chalky soils. Knowing the characteristics of smart manna ash forests is useful for conserving and promoting them.

Key words: manna ash, smart forests, altitude, exposition, Banatului Mountains

INTRODUCTION

Manna ash (*Fraxinus ornus L.)* is a shrub or tree of average dimensions (12-14 m in height) that is spread out in South-West Europe, including Mediterranean and sub-Mediterranean areas. In our country, the north limit is represented by Apuseni Mountains and is present especially in hill areas from sunny and warm stations. In Banatului area, the species can be found along the Danube and another place is the Olt's ravine (Șofletea, Curtu, 2007). It is a species that prefers chalky soils, resistant to drought and requiring annual average precipitations between 500-650 mm/year. As it supports drought, manna ash is used as soil fixing species in areas affected by landslides, fires or forest exploitations. Manna ash is found in mixt forests together with *Quercus pubescens, Q. cerris, Q. frainetto, Castanea sativa, Carpinus* spp., etc. (Ibrahim et al., 2017; Caudullo, de Rigo, 2016; Paoletti et al., 2009).

Different concepts were developed over time intending to evaluate or offer guidance for the management of adapting to and diminishing climatic changes. "Climate-Smart Forestry – CSF" is a new concept that contains certain measures that can be used for the attenuation of climatic changes. This concept's main objectives are: reducing gas emissions with hothouse

Corresponding author

effects, the long-lasting increase of stand productivity and adjusting the vulnerability of stands towards climatic changes (Nabuurs et al., 2017; Yousefpour et al., 2018).

Banat region is situated in South-West Romania and has a diverse relief due to its position. This region has a temperate continental climate with oceanic and Mediterranean influences (Dunca, Bădăluță-Minda, 2017).

In Banatului Mountain, the average annual temperature is situated between 6-12 °C, while precipitations vary between 600-1100 mm/year based on the relief form (Hoancea et al., 2018).

The present paper identifies the criteria that can underlie the framing of a forest species (manna ash) from a certain area (Banatului Mountains) in the category of smart forests, followed by the stands' characterization.

MATERIAL AND METHOD

Only stands older than 40 years were taken into account as a clear demarcation of their characteristics is present only after this age. All manna ash stand elements were centralized and analysed (1371 elements) from forestry management plans dating from 1993-2007 and covering 13 forest districts. The very large number of data ensures a good statistical representation.

Stand elements were grouped on 15 categories: site (altitude, litter, flora, soil type, station type), stand (pruning, consistency, structure, average diameter, average height, volume, current growth, production class) or landscape (production/protection subunit and group and functional category).

Each analysed parameter was graded from 1 to 5, namely: 1 = very low; 2 = low; 3 = average; 4 = high; 5 = very high (tab 1). A total grade was obtained for each sub parcel that contains manna ash by adding all these values. The parcels with a certain maximum score were considered as representing smart manna ash forests.

The meaning of terms from Table 1 (excerpt):

Litter: 1 = litter missing; 2 = narrow discontinued litter; 3 = narrow continuous litter; 4 = normal continuous litter; 5 = dense continuous litter.

Flora: Norway spruce stands: 31 = *Asperula-Dentaria*; 41 = *Asperula-Asarum*; 44 = *Festuca altissima*; 46 = *Vaccinium-Luzula*; 61 = *Asarum-Stellaria*; 63 = *Carex pilosa*; 66 = *Festuca heterophylla*; 68 = *Luzula albida*; 91 = *Carex-Poa pratensis*; 93 = *Festuca pseudovina*;

Soil type (Florea, Munteanu, 2003): 201 = peat soil; 1404 = argic paheozem; 1701 = rendzic leptosol; 1703 = litic rendzic leptosol; 2401 = luvisol; 2405 = litic luvisol; 2506 = albic litic luvisol; 3101 = eutric cambisol; 3104 = calcic eutric cambisol; 3107 = litic eutric cambisol; 9101 = litosol.

Station types (TS): 4120 = Mountain-pre-mountain Bi common beech stand, rockland and excessive erosion; 4210 = Mountain-pre-mountain Bi common beech stand, low edaphic rendzinic; 5112 = Hill Bi holm stand, rockland and excessive erosion; 5131 = Hill Bi holm stand, low edaphic preluvisol and luvisol with *Vaccinium Calluna*; 5132 = Hill Bm holm stand, preluvisol and luvisol with mezophit graminaea flora; 5133 = Hill Bm holm stand, average edaphic preluvisol with mezoxerophite gramineae +- *Luzula*;

Table 1

Grades obtained by each stand characteristic

Nr crt	**Characteristic**	**Grade**				
		1	**2**	**3**	**4**	**5**
1	Altitude (m)	801-1100	90-300	301-400	551-800	401-550
2	Litter	1	2	3	4	5
3	Flora	46	62; 68	44; 66; 91 ; 93	31; 61	41
4	Soil type	201; 2506; 9101	1703; 2405; 3107	1404; 2401	1701; 3104	3101
5	Station type	4120; 5112 ; 6112	4210; 5131; 5231; 6121	5121; 5241; 6131	5132; 5242; 6132	5133
6	Pruning	0.1	0.2-0.3	0.4; 0.7	0.5	0.6
7	Consistency	0.2-0.3	0.4-0.5; 0.9	0.6	0.7	0.8
8	Structure	1	2	3		
9	Average diameter (cm)*	4-8	10-12	14	16	18-42
10	Average high (m)*	3-7	8	9-10	11-12	13-27
11	Volume (m^3)*	1-7	8-11	12-16	17-27	28-127
12	Current growth (m^3/an/ha)*	0	0.1	0.2	0.3	0.4-1.0
13	Production class	5	4	3	2	1
14	SUP	C	A		M	E
15	Functional group + functional category	1,2A	1,2B; 1,2L	1,1C; 2,1B	1, 4B; 1, 5L	1,5A; 1,5C

*For these characteristics, the entire value series was divided in 5 categories each one graded accordingly, 1 = the lowest (ex: average height of 3-7 m), 5 = the highest (ex: current growth of 0.4-10 m3/year/ha). The category division was realized so that the analyzed biometric characteristics were also taken into account as well as for ensuring a balanced division as value number for each category.

5231 = Hill Bi common beech stand, low edaphic luvisol with *Vaccinium-Luzula*; 5241 = Hill Bi common beech stand, low edaphic eutric cambisol; 5242 = Hill Bm common beech stand, average edaphic eutric cambisol with *Asperula-Asarum*; 6112 = Hill oak, rockland and excessive erosion; 6121 = Hill Bi oak low edaphic rendzinic; 6131 = Hill Bi oak low edaphic preluvisol with mezoxerophite acidophil; 6132 = Hill Bm oak average edaphic preluvisol with mezoxerophite gramineae.

Structure: 1 = even-aged stand; 2 = relatively even-aged stand; 3 = relatively uneven-aged stand; 4 = uneven-aged stand.

Production/protection subunits (SUP) (excerpt): A = regular forest, common assortment: wood for timber, construction, celluloses; C = Conversion; E = Reservations for the integral natural protection; M = Forests under special conservation regime.

Functional group (GF) and functional category (FCT) (excerpt): 1,1C = forests from river slopes located in the mountain and hill areas that supply present or future accumulation lakes, situated at distances of 15-30 km upstream from the accumulation limit, based on the lake's volume and surface, alluvial transport and basin torrentiality; 1,2A = forests located on rocks, debris and fields with depth erosion, on fields with an inclination higher than 35°, and higher than 30° for those situated on flysch, sand or gravel substratum; 1,2B = forests consisting of entire parcels, near public roads of high interest of normal railroads, in areas with rugged relief (fields with slopes higher than 35° and endangered by landslides); 1,2L = forests located on fields with very vulnerable lithological substratum towards erosion and landslides; 1,5A = national parks ; 1,5C = natural reservations; 1,5L = forests from reservation protection areas (buffer areas); 2,1B = forests destined to produce mainly bulk trees of superior quality for timber.

RESULTS AND DISCUSSION

The cumulated grade of all factors from Table 1 is gathered between 23 and 60. We consider smart forests as those that fulfil a minimum grade of 54 points, namely 34 stand elements (2 % of the total manna ash stand elements).

From a geographic repartition point of view (Fig. 1 and Table 2), most manna ash smart forest is situated in Reșița, Sasca Montană, Bocșa Montană and Oravița Forest Districts.

Smart manna ash stands from Banatului Mountains are present at altitudes between 225 m (Bocșa Montană) and 780 m (Reșița), having a relative uniform distribution between these altitudes (Fig. 2). Unlike the forests from the Southern Carpathians (Dincă et al., 2019), the minimum altitudes from this area are much lower.

Field slope ranges between 7° and 50°, with many stands located on fields with a very high slope (Fig. 3). From this point of view, smart manna ash stands from Banatului Mountains are distinguishable from the alder ones from Southern Carpathians that are situated especially of plain fields or with a reduced slope (Blaga et al., 2019).

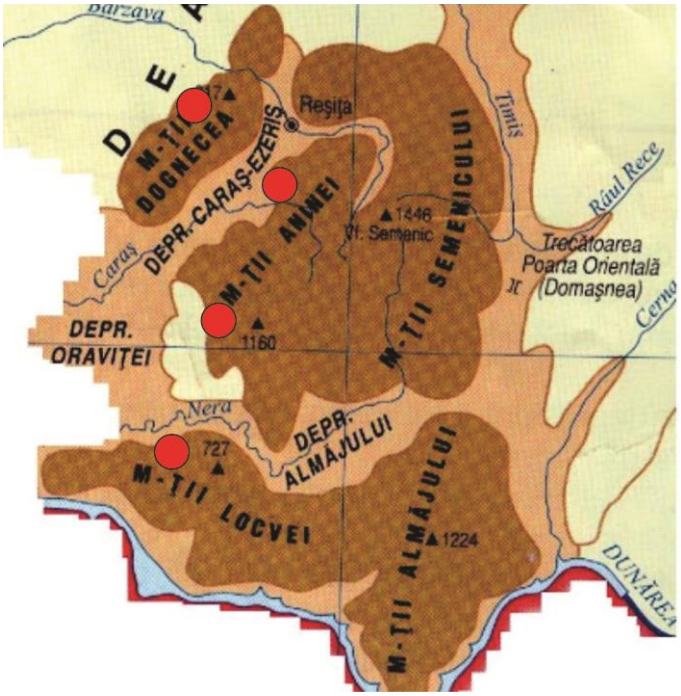

Fig. 1. Distribution of main smart manna ash forests from Banatului Mountains (initial map from http://geografiebranesti.blogspot.com)

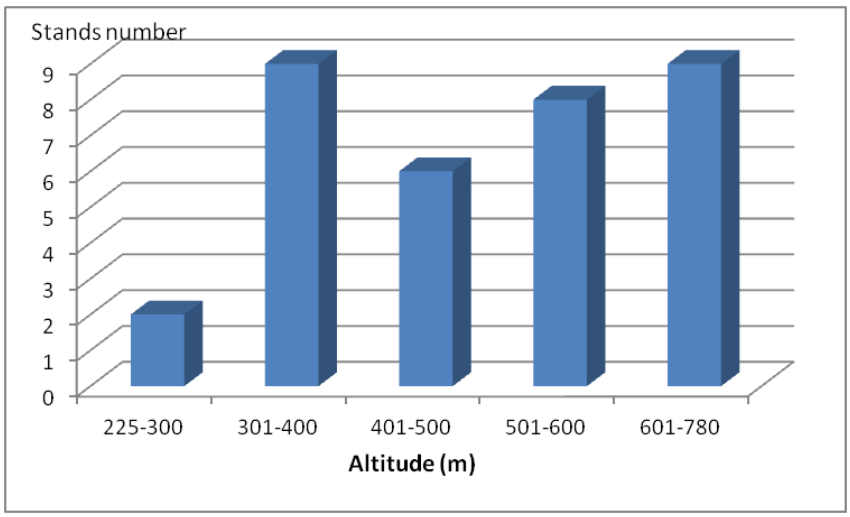

Fig. 2. Distribution of smart manna ash forests from Banatului Mountains on altitudes

Table 2

The characteristics of smart manna ash stands from Banatului Mountains

Nr crt	**Forest District**	**Age (years)**	**Forest type**	**Exposition**	**Inclination (%)**	**Altitude** (m)
1	Bocșa Română	60	5322	SE	20	340
2	Băile Herculane	105	4212	N	33	595
3	Băile Herculane	60	4331	N	37	455
4	Bocșa Română	60	5131	E	15	360
5	Moldova Nouă	75	4212	S	36	650
6	Bocșa Montană	80	5322	SE	25	340
7	Sasca Montană	65	4213	SE	30	530
8	Oravița	100	4213	NV	40	485
9	Sasca Montană	95	4213	S	36	550
10	Reșița	40	4214	SV	17	635
11	Bocșa Montană	55	7311	E	20	340
12	Bocșa Montană	50	7311	SV	12	350
13	Sasca Montană	90	4212	NE	40	515
14	Anina	70	2321	V	45	615
15	Oravița	90	4213	N	16	340
16	Moldova Nouă	95	4213	S	38	410
17	Bocșa Montană	50	5131	V	15	300
18	Reșița	75	4213	SE	25	540
19	Reșița	80	4212	SE	25	520
20	Reșița	110	4114	V	15	710
21	Bocșa Română	45	7411	NV	25	365
22	Oravița	55	5321	SV	7	330
23	Sasca Montană	90	4213	SE	50	455
24	Sasca Montană	90	4213	N	50	465
25	Anina	70	2324	SE	27	750
26	Sasca Montană	60	4331	NE	10	670
27	Anina	90	4213	E	24	505
28	Oravița	85	4331	SV	36	585
29	Bocșa Montană	60	5324	SV	32	225
30	Anina	50	2321	V	12	710
31	Reșița	50	4213	SV	19	685
32	Reșița	70	4213	S	40	455
33	Reșița	60	4181	E	20	780
34	Bocșa Română	45	7421	E	16	320

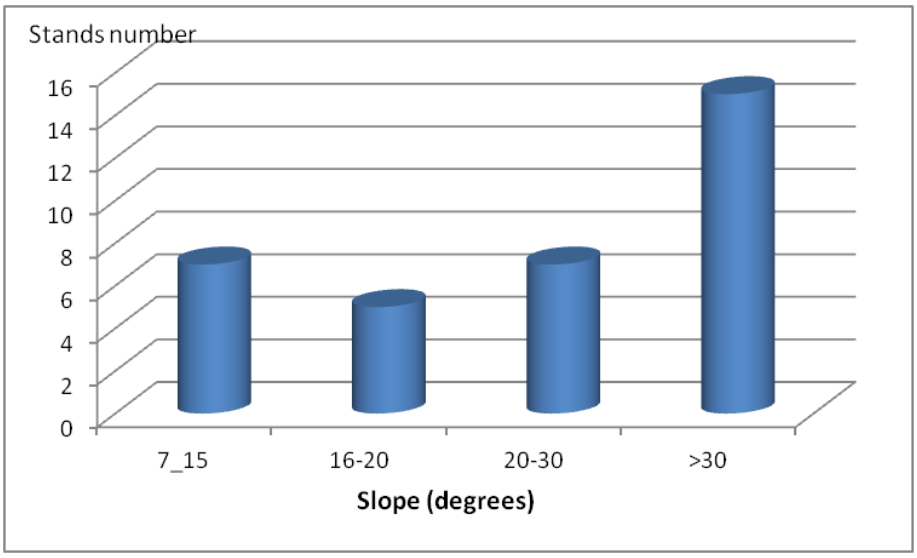

Fig. 3. Distribution of smart manna ash forests from Banatului Mountains on field slope categories

The Southeast and South-West expositions are characteristic for these stands (Fig. 4). Shady expositions are avoided by manna ash as the species is exigent towards heat (thermophile) and resistant to drought (mezoxerophit-mezophit).

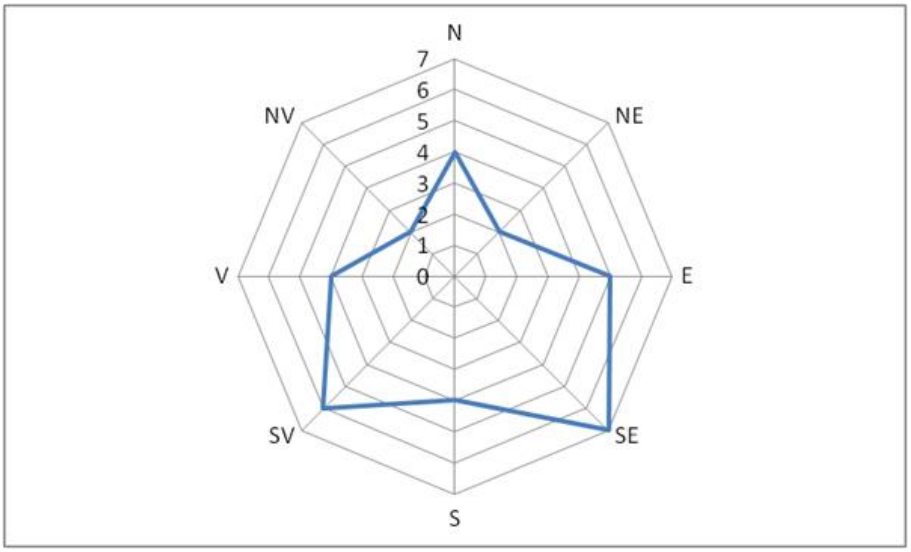

Fig. 4. Distribution of smart manna ash forests from Banatului Mountains on expositions

Smart manna ash forests from Banatului Mountains have ages between 40 years (Bocșa Română) and 110 years. The stand from this last age is located at Reșița and is an exception for this species (Fig. 5).

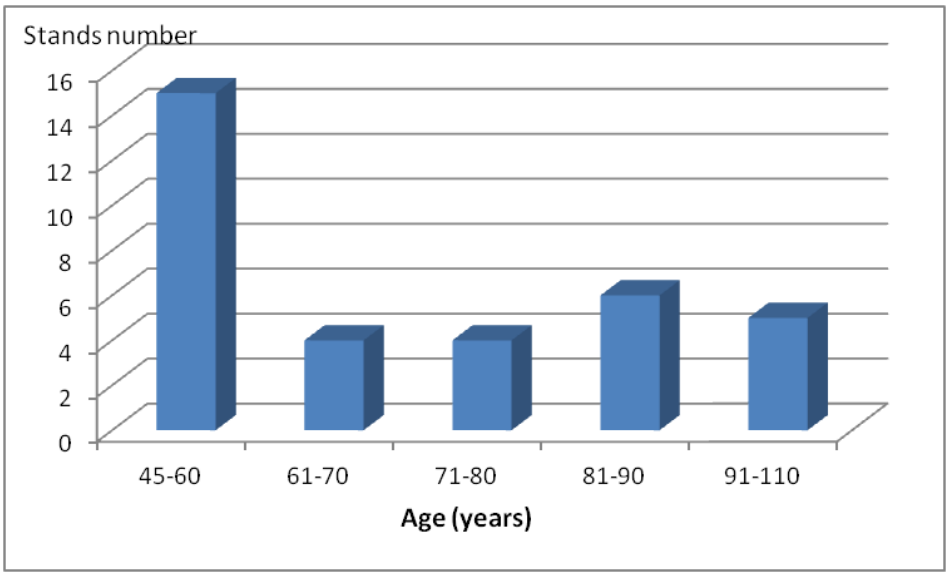

Fig. 5. Distribution of smart manna ash forests from Banatului Mountains on ages

These forests generally belong to the A production subunit – regular forest, common assortments and M subunit – forests under extreme conservation regime, with 1,5A – national parks and 2,1B – forests destined to produce bulk trees for timber.

The soil types characteristic for these stands are eutric cambisol or rendzic leptosol, soils that are rich in humus, nutritive elements or bacteria (Filipov, 2005; Crișan, Dincă, 2017; Oneț et al., 2019).

The characteristic forest types are: 4212= Hill common beech on skeletal soils with mull flora and 4213= Hill common beech on superficial soils with chalky substratum. The types are characteristic for the studied area and species (Chisăliță et al., 2015; Dincă et al., 2018; Oneț et al., 2019).

CONCLUSIONS

Manna ash forests from Banatului Mountains can be situated in the smart forest category if they fulfil a cumulated tally of 54 ° (for 15 stand, site or landscape characteristics).

These forests represent only 2 % of the total number of stands formed of this species for the studied area. They are situated in Dognecei, Aninei and Locvei Mountains, at altitudes between 225 m and 780 m, on slopes between 7° and 50°, and on south expositions.

The ages range between 40 and 110 years, they belong to the production or conservation subunits (national parks) and appear on eutric cambisol or rendzic leptosol soils in forest type characteristic to hill common beech stands.

REFERENCES

1. Blaga T., Dinca L., Plesca I.M., 2019, How can smart alder forests (Alnus glutinosa (L.) Gaertn.) from the Southern Carpathians be indentified and managed. Scientific papers series „Management, Economic Engineering in Agriculture and Rural Development", 19(4), pp.29-35;
2. Caudullo G., de Rigo D., 2016, Fraxinus ornus in Europe: distribution, habitat, usage and threats. European Atlas of Forest Tree Species. San-Miguel-Ayanz, J. et al., Eds. Publication Office of the European Union, Luxembourg;
3. Chisăliță I., Dincă L.C., Spârchez G., Crăciunescu A., Vișoiu D., 2015, The influence of some stagnoluvisols characteristics on the productivity of *Quercus cerris* and *Qurecus frainetto* stands from OS Făget, DS Timiș. Research Journal of Agricultural Science, 47 (3), pp.23-28;
4. Crișan V., Dincă L., 2017, The predominant forest soils from Timiș Forest Administration County. Journal of Horticulture, Forestry and Biotechnology, 21(3), pp.137-141;
5. Dinca L., Badea O., Guiman G., Braga C., Crisan V., Greavu V., Murariu G., Georgescu L., 2018, Monitoring of soil moisture in Long-Term Ecological Research (LTER) sites of Romanian Carpathians. Annals of Forest Research, 61(2), pp.171-188;
6. Dincă L., Murariu G., Iticescu C., Budeanu M., Murariu A., 2019, Norway spruce (*Picea Abies* (L.) Karst.) smart forests from Southern Carpathians. International Journal of Conservation Science, 10(4), pp.781-790;
7. Dunca A.M., Bădăluță-Minda C., 2017, The Complex Hydrotechnic Structure in Banat Hydrographical Area. Aerul si Apa - Componente ale Mediului, pp.151-158;
8. Filipov F., 2005, Pedologie. Iasi RO: Ion Ionescu de la Brad Publishing House;
9. Florea N., Munteanu I., 2003, Sistemul Român de Taxonomie a Solurilor (SRTS). Institutul de Cercetări pentru Pedologie și Agrochimie, Edit. Estfalia, București;
10. Hoancea L., Simon M., Rain P., Copăcean L., Cojocariu L., 2018, Influence of environmental factors on the beginning of grazing on grasslands from ATU Oravița, in correlation with pastoral traditions. Research Journal of Agricultural Science, 50(4), pp.391-398;
11. Ibrahim M., Sieber T.N., Schlegel M., 2017, Communities of fungal endophytes in leaves of Fraxinus ornus are highly diverse. Fungal ecology, 29, pp.10-19;
12. Nabuurs G.J., Delacote P., Ellison D., Hanewinkel M., Hetemäki L., Lindner M. 2017, By 2050 the mitigation effects of EU forests could nearly double through climate smart forestry. Forests, 8(12), pp.484;
13. Onet A., Dincă L.C., Grenni P., Laslo V., Teusdea A.C., Vasile D.L., Enescu R.E., Crisan V.E., 2019, Biological indicators for evaluating soil quality improvement in a soil degraded by erosion processes. Journal of Soils and Sediments, 19(5), pp.2393-2404;
14. Oneț A., Dincă L., Teușdea A., Crișan V., Bragă C., Enescu R., Oneț C., 2019, The influence of fires on the biological activity of forest soils in Vrancea, Romania. Environmental Engineering and Management Journal, 18(12), pp.2643-2654;
15. Paoletti E., Contran N., Bernasconi P., Günthardt-Goerg M.S., Vollenweider P., 2009, Structural and physiological responses to ozone in Manna ash ash (Fraxinus ornus L.) leaves of seedlings and mature trees under controlled and ambient conditions. Science of the Total Environment, 407(5), pp.1631-1643;

16. Şofletea N., Curtu L., 2007, Dendrologie. Brasov, RO: Universităţii" Transilvania" Publishing House;
17. Yousefpour R., Augustynczik A.L.D., Reyer C.P., Lasch-Born P., Suckow F., Hanewinkel M., 2018, Realizing mitigation efficiency of European commercial forests by climate smart forestry. Scientific reports, 8(1), pp.1-11;
18. ***, Amenajamentele silvice ale ocoalelor: Anina (2007), Băile Herculane (2001), Berzeasca (1995), Bocşa Română (2004), Bozovici (2004), Caranesbeş (1995), Dobra (1997), Hunedoara (1993), Mehadia (1993), Moldova Nouă (2006), Oraviţa (2008), Reşiţa (2001), Sasca Montană (2007);
19. http://roifn.ro/site/rezultate-ifn-2/;
20. http://geografiebranesti.blogspot.com

Received: March 25, 2020
Revised: May 07, 2020
Accepted and published online: May 31, 2020

Natural Resources and Sustainable Development

Volume 10, Issue 1, 2020
DOI: 10.31924/nrsd.v10i1.048

STUDY OF THE MINERALISATION OF PELLETIZED CHICKEN MANURE AT DIFFERENT SOIL MOISTURE CONTENT OF A SANDY SOIL

Nagy Péter Tamás*#, Karanja Mary*, Magyar Tamás*

*University of Debrecen, Faculty of Agricultural and Food Sciences and Environmental Management, Institute of Water and Environmental Management, Böszörményi St. 138, Debrecen, Hungary, e-mail: nagypt@agr.unideb.hu

Abstract

This study evaluates the effect of soil moisture content on mineralization process of composted and pelletized chicken manure on pH, nitrate and ammonium contents at a sandy soil. To establish the mineralisation rate of the composted chicken manure in the soil a short soil incubation method was used.

The objectives of the study were: (1) To assess the effects of three types of composted chicken manure on soil pH at different moisture contents conditions, (2) To assess the effects of the three types of composted poultry manure on soil easily soluble mineralised N forms (nitrate and ammonium) at different moisture contents. For study of mineralisation rate of composted and admixtured chicken manure pellet a short soil incubation experiment was set up. Beside the control three treatments, each containing 12 pots (three replicates for soil samples with four different moisture content; 40 %, 50 %, 60 % and 70 %) were used. The pH value and nitrate and ammonium contents and their changing were assessed after the first, second, third and fourth weeks respectively. In each of the four experiment blocks, the soil samples were subjected to four treatments: control, P+K, P+K "C", and Humin Plus.

Statistical analysis of the data showed that the three manure types had significant impact on the soil nitrate and ammonium levels at different soil moisture conditions. No significant effect on soil pH was identified during the experiment period. This implies that in order to achieve optimum benefits from application of chicken manure on the farm, it is necessary to do soil testing to assess the nitrate and ammonium status of the soil first. This can provide a basis to make a well-informed decision on which manure is the best in the supply of either nitrate and ammonium to the soil depending on the soil amendment needs.

Key words: mineralization of chicken manure, soil incubation, easily soluble N forms of soil, organic fertilization

INTRODUCTION

Mineralisation and so the nutrient supply of organic manures is a cardinal problem of farmers mainly at sandy soils where the sufficient mineralisation processes are often hindered (Tamás, Nagy, 2009). Moreover, the potential for N mineralization varies among different organic amendments. This implies that the type and dose of amendment and application timing should meet the crop's nutritional needs. Furthermore, soil properties, like temperature, moisture soil enzyme activity, soil microorganisms and organic matter content basically determine the mineralisation processes. Hydrological condition can significantly influence the decomposition, output and accumulation of organic matter and thus

Corresponding author

affect the cycling and availability of soil nutrients (Mitsch, Gosselink, 2007; Nagy et al., 2018).

To find a stable organic matter source to improve soil properties is essential for the future's growers. Over the last three decades there has been a great increase in the production of waste from urban, industrial and mainly agricultural activity that could be recycled as a source of plant nutrients, and used to enhance soil quality. The use of these materials could partially offset the need for mineral fertilizers, giving both economic and environmental benefits (Cordovil et al., 2005).

Intensification of cattle, swine, and poultry operations is projected to continue in both developed and developing countries, with annual increases in production through 2050 estimated at 0.5 % and 1.7 %, respectively (Alexandratos, Bruinsma, 2012). As such, the collection and spreading of manure will also increase in the future.

Hungary was responsible for about 3.5 % of the European Union's total poultry meat production in 2018, according to Eurostat, (the European Commission's official statistics directorate-general). And the EU produced a record 15.2 million tonnes of poultry meat in 2018. This represents a cumulative rise of about one quarter or 3.2 million tonnes since 2010, Eurostat says. Therefore, it is very important that how to use manures which are potentially dangerous for environment when used them without composting.

In order to achieve quick disposal of poultry manure and prevent the loss of nutrients from the manure and avoid pollution of the environment, poultry manure may be utilized in land applications as fertilizer. It is widely known that chicken manure is very high in nitrogen and also contains a good amount of potassium and phosphorus (Szabó et al., 2019). But, the chicken manure as waste from the poultry industry includes a mixture of excreta (manure, feces and urine), bedding material or litter (e.g. wood shavings or straw), waste feed, dead birds, broken egg sand feathers removed from poultry houses. Other wastes include those from cage, conveyer belt and water-flushing systems. Poultry manure is acquired through regular cleaning of the poultry house (Kobierski et al., 2017).

The litter and manure component of this waste has a high nutritional value and is used as an organic fertiliser, thus recycling nutrients such as nitrogen, phosphorous and potassium. These components (poultry litter) have traditionally been land spread on soil as an amendment. The mature compost can improve soil fertility and plant growth (Haga, 1999). However, immature compost applied to soil would cause N starvation (Bernal et al., 2009; Moral et al., 2009), phytotoxic effects, and presence of harmful microbes (Fang et al., 1999; Tiquia, Tam, 2000).

Measurement of mineralisation rate and circumstances of the biomass nitrogen is essential in understanding the fate of manure nitrogen following soil application. As investigated by Bhat et al., 2015, soils that receive organic manure and integrated nutrient management have high rates of nitrogen mineralization at optimum time periods and temperatures.

Moreover, when the rates of nitrogen mineralization of poultry litter are compared with that of conventional fertilizer, it can be deduced that upon application, poultry manure is a better alternative to the conventional fertilizer as suggested by Hirzel et al., 2010.

The high nitrogen and balanced nutrients is the reason that chicken manure compost is the best kind of manure to use. But the high nitrogen in the chicken manure is dangerous to plants if the manure has not been properly composted. Raw chicken manure fertilizer can burn, and even kill plants. Moreover, over-application of this material can lead to an enriching of water nutrients resulting in eutrophication of water bodies, the spread of pathogens, the production of phytotoxic substances, air pollution and emission of greenhouse gases (Fan et al., 2000; Kelleher et al., 2002). Bitzer and Sims, 1988 reported that excessive application of poultry litter in cropping systems can result in nitrate contamination of groundwater. Excessive application of fresh poultry manure on the farm may result to excess accumulation of ammonia hence may damage the crop roots (Köteles, Pereș, 2017; Tamás et al., 2017). In order to prevent excessive application of the manure and potentially causing ground water and surface water contamination, it is essential to prepare a worksheet to manage the nutrient budget for each crop of field.

Proper handling of the manure can be achieved through proper manure composting and appropriate practices of feed management (Bolan et al., 2010). Properly composted poultry manure results into effective nitrogen mineralization hence reducing nitrate leaching and the harmful environmental effects of excess ammonia. Nahm, 2005, recommends that poultry manure should be applied to soil at rates that are determined by the level of soil - available N and the amounts of nitrogen required by the crops. When the soil samples are incubated at optimum soil moisture (approximately 40 %) the soil sample nitrate level are expected to increase significantly due to optimum microbial activity in the soil that encourage nitrification to occur. However, if the soil samples are incubated at waterlogged conditions (60 – 70 %) it is expected that the ammonium levels will be significantly higher compared to nitrates due to anaerobic conditions that limit conversion of ammonium to nitrates. In waterlogged soil conditions, the soil bacteria are made to use nitrate as an energy source, hence facilitating for denitrification process where the NO_3^- is converted to

NO_2^- and ultimately into nitrogen gas (N_2) that escapes into the atmosphere (Marin et al., 2016).

MATERIAL AND METHOD

Soil samples were collected from the Pallag Experimental Station area of Institute of Horticultural Science of University of Debrecen in Hungary. After that soil was pretreatment: dried, sieved and removed the possible dirts. The dominant type of soil in Pallag area is sandy soil. The basic parameters of the Pallag soil were as follows (Table 1).

Table 1

Basic parameters of Pallag soil

Pallag soil basic soil parameters	**Value**
pH (KCl)	5.50
Plasticity index (KA)	35.00
Water soluble salts (m/m)%	0.02
Carbonate (m/m)%	< 0.10
Humus (org. C) (m/m)%	2.05
Phosphor pentoxide (mg/kg) (AL)	259.00
Potassium-oxide (mg/kg) (AL)	490.00
Nitrate (mg/kg) (KCl)	18.20
Sodium (mg/kg) (AL)	49.80
Magnesium (mg/kg) (KCl)	114.00
Sulphur (mg/kg) (KCl)	4.98
Manganese(mg/kg) (EDTA)	173.00
Zinc (mg/kg) (EDTA)	4.12
Copper (mg/kg) (EDTA)	3.40
Organic Nitrogen (m/m)%	0.11

Soil is a slightly acidic sandy soil with larger humus content. Water soluble salts and carbonate content are low. Nitrogen availability is medium but phosphorous and potassium content of the soil are high according to the regular significant P and K fertilization management. Micronutrient concentrations (Zn, Cu) are medium with significant Mn content in the upper soil layer.

Experimental design

500 g of the air dried soil was placed in each experiment pot where 400 g of the soil sample was first put into the pots, then four weighted pellets of composted chicken manure, as calculated from manufacturer's

recommendation, were put on the soil samples in the pots and then the pellets were covered with another 100 g of soil. All treatments containing 12 pots (3 replicates for soil samples with four different moisture contents; 40 %, 50 %, 60 % and 70 %) were used. The pH, nitrate and ammonium content were measured after the first, second, third and fourth weeks respectively.

Beside the control the applied treatments were: P+K, P+K "C", and Humin Plus. The contents of the applied products were as follows:

- P+K: 60 % composted chicken manure, 15 % meat powder, 15 % superphosphate and 10 % potassium-sulphate,
- P+K „C": 60 % composted chicken manure, 15 % meat powder, 15 % superphosphate, 10 % potassium-sulphate and 0.4 % zinc-sulphate,
- Humin Plus: 50 % composted chicken manure, 20 % meat powder, 20 superphosphate, 10 % dudarite (clay mineral) and 0,4 % zinc-sulphate.

During the experiment, the pots were divided into two main parts: the upper part was surrounding the pellets and the lower part was situated below the pellets. 10 g of soil from the upper part of the pots (surrounding the placement area of the manure) and 10 g of soil at the bottom of the pots were collected from each sample and labelled as "upper" and "lower" layer, respectively. A total of 24 sub-samples were made out of the replicates from each block. Soil extraction was done by adding 25 ml of 1M KCl to each sub-sample according to the Hungarian Standard (MSZ 20135, 1999). The contents were placed in a shaker, for one hour and then filtered. The filtrate was collected in test tubes to measure the experiment variables. The first variable to be measured was the soil pH using a pH meter (HANNA HI 2550). The nitrate and ammonium content were measured by photometrical methods used PF 12 spectrophotometer.

Statistical analysis

All the obtained data were tabulated and statistically analyzed using the L.S.D. test at 5 % level to recognize the significance of the differences between various treatment methods. The effects of the different treatments were assessed within ANOVA and Fisher's least significant differences were calculated following a significant ($P \leq 0.05$) F test.

RESULTS AND DISCUSSION

Effect of the applied manures on soil pH

The measured soil pH values of different treatments are not showed in this study but the results of statistical probes are showed in Table 2.

At 40 % soil moisture content, there were significant differences in the pH ($p < 0.05$) for the lower sub-samples of the experiment treatments. This was attributed to the activation of soil microorganisms in the samples as water was introduced to the soil at optimal levels for microbial physiological activities. In their study to identify the relationship between soil moisture content and the development and growth of microorganisms, Borowik and Wyszkowska, 2016, found out that the optimal soil moisture content for the development and activity of actinomycetes and Azotobacter was 40 % of the soil's maximum water capacity. Upon respiration during growth and development, the microorganisms in the soil samples released carbon dioxide (CO_2) that reacted with the water hence resulting to formation of weak carbonic acid that dissociated in the soil and released hydrogen and carbonate ions (Strawn, et al., 2019). The carbon dioxide released in the lower soil could not escape easily hence was retained in the soil and the acidic hydrogen ions (H^+) affected the pH of the lower soil. At 40 % moisture content, the lower sub-samples demonstrated significant variations in the pH values, a phenomenon that could be attributed to differences in the levels of microbial activities and release of CO_2 in the soil samples. In the upper soil, some of the carbon dioxide easily escaped into the atmosphere. This explains why there were no significant differences in the pH values ($p > 0.05$) for the upper sub-samples at this moisture content level.

Table 2

P-values obtained from ANOVA test of the pH data at different soil moisture levels

Moisture level		40 %	50 %	60 %	70 %
pH	Lower layer	0.014198	0.218566	0.34621	0.637979
p-values	Upper layer	0.307131	0.3769	0.431725	0.246183

At 50 %, 60 % and 70 % soil moisture contents, there were no significant statistical differences in the pH values of the soil as all p - values were greater than 0.05 in all lower and upper sub-samples. The original pH value of the Pallag soil was 5.50 (see Table 1) before amendment with poultry manure pellets. The pH of the manure pellets was 6.6. After amendment with the manure, the pH values recorded for all the samples ranged between 6.54 ± 0.173 and 6.79 ± 0.826 at the end of the 4-weeks experiment period. The variations of the pH values recorded after manure application on the soil were statistically insignificant. It can be inferred that, manure pellets were not alkaline or acidic enough to significantly alter the soil's original pH status. With subsequent increase in moisture content of soil beyond the optimal level (40 %), the microorganism's respiration activity and release of carbon dioxide was gradually limited due to

saturation of the pores in the soil matrix with water hence the insignificant changes in the soil pH at 50 %, 60 % and 70 % soil moisture content. Limited microbial respiration processes, accounted for the insignificant changes in either reduction or increase in the soil pH after manure application at 50 %, 60 % and 70 % soil moisture contents.

Effect of the applied manures on soil nitrate content

The measured soil nitrate-values of different treatments are showed in Table 3-6. The effects of length of incubation time and moisture content are investigated and presented in these tables.

Table 3 above shows the nitrate levels obtained from the control treatment. The results pointed out that the studied soil has a significant amount of nitrate ranged between 15 and 35 mg/kg in the lower and between 6 and 29 mg/kg in the upper layer. For lower sub-samples, the figures showed an increasing trend that appeared to level off and drop after week 3 at all moisture contents. For upper sub-samples, nitrate levels showed a steady increasing from week 1 to week 4, for all moisture contents. It can be explained by the effect of soil moisture on the amount of nitrate. In dry soils, microbes can't convert the organic materials into inorganic forms such as nitrates.

Table 3

Effects of control on soil nitrate content at different soil moisture level during the incubation period

	Soil nitrate content (mg/kg)							
moisture level (%)	Upper layer				Lower layer			
	weeks							
	1st	2nd	3th	4th	1st	2nd	3th	4th
40	11.23	17.87	17.77	23.00	25.77	27.60	25.50	25.07
50	7.60	12.40	17.20	22.07	16.27	19.17	34.93	25.57
60	8.67	13.93	19.87	28.80	16.67	21.57	23.43	21.77
70	6.33	12.67	18.47	17.23	14.73	19.80	27.20	27.70

In Table 4, soil nitrate contents obtained from P+K treatment are showed. In the upper layer an enormous, increase of nitrate content can see independently of the soil moisture level. However, in the lower layer this increasing trend can't have observed. More balanced soil nitrate concentrations were measured in this layer. The findings can be explained by the situation of the manure pellets. The soil surrounding the pellets are richer in nitrates than the lower layer. Moreover, the increasing nitrate concentration is observed as the mineralization process proceeds.

In Table 5, the soil nitrate contents obtained from P+K "C" treatment are showed. The nitrate content of the soil was continuously increased in the upper layer in the examined period. The tendency was independent from the

soil moisture level but the degree of the increment strongly affected by the moisture level. The obtained results are almost similar to those of P+K product.

In Table 6, the soil nitrate contents obtained from Humin Plus treatment are showed. Although the nitrate trend shows variations at the different moisture content levels, there is a general decreasing trend from week 1 to week 4 for the lower sub-samples. There is a decline in the values from week 1 to week 2, from about 5.7 - 8.2 to about 4.3 - 5.2. Then the values slightly increase and stabilized from week 3 to week 4. For the upper subsamples, there is a sharp increase in the values from week 1 to week 2 and later an enormous drop in the third week, which was increased again to the fourth week.

Table 4

Effects of P+K treatment on soil nitrate content at different soil moisture level during the incubation period

	Soil nitrate content (mg/kg)							
moisture level (%)	Upper layer				Lower layer			
	weeks							
	1st	2nd	3th	4th	1st	2nd	3th	4th
40	9.33	17.83	22.97	24.97	30.00	26.53	25.47	31.10
50	17.20	10.17	18.87	25.53	23.13	22.70	21.00	25.47
60	11.47	9.37	17.20	19.30	23.93	18.30	18.53	26.57
70	4.43	8.13	20.29	14.63	27.73	21.73	25.29	20.97

Table 5

Effects of P+K "C" treatment on soil nitrate content at different soil moisture level during the incubation period

	Soil nitrate content (mg/kg)							
moisture level (%)	Upper layer				Lower layer			
	weeks							
	1st	2nd	3th	4th	1st	2nd	3th	4th
40	12.40	11.40	18.33	20.70	28.63	24.10	18.53	21.63
50	12.30	13.93	17.10	21.80	17.23	17.33	16.77	14.93
60	6.47	10.43	16.73	19.67	21.93	24.43	15.53	19.93
70	4.67	10.23	12.47	15.03	16.97	16.87	13.90	16.87

Table 6

Effects of Humin Plus treatment on soil nitrate content at different soil moisture level during the incubation period

	Soil nitrate content (mg/kg)							
moisture level (%)	Upper layer				Lower layer			
	weeks							
	1st	2nd	3th	4th	1st	2nd	3th	4th
40	9.20	11.87	4.23	6.07	5.67	5.27	5.20	4.37
50	4.25	8.63	4.40	4.53	8.15	4.87	4.83	5.47
60	6.90	8.70	4.03	5.90	6.73	4.40	5.70	4.37
70	7.60	7.07	4.10	4.47	6.20	4.33	5.47	5.53

In reference to Table 7, at all moisture contents 40 %, 50 %, 60 % and 70 %, there were significant differences in the nitrate values as they were less or equal to 0.05 ($P \leq 0.05$) under all the experiment treatments over the four-week period. High nitrate contents were recorded at 40 % soil moisture content while the lowest nitrate concentration was recorded under the highest soil water content (70 %).

Table 7

P-values obtained from ANOVA test of the nitrate data at different soil moisture levels

Moisture level		40%	50%	60%	70%
NO_3^- *P-values*	Lower layer	0.00000465	0.001086	0.000587	0.0000704
	Upper layer	0.008965	0.05067	0.052006	0.030062

Among the three manure type treatments, P+K recorded the highest nitrate release in the soil at 40 % soil moisture content levels conditions in both lower and upper subsamples (maximum value was 30.00 mg/kg), and Humin plus released the lowest amount of nitrate in the soil (maximum value was 11.87 at 40 % moisture content) in the upper sub-samples as seen in tables above.

High nitrate contents in the soil can be attributed to a high rate of nitrification process facilitated by the aerobic soil microorganisms at moderate water content levels (40 %) due to adequate soil aeration. As the moisture content of the soil increases, the soil becomes more waterlogged over time as in the cases where the soil has more than 40 % water content due to continuous irrigation.

In water-logged conditions, soil microorganisms are unable to effectively mineralize the organic nitrogen into nitrates as oxygen supply in the soil matrix is inhibited by the saturated soil conditions (Castaldelli et al., 2019). Other than the aspect of soil water content, it can be inferred that P+K manure is the best choice to supply nitrates to the soil at moderate soil moisture conditions. Humin plus is a poor choice for nitrates supply in the soil as demonstrated by the negative trends in the nitrate values obtained after soil application as demonstrated in table 6 above.

Generally, there is a clear increasing trend in the nitrate values recorded for all upper subsamples in all treatments except for the Humin Plus treatment, as demonstrated in Tables 4 - 6 above. However, many variations are observed in the lower sub-sample nitrate values. This observation can be attributed to the higher exposure of upper subsamples to air compared to the lower subsamples. Adequate soil aeration is an important factor to consider in the nitrification process, and in the nitrate distribution between layers also important factor is the leaching process of nutrients.

Effect of the applied manures on soil ammonium content

The measured soil ammonium contents of different treatments are showed in Tables 8 - 11. The effects of length of incubation time and moisture content are investigated and presented in these tables.

Table 8 shows the soil ammonium contents obtained from the control treatment. The ammonium values demonstrated an increasing trend from week 1 to week 2 and dropped progressively by week 4 at all moisture contents in the lower and upper sub-samples.

Table 8

Effects of control on soil ammonium content at different soil moisture level during the incubation period

moisture level (%)	Soil ammonium content (mg/kg)							
	Upper layer				Lower layer			
	weeks							
	1st	2nd	3th	4th	1st	2nd	3th	4th
40	2.50	5.81	5.47	1.43	1.83	8.67	7.47	2.83
50	1.77	5.99	3.17	1.67	2.07	5.83	5.33	3.00
60	2.20	5.96	2.83	1.00	2.40	4.83	5.00	1.17
70	1.60	6.13	5.17	1.67	1.87	3.33	2.03	0.83

Table 9 shows the soil ammonium contents obtained from the P +K treatment. The ammonium values demonstrated a continuous decreasing trend at all moisture contents in the upper and lower sub-samples during the incubation period.

Table 9

Effects of P+K treatment on soil ammonium content at different soil moisture level during the incubation period

moisture level (%)	Soil ammonium content (mg/kg)							
	Upper layer				Lower layer			
	weeks							
	1st	2nd	3th	4th	1st	2nd	3th	4th
40	8.67	1.67	3.67	0.83	7.67	2.67	2.67	1.23
50	7.33	2.00	4.33	0.97	6.67	1.33	2.67	1.00
60	7.33	1.67	4.00	0.83	5.00	2.00	3.67	0.77
70	11.67	3.33	4.00	0.83	5.33	1.33	2.67	0.73

Table 10 shows the soil ammonium contents obtained from the P+K "C" treatment. Both upper and lower subsamples show a progressive decreasing trend for the soil ammonium at all moisture content levels. Moreover, a bit higher values are observed in the upper subsamples compared to the lower subsamples.

Table 11 shows the soil ammonium contents obtained from the Humin Plus treatment. In both upper and lower subsamples, the ammonium levels

drop in the second week and then increase sharply to week 3 after which the levels slightly drop again. The highest soil ammonium contents were observed at 70 % moisture content in both upper and lower sub-samples.

Table 10

Effects of P+K "C" treatment on soil ammonium content at different soil moisture level during the incubation period

moisture level (%)	Soil ammonium content (mg/kg)							
	Upper layer				Lower layer			
	Weeks							
	1st	2nd	3th	4th	1st	2nd	3th	4th
40	8.33	6.40	1.73	0.77	8.00	4.37	1.13	0.57
50	9.67	6.39	1.17	0.53	7.67	4.30	0.77	0.50
60	10.67	6.39	2.20	0.60	8.67	3.80	0.63	0.63
70	12.00	6.41	2.77	0.50	7.67	3.90	0.60	0.43

Table 11

Effects of Humin Plus treatment on soil ammonium content at different soil moisture level during the incubation period

moisture level (%)	Soil ammonium content (mg/kg)							
	Upper layer				Lower layer			
	Weeks							
	1st	2nd	3th	4th	1st	2nd	3th	4th
40	6.47	4.50	16.00	13.33	7.63	6.20	13.00	11.33
50	6.73	3.57	15.00	21.67	7.03	5.67	14.33	8.33
60	6.60	5.00	17.00	14.67	7.83	6.07	14.33	13.00
70	5.27	6.20	18.00	16.00	7.60	6.23	16.33	12.67

As shown in Table 12, at all the four soil moisture conditions, there were significant differences in ammonium content ($P \leq 0.05$) for all the sub-samples at 40 %, 60 %, 70 % and 50 % moisture conditions.

Table 12

P-values obtained from ANOVA test of the ammonium data at different soil moisture levels

Moisture level		40%	50%	60%	70%
NH_4^+ *P-values*	Lower layer	0.014198	0.02096	0.009296	0.005666
	Upper layer	0.05336	0.076097	0.044853	0.026087

However, there was no significant difference in the soil ammonium at 40 and 50 % (upper sub-samples) soil moisture condition by the end of the experiment period. Humin plus released the highest amount of ammonium in the soil compared to the other two manure products. High soil ammonium content in the highest soil water content can be associated with a more anaerobic environment that inhibits conversion of ammonium to nitrate compared to lower soil water content. Furthermore, the Humin Plus manure product contained 10 % dudarite (clay mineral) that was absent in the other

manure types. Clay minerals have negative charges on their surface that attracts positive cations including ammonium ions hence high levels of NH_4^+ in the soil samples that were treated with Humin Plus as the clay mineral facilitated for ammonium ion fixation into the soil (Nieder et al., 2011).

Dudarite also stimulates the growth of soil microbes, which accelerate the decomposition of organic matter and increases the capacity of the soil buffering capacity hence resulted favourable conditions for plant growing. It seems that applying Humin Plus product the nitrogen mobilization processes are affected basically. Ammonification process in soil was fortified while the nitrification process was hindered (see the lowest soil nitrate content – Table 6). This effect may be explained by the lower manure, higher meat powder and added dudarite content.

CONCLUSIONS

In summ, it can be stated that the P+K chicken manure product is the best in nitrate supply on a crop farm irrigation should be done while maintaining the optimal soil moisture content.

Humin Plus is the best chicken manure product for the supply of ammonium. In order to achieve its benefits in supplying soil NH_4^+ on the farm, the released ammonium content has a great opportunity to convert nitrate as the soil conditions is getting better and better. Moreover, the slightly hindered nitrification (as long-continued N supply) is sometimes desirable, mostly at sandy soils where the nitrate leaching process is enhanced.

Acknowledgment

The research was carried out and financed by GINOP-2.2.1-15-2017-00043 project at the University of Debrecen.

The research was financed by the Thematic Excellence Programme of the Ministry for Innovation and Technology in Hungary (ED_18-1-2019-0028), within the framework of the Space Sciences thematic programme of the University of Debrecen.

REFERENCES

1. Alexandratos N., Bruinsma J., 2012, World agriculture towards 2030/2050: the 2012 revision. ESA Working paper No.12-03. Rome, FAO;
2. Bernal M.P., Alburquerque J.A., Moral R., 2009, Composting of animal manures and chemical criteria for compost maturity assessment. A review. Bioresour. Technol., 100 (22), pp.5444-5453;
3. Bhat Z.A., Saroa G.S., Benbi D.K., Choudary O.P., Padder S.A., 2015, Nitrogen mineralization kinetics in soil incubated at different temperatures amended with organic and inorganic fertilizers. The Ecoscan, 9(3&4), pp.699-703;
4. Bitzer C.C., Sims J.T., 1988, Estimating the availability of nitrogen in poultry manure through laboratory and field studies. J. Environ. Qual. 17, pp.47-54;

5. Bolan N.S., Szogi A.A., Chuasavathi T., Seshadri B., Rothrock M.J., Panneerselvam P., 2010, Uses and management of poultry litter. World's Poultry Science Journal, 66(4), pp.673-698;
6. Borowik A., Wyszkowska J., 2016, Soil moisture as a factor affecting the microbiology and biochemical activity of soil. Plant, Soil and Environment, 62(6), pp.250-255;
7. Castaldelli G., Colombani N., Soana E., Vincenzi F., Fano E.A., Mastrocicco M., 2019, Reactive nitrogen losses via denitrification assessed in saturated agricultural soils. Geoderma, 337, pp.91-98;
8. Cordovil C.M.D.S., Coutinho J., Goss M., Cabral F., 2005, Potentially mineralizable nitrogen from organic materials applied to a sandy soil: fitting the one-pool exponential model. Soil Use and Management, Vol.21. (1), pp.65-72;
9. Fan Z.J., Ai Y.W., Li J.M., Li G.W., 2000, Discussion of controlling N loss from volatilization in animal manure. J. Sichuan Normal Univ. (in Chinese) 23 (5), pp.548-550;
10. Fang M., Wong J.W.C., Ma K.K., Wong M.H., 1999, Co-composting of sewage sludge and coal fly ash: nutrient transformations. Bioresour. Technol. 67, pp.19-24;
11. Haga K., 1999, Development of composting technology in animal waste treatment-review. Asian Austral. J. Anim. Sci. 12 (4), pp.604-606;
12. Hirzel J., Undurraga P., Walter I., 2010, Nitrogen mineralization and released nutrients in a volcanic soil amended with poultry litter. Chilean Journal of Agricultural Research, 70(1), pp.113-121;
13. Kelleher B.P., Leahy J.J., Henihan A.M., O'Dwyer T.F., Sutton D., Leahy M.J., 2002, Advances in poultry litter disposal technology – a review. Bioresource Technology 83, pp.27-36;
14. Kobierski M., Bartkowiak A., Lemanowicz J., Piekarczyk M., 2017, Impact of poultry manure fertilization on chemical and biochemical properties of soils. Plant, Soil and Environment, 63(12), pp.558-563;
15. Köteles N., Pereş A.C., 2017, The level of air pollution with ammonia in the city of Satu Mare in 2014-2016. Natural Resources and Sustainable Development 7, pp.57-60;
16. Marin J.C.A., Caravelli A.H., Zaritzky N.E., 2016, Nitrification and aerobic denitrification in anoxic–aerobic sequencing batch reactor. Bioresource technology, 200, pp.380-387;
17. Mitsch W.J., Gosselink J.G., 2007, Wetlands. 4th Ed., John Wiley & Sons, Hoboken;
18. Moral R., Paredes C., Bustamante M.A., Marhuenda-Egea F., Bernal M.P., 2009, Utilization of manure composts by high-value crops: safety and environmental challenges. Bioresour. Technol. 100 (22), pp.5454-5460;
19. MSZ 20135, 1999, Determination of the soluble nutrient element content of the soil. Hungarian Standards Institution. Budapest (in Hungarian);
20. Nagy A., Fehér J., Tamás J., 2018, Wheat and maize yield forecasting for the Tisza river catchment using MODIS NDVI time series and reported crop statistics. Computers and Electronics in Agriculture 151, pp.41-49;
21. Nahm K., 2005, Factors influencing nitrogen mineralization during poultry litter composting and calculations for available nitrogen. World's Poultry Science Journal, 61(2), pp.238-255, doi:10.1079/WPS200455;
22. Nieder R., Benbi D.K., Scherer H.W. 2011, Fixation and defixation of ammonium in soils: a review. Biology and Fertility of Soils, 47(1), pp.1-14;

23. Strawn D.G., Bohn H.L., O'Connor G.A., 2019, Soil chemistry. John Wiley & Sons;
24. Szabó A., Tamás J., Nagy A., 2019, Spectral evaluation of the effect of poultry manure pellets on pigment content of maize (*Zea mays L.*) and wheat (*Triticum aestivum L.*) seedlings. Natural Resources and Sustainable Development 9:1, pp.70-79;
25. Tamás J., Nagy A., 2009, Advanced Evaluation of Spatial Inhomogenity of Ligth Sandy Soil. Analele Universitátii din Oradea, Fascicula Protectia Mediului, 14, pp.364-374;
26. Tamás J., Gorliczay E., Borbély J., 2017, Atmospheric spreading model for ammonia released from the poultry house. Analele Universitatii din Oradea, Fascicula Ecotoxicologie, Zootehnie si Tehnologii de Industrie Alimentara, 15, pp.331-338;
27. Tiquia S.M., Tam N.F.Y., 2000, Fate of nitrogen during composting of chicken litter. Environmental Pollution 110, pp.535-541.

Received: March 25, 2020
Revised: May 11, 2020
Accepted and published online: May 31, 2020