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META-ANALYSES OF SWEETPOTATO (*IPOMOEA BATATAS L. LAM*) STABILITY PERFORMANCE IN DIFFERENT AGRO-ECOLOGIES OF THE TIGRAY REGION, ETHIOPIA

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ABSTRACT

The study aimed at evaluating the influence of environment on sweetpotato stability and identifying superior genotype(s) with high yield stability in the farmers' field conditions. Six sweetpotato genotypes were evaluated for two years in 'meher' season (July- December), 2014 and 2016; four of the six genotypes were assessed for three years in the 'meher' season, 2012, 2014, and 2016. Planting was done in three replications in RCBD in three unique agro-ecologies: Endayesus-dry highland, Fachagama-dry lowland, Rarhe-moist lowland. Genotypes genetic merits were predicted using BLUP. The AMMI and GGE were used to test the genotypes stability. The ANOVA for AMMI model showed high significant difference ($P < 0.01$) for genotypes, environments, seasons, and the interactions. Environment (41.67%) and the genotype main effect (35.71%) contributed largely to the cumulative variance for three years testing of four genotypes and two years testing of six genotypes, respectively. Berkume (42.44 t/ha), Tulla (33.92 t/ha) and Kulfo (33.67 t/ha) were superior for total storage root tuber yield (TTRY). Both the AMMI and GGE biplot predicted Tulla and Kulfo as ideal genotypes with dynamic stability; Berkume with static stability to Rarhe. The environment main effect had significant influence in determining how genotypes expressed their genetic potentials and stability as shown by the AMMI model and GGE biplot. The AMMI model partitioned the studied agro-ecologies of the Tigray region into two mega sweetpotato growing environments; the dry high/lowland in one environment and the moist lowland in another, completely different, but with high potentials for sweetpotato production.

Key words: Stability, Agro-ecologies, Yield, Sweetpotato, Superior.

INTRODUCTION

Sweetpotato (*Ipomoea batatas* L. Lam) is the most important storage root tuber food security resilient crop in Sub Saharan Africa and Asia grown in diverse soils conditions with low input requirements (Low, 1995; FAOSTAT, 2013). The crop is widely adopted in Africa and Asia as an important root crop with tremendous nutritional, health, industrial and economic benefits (Islam, 2006; Kapinga et al., 2010; Zhu et al., 2010). However, in Ethiopia, it's newly introduced and its production, adoption and consumption are very low especially in the Tigray region (CSA, 2013). Sweetpotato is grown in small scale for livestock feeds majorly although in the Southern Nations Nationalities Peoples Region State, and Oromia, it forms a staple diet of the community (Fekadu et al., 2015). Tigray region prevails in malnutrition and deep hunger above the country's level with at least 42% of the total children's population (<5 years) malnourished. Both hidden and deep hunger intensifies with recurring drought in this region (CSA, 2015). Vitamin A supplementary high dose capsules reached only 79% leaving about 21% of the children's population uncovered at all (CSA, 2015; WHO, 2015). Sweetpotato can be use to answer the dire need of food and nutritional security in the Tigray region and Ethiopia at whole. Sweetpotato tops (soft stems and leaves) and storage root tubers (SRT) are edible and nutritious (Islam, 2006; Tewe et al., 2003). The α -xanthophylls and lutein in it protects the eyes against night blindness, meanwhile the Polyphenols, carotenoids, vitamins and minerals are strong anti-oxidants, anti-mutagens, anti inflammations, anti hypertension, anti diabetics, and reduces liver, kidney damage and cardiac arrest (Islam, 2006; Zhu et al., 2010; Matsui et al., 2004). Many attempts have been made to make sweetpotato familiar in the Tigray region through free distribution of quality high yielding cultivars to the farmers but the production and consumption coverage has not improved much (CIP, 2000; CSA, 2013). Even the highest yielding genotypes released to the farmers by the research centers were not giving high SRT yield in the farmers' fields (Assefa et al., 2007). Sweetpotato average yield in Tigray ranges between 0-4 t/ha in the farmers' field far below the mean yield range at research centers of between 9-31 t/ha (FAOSTAT, 2011). Thus there was urgent need to investigate much on the stability of the quality sweetpotato genotypes to the farmers' field conditions in the different agro-ecologies of the Tigray region to come-up with genotypes with high stability in multi environment with better yield returns.

MATERIALS AND METHODS

Three unique agro-ecological sites were used for the experiment; Endayesus (dry highland) found at an altitude of 2223 meters above sea-level (masl), characterized by Silty Clay soil, minimum and maximum temperature of 12.5°C and 26.0°C, and an average annual rainfall of 450 mm. Fachagama (dry lowland) characterized by Silty Clay loam soil, minimum and maximum temperature of 22.0°C and 31.0°C, located at an altitude of 1585 masl, with an average annual rainfall of 350 mm. Rarhe (moist lowland) characterized by Sandy Clay loam soil, with average annual

mean rainfall of 733 mm, minimum and maximum temperature of 15.0°C and 30.9°C located at an altitude of 1460 masl.

The study consisted of four orange fleshed (Tulla, Kulfo, Kabode and Vitae) and two white fleshed (Awassa-83 and Berkume) sweetpotato genotypes; two released check varieties (Tulla and Kulfo) and four germplasm sourced from Awassa Research center (AwARC), Ethiopia. Four of the genotypes were first planted in the “Meher” season (July- December) 2012. All the six genotypes were evaluated in the “meher season of 2014 and 2016 respectively. Planting was done on the ridges at a spacing of 0.3 m x 0.6 m in a 3.0 m x 2.4 m randomized complete block design (RCBD) with three replications having 1m in between each block. Each block received a treatment of each genotype, 30 vines cut at 30 cm long. All other basic agronomic practices were done timely including supplementary irrigation using furrow application once a week (September to November). At harvest, data were collected on SRT yield traits. The TTRY was calculated using the formula;

$$TTRY = \frac{TMTY \left(\frac{t}{ha} \right) + TUTY \left(\frac{t}{ha} \right)}{\text{Total net area (m}^2\text{)}} \quad \text{Where; TTRY= total storage root tuber}$$

yield; TMTY= total marketable storage root tuber yield; TUTY= total unmarketable storage root tuber yield; t/ha= tons per hectare; m²= meter square. The TTRY data were analysed using the general linear model of statistical analysis system (SAS) (SAS, 1995). The genotypes and environments’ mean coefficient of variations, mean standard errors and mean least significance difference were accounted for. The environment, seasons and replication were considered as random factor source of variations, and the genotypes were considered as a fixed factor to be tested by the different environments and seasons. The genotypes genetic merit was estimated by BLUPs and the mean was subjected to the Additive Main effects and Multiplicative interactions (AMMI) to test the genotype by environment interactions effects, using Genstat 14th version (Payne et al., 2011). The AMMI model equation was:

$$Y_{ij} = \mu + G_i + E_j + \sum_{k=1}^n \lambda_k \alpha_{ik} \gamma_{jk} + e_{ij}. \quad \text{Where; } Y_{ij} \text{ is the yield of the } i^{\text{th}}$$

genotype in the jth environment; μ is the grand mean; G_i and E_j are the genotype and environment deviations from the grand mean, respectively; λ_k is the singular value of the kth axis in the principle component analysis; α_{ik} and γ_{jk} are the genotype and environment principal component scores for axis k; n is the number of principle components retained in the model; e_{ij} is the error term (Guach, 2008). Genotypes Main effects, Genotype by Environment Interactions (GGE) biplot were used to find which genotype won where. The cumulative interaction percentage of the environment and genotypes, as well as the percentage contributions of the environment and that of the genotypes registered by the GGE Biplot were recorded as described by Yan and Tinker (2006).

RESULTS AND DISCUSSION

Combined Stability Analysis of Four Common Genotypes Performance for TTRY Trait across Environments in Three Years (2012, 2014, and 2016)

Generally, the environment grand mean yield of these genotypes (Kulfo, Tulla, Kabode, and vitae) showed great variations. The highest annual TTRY mean was obtained in the year 2014 (137.58 t/ha) followed distantly by 2016 (97.66 t/ha) and 2012 (80.89 t/ha) least. Fachagama (30.85 t/ha) and Rarhe (47.50 t/ha and 33.81t/ha) gave high annual TTRY in the year 2012, 2014 and 2016 respectively and the lowest mean TTRY was observed in Rarhe (13.53 t/ha), Endayesus (24.20 t/ha) and Fachagama (15.66 t/ha) in the year 2012, 2014, and 2016 respectively (Table 1). This may signify how change in seasons affected genotypes' TTRY performance and stability in multi-environments over time. This finding corresponded to similar studies done by Mcharo et al (2013). Vitae (16.40 t/ha) and Kabode (16.85 t/ha) persistently maintained low yield in all the environments in the three years (Table 1), however, their average yield recorded in this study is still within the Variety release check yield range (16.0 t/ha to 34 t/ha) reported (Kapinga et al., 2010; Mwanga et al., 2009). This could be because these genotypes comparatively have longer days to maturity and the testing environment had short growing periods.

The combined ANOVA for AMMI model, showed a highly significant variation ($P<0.01$) for genotypes, environment and seasons main effects as well as genotype x environment x seasons interactions. Environment (41.67%), contributed very highly to the cumulative variance, followed by interactions (39.94%) and genotypes main effects (17.97%) (Table 2). This may signify how environment dictated on the genotypes expressions of their genetic potentials which complicated the selection process of these genotypes. It also showed how change in seasons over time affected the SRT yield formation in sweetpotato in the same environment. The significant interactions effect may imply that genotype interact differently with seasons and environment which caused variations in the TTRY across environments over time. This is in agreement with similar studies (Adebola et al., 2013; Mcharo et al., 2013), who found variations in root yield stability of sweetpotato cultivars across environments. The model partitioned the interactions into three significant Interaction Principle Component Analysis axes (IPCA) in the order of their relevance that is IPCA1 explained 75.76%, IPCA2 18.86% and IPCA3 5.38% of the variance. The percentage contribution of each IPCA to the overall variance decreased with increase in the number of IPCA. All the IPCAs were statistically highly significant ($P<0.01$) (Table 2).

Table 1. The overall blups prediction of the TTRY for the six genotypes performance for three years

Total storage root tuber yield (t/ha)										
Seasons	2012			2014			2016			
Genotypes/Environment	Enday esus	Fachaga ma	Rarhe	Enday esus	Fachag ama	Rarhe	Enday esus	Facha gama	Rarhe	Mean
Kabode	7.00	18.83	5.43	16.53	20.39	36.68	21.13	18.17	7.53	16.03
Kulfo	24.44	43.49	13.71	34.09	65.68	63.21	30.58	19.69	39.74	33.67
Tulla	24.63	45.55	17.87	26.53	33.69	55.98	29.44	24.49	54.26	33.92
Vitae	9.08	15.54	17.09	13.56	15.57	30.83	13.29	14.65	20.00	16.40
Awassa-83				14.85	21.52	28.00	13.36	9.04	21.89	18.11
Berkume				39.63	60.82	70.32	16.49	7.93	59.46	42.44
Site means	16.29	30.85	13.53	24.20	36.28	47.50	20.72	15.66	33.81	26.76

Table 2. The AMMI analysis of TTRY for the four genotypes over three environments for three years production

SOV	df	SS	Total Variation explained (%)	G x E explained (%)	MS
Total	107	26083			243.8
Genotypes	3	4688	17.97		1562.7**
Environments	8	10869	41.67		452.9**
seasons	18	55	0.21		3.1**
Interactions	24	10417	39.94		1302.2**
IPCA1	10	9323		75.76	932.3**
IPCA2	8	1435		18.86	179.3**
IPCA3	6	111		5.38	18.5**
Error	72	109			1.5

SOV= Source of variations; df= Degree of Freedom; SS= Sum of Squares; MS= Mean Square; IPCA= Interaction Principle Component Analysis; ** highly significant at probability ($P < 0.01$).

To identify the ideal genotype(s), the average–environment coordination (AEC) ordinate graph was plotted using the genotypes' and environments' mean scores. Tulla and Kulfo aligned themselves close to the centre of the concentric circles marked with AEC dot, considered to be a point of total stability in the positive direction (Figure 1). Thus Kulfo and Tulla were the most desired genotypes. This signified that Kulfo and Tulla maintained high stability and mean yield performance in all the tested agro-ecologies and seasons (Yan and Tinka, 2006).

Evaluation of the Six Genotype Performance for TTRY Stability in the Year 2014 and 2016 using AMMI

The combined ANOVA for the AMMI model showed highly significant ($P < 0.01$) difference among genotypes, environment, and genotype \times environment \times seasons interactions meanwhile, replication was statistically non significant for TTRY trait. The largest contribution to cumulative variance was genotypes (35.71%). The interactions were separated into two IPCA in their order of importance; both IPCA1 and IPCA2 were highly significant ($P < 0.01$) and IPCA1 accounted for 92.10% meanwhile, IPCA2 contributed 7.90% of the total variations due to interactions sum of squares (Table 3). This may show that genotypes exhibited different stability response in the testing environment in the two years trials.

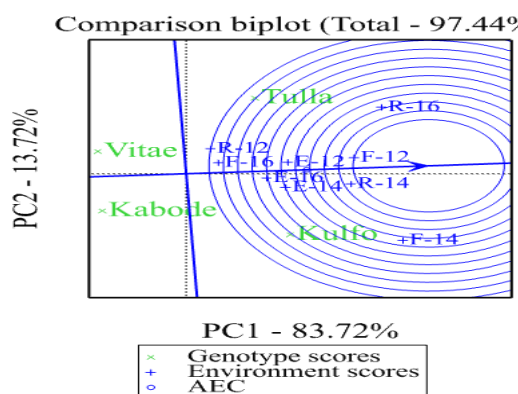


Figure 1. The AEC view to rank genotypes relative to an ideal genotype for the year 2012, 2014 and 2016.

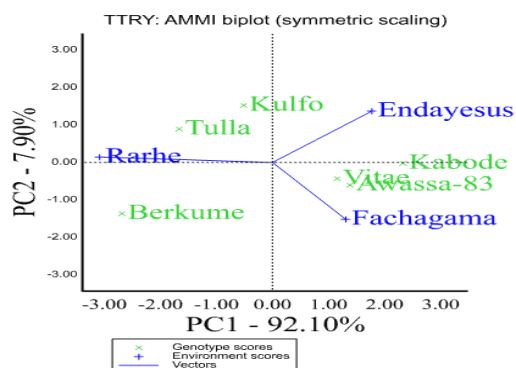


Figure 2. The AMMI Biplot showing Mega Growing Environments

R-14=Rarhe 2014; R-16= Rarhe 2016; F-14=Fachagama 2014; F-16= Fachagama 2016; E-14=Endayesus 2014; E-16= Endayesus 2016.

Table 3. ANOVA for AMMI model for genotypes interactions in the year 2014 and 2016

SOV	df	SS	Total explained (%)	Variation	G x E explained (%)	MS
Total	5	1255				243.8
	7	3				896.6*
Genotypes	5	4483	35.71			*
Environments	5	4132	32.92			826.3*
Replications	6	1162	9.26			193.6
Interactions	2					ns
	5	2776	22.11			111**
						222.7*
IPCA1	9	2004			92.10	*
IPCA2	7	634			7.90	90.5**
Error	6	138				15.3

SOV= Source of variations; df= Degree of Freedom; SS= Sum of Squares; MS= Mean Square.

When the IPCA1 AMMI biplot graph of genotype against environment scores was plotted, genotypes main effect (PC1) and G x E interactions (PC2) accounted for 92.10% and 7.90 (total 98.00%) of the variance respectively (figure 2). AMMI model grouped the agro-ecological environments into two mega sweetpotato growing environments with Fachagama and Endayesus falling within one environment and Rarhe in another growing environment. The angle vertex between Fachagama and Endayesus was acute angle showing positive correlations between them. Nevertheless, the angle between either Fachagama/Endayesus with Rarhe was obtuse that implied their low correlations (Figure 2). This may also show that Rarhe comparatively had large G x E contribution to the cumulative variance (Yan and Tinka, 2006).

Ranking of the genotypes for TTRY comparative to the ideal genotype singled out Kulfo as the most desirable genotype followed by Tulla then Berkume surrounding the ideal genotype. Kabode, Vitae and Awassa-83 located below the vertical line and were the undesirable genotypes; they performed below the vertical line (Figure 3). This signified that Kabode, Vitae and Awassa-83 were very unstable in the testing environment (Yan and Tinka, 2006).

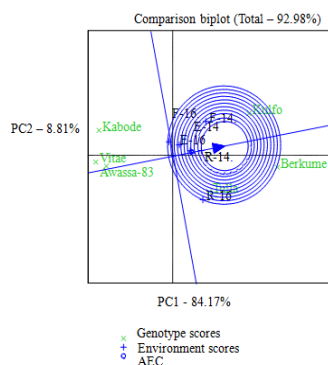


Figure 3. The AEC view to rank genotypes relative to an ideal genotype for the year 2014 and 2016

R-14=Rarhe 2014; R-16= Rarhe 2016; F-14=Fachagama 2014; F-16= Fachagama 2016; E-14=Endayesus 2014; E-16= Endayesus 2016.

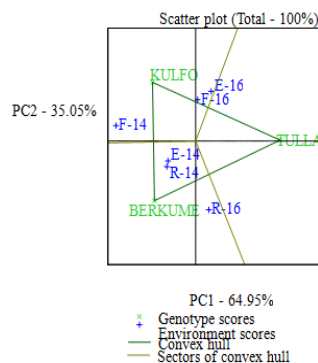


Figure 4. GGE Biplot showing the Genotype which Won where in TTRY Trait in Seasons 2014 and 2016

Further analysis of the three high yielding genotypes (Kulfo, Tulla, and Berkume) specifically for TTRY was done using which-won-where function which explained 100% of the variations due to genotype main effect and G x E interactions effect. PC1 contributed 64.95% and PC2 contributed 35.05% (total 100%) cumulative variance. Kulfo won in Fachagama in 2014, 2016, and Endayesus in 2016. Meanwhile, Berkume won in Rarhe in the year 2014 and 2016, and Endayesus in 2014 respectively. Much as Tulla performed below Kulfo and Berkume in these testing environments, it showed more dynamic stability for TTRY (Figure 4). This finding is in agreement with findings from Yan and Tinka (2006).

CONCLUSIONS

This study observed high significant difference in the environment's main effect, genotype's main effects, and genotypes by environment by season's interactions in the formation of storage root tuber yield stability in sweetpotato genotypes across the different agro-ecologies of the studied areas. Environment had a significant influence on sweetpotato genotypes stability and the way in which each genotype unleashed its genetic potentials in the different environments ultimately. The study also observed that the tested agro-ecologies of the Tigray region have two mega growing environments for sweetpotato production; the dry highlands/lowlands represented by Endayesus, and Fachagama in environment I and the moist lowlands represented by Rarhe in environment II which are completely different and thus need different genotypes for better TTRY production. The dry highlands/lowlands, preferably short maturing genotypes and the moist lowlands both long and short maturing genotypes. Genotypes Tulla and Kulfo had dynamic stability and can be grown in any agro-ecology as opposed to Berkume which showed static stability to Rarhe (moist lowland) over time. There is hope that these

genotypes Kabode and Vitae when grown in environment with long growing period of at least 140 days may do well. Rarhe depicted high variability in the expression of TTRY trait making it more representative and discriminatory.

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SUPPLY OF NPK ELEMENTS THROUGH PRECIPITATION AND THROUGHFALL IN A COPPICE OF GREEN OAK IN THE EAST OF ALGERIA

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ABSTRACT

Nutrient provisions through precipitation and throughfall represent major factor of the sustainability of the forest ecosystem. Nevertheless, data related to this aspect are non-existent in Algeria. Precipitation and throughfall volumes and their contributions in NPK elements were evaluated between 2012 and 2013, in a green oak coppice at Marconna in Aurès (eastern Algeria). Precipitation volumes were evaluated by the placement of 10 containers in a bare soil. To quantify the throughfall, four containers were installed under the canopy of each tree among 25 selected trees. Water samples taken from previously rinsed plastic bottles with distilled water were kept away from light and transported to the laboratory for volume estimation and chemical analysis, as quickly as possible. After rapid filtration, samples became ready for NPK analysis. Various devices and chemicals were used for the measurements of NPK elements in the laboratory. Kjeldahl's method, colorimetry and flame photometry were used for quantifying total nitrogen, phosphorus and potassium respectively. The results showed that annual rainfall amounts varied between 223,9 and 289,6 mm, whereas the annual throughfall was 127,1 mm for 2012 and 189,8 mm for 2013. Besides, the annual quantities of N, P and K returned to the soil by the rainfall ranged from 5,05 to 7,62 kg/ ha/year. However, the throughfall results showed that the coppice accumulated amounts of N, P and K elements varying between 4,08 and 5,47 kg / ha / year. On average, nitrogen was the most provided element. It represented 47,07%.

Keywords: *Nitrogen, potassium, phosphorus, rainfall, Marconna.*

INTRODUCTION

Green oak (*Quercus ilex* L.) is one of the most important forest species in the Mediterranean region (Aguillaume *et al.*, 2017). In Algeria, its area decreased from 354 000 (Leutrech-Belarouci, 1991) to 149 000 hectares (El Achi, 2010), in few years. In the Aurès, it is often in the form of simple coppice characterized with low productivity. The low density and the weak average height of the trees (2,5 m)

constitute signs of the impact of the climatic constraints and the anthropic action (Khater, 2010).

Atmospheric supply appears to be one of the major pillars of the sustainability of the low mineral fertility ecosystem (Legout, 2008). Evaluating the amount of water and nutrients provided by precipitation and throughfall are very useful for better management of forest ecosystems (Lequy, 2012). In a context of climate change and for a forest ecosystem with low mineral fertility, a reduction in annual rainfall would cause a drop in atmospheric inputs, which would very quickly be influenced the flow of elements circulating in the ecosystem (Legout, 2008). Studies on the contribution of biogenic elements through precipitation and rainfalls are numerous for forest environments in Europe (Mangenot and Toutain, 1980; Lequy, 2012). However, this type of research remains very limited in North Africa (Badri, 2003). For Algeria, to our knowledge, no data are available on the contributions of NPK biogenic elements by precipitation and throughfall in a green oak coppice. That is why the present study aims to fill this gap and provide necessary data for the sensible management of green oak forests in semi-arid environments.

MATERIALS AND METHODS

Study site

Precipitation and throughfall measurements and their contribution in NPK elements were carried out continuously between January 2012 and December 2013 in a green oak coppice in the Aurès (East of Algeria). The latter is located at 1310 m above sea level, 12 km south of the Batna city. Its age is more than 25 years.

The density is 370 stems / ha. Their soil is of calcimagnetic type, with 10 to 18 % gradient. The average annual precipitation over the 22 years period (1989-2010) was 331,28 mm. For the same period, the average temperature was 15,6 ° C. The drought period was very long and it is often longer than five months (from May to November).

Experimental plan

Precipitation and throughfall water were collected manually using a total of 110 inverted cone-shaped plastic containers, with a lid whose conical bottom is pierced with small holes to minimize evaporation and retain plant and animal debris. The containers were fixed on metal supports well embedded in the ground.

The amounts of precipitation were evaluated by the placement of 10 randomly distributed containers in a bare soil area, about 10 m away from the canopy.

To quantify the throughfall water, four containers were installed under the canopy of each tree among the 25 selected trees. The overall collection area for all containers (100 containers) was 4,9 m². The latter is considered sufficient to adequately estimate throughfall (Rodrigo and Avila, 2001; Llorens and Domingo, 2007).

Protection against light, to avoid algal pollution, is ensured by the use of dark opaque containers. The cleaning of the containers used to recover the throughfall to be analyzed was carried out regularly after each measurement.

Water samples taken from plastic bottles previously rinsed with distilled water were kept away from light and transported to the laboratory for volume estimation and chemical analysis as quickly as possible.

After rapid filtration of the collected water with filter paper to remove floating material, precipitation and throughfall samples were ready for NPK measurements. Three methods were used in total: Kjeldahl's method for quantifying total nitrogen, colorimetry for total phosphorus and flame photometry for potassium.

It should be noticed that the quantities of precipitation and throughfall collected are expressed in mm. However, the results relating to N, P and K inputs by precipitation and throughfall are expressed in kg / ha / year.

Data analysis

The obtained results were subjected to variance analysis (ANOVA) at the error threshold of 5%. The software used is SPSS version 10.0.5 (SPSS Inc.). Moreover, Microsoft Excel 2007 was used to draw nutrient provisions curves.

RESULTS AND DISCUSSION

Nutrient provisions by precipitation

Figure 1 showed that the annual quantity of N, P and K brought by precipitation varied depending on the year, from 5,05 (2012) to 7,62 kg / ha (2013). However, ANOVA analysis did not reveal any significant difference between years (P ranged from 0,106 to 0,600).

These quantities of nutrients were provided by 223,9 (2012) and 289,6 mm of precipitations (2013).

Aurès region is well exposed to desert influence and wind erosion. It seems that these two phenomena would contribute significantly to the contribution of NPK elements by precipitation and throughfall.

Moreover, the low nutrient supply in 2012 compared to 2013 was due to reduced volumes of precipitation. An increase of 65,7 mm of rainfall brought a significant additional quantity of 2,57 kg / ha / year of nutrients to the forest floor in 2013.

NPK provisions through precipitation found in this study, are low comparatively to values from other studies (Allen *et al.*, 1968; Nihougrade, 1970; Badri, 2003; Legoute, 2008) which reported amounts ranging from 10 to 17,7 kg NPK / ha / year for sites that often receive more than 600 mm of rainfall per year.

The NPK contribution by precipitation, was dominated by nitrogen, which constitutes 86,75% of the total average supply.

The contribution during the two years of study for phosphorus remains very modest. It fluctuated from 0,27 to 0,39 kg / ha / year (figure 1). These results are in agreement with those of Lequy (2012) which observed in France, a total atmospheric deposition of phosphorus by precipitation between 0,2 and 0,8 kg / ha / year.

Besides, the amount of potassium brought by precipitation is also weak. It was on average 0,51 kg / ha / year for our study period (Figure 1). It was slightly superior to that found by Duchesne, (1999) (0,36 Kg /ha / year).

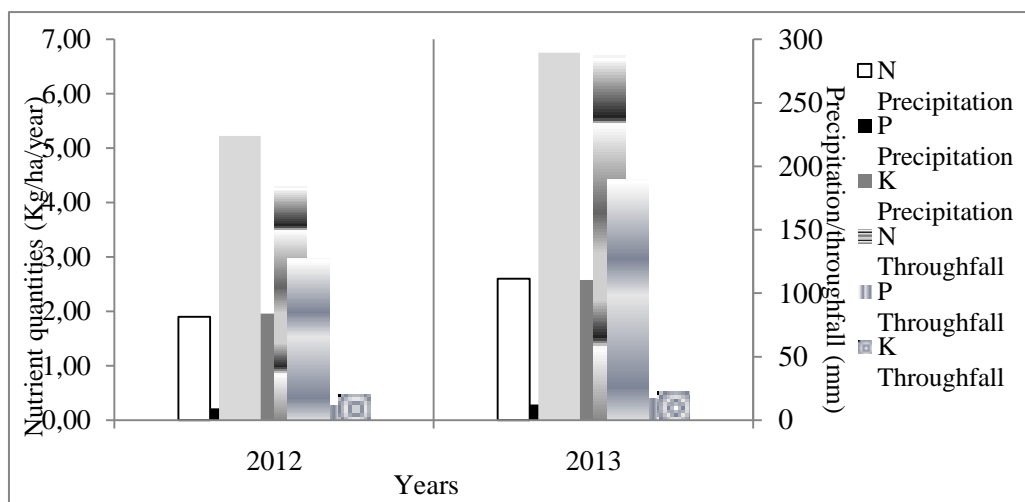


Figure1. Quantities of precipitation, throughfall, and nutrient provisions by them in Marconna green oak coppice

Throughfall

Our results showed that the soil accumulates, through throughfall, quantities of elements N, P and K which vary between 4,08 and 5,47 kg / ha / year. It should be noticed that the interannual variations remain low and not significant for the measured elements (*P* varied between 0,337 and 0,531).

The nutrient supply found in this study are relatively small compared to those reported by various authors (Carlisle *et al.*, 1966; Rodrigo *et al.*, 2003) who assessed this intake between 12,9 and 31,8 kg / ha / year. Nevertheless, the low intakes obtained in the present study were accompanied by small volumes of throughfall which did not exceed during the two years of study 190 mm/ year. The average throughfall rate found in Marconna coppice (66,3 %) is consistent with other researches on oak (63,8 to 77,8 %) mentioned by Llorens and Domingo (2007) for various Mediterranean countries, having a very important annual rainfall of 478 to 1275 mm. However, if we consider our throughfall in mm, it remains on average very weak with 158,45 mm. Throughfall volumes reflect the total provision of nutrients regardless of their concentrations (Matias *et al.*, 2011).

In addition, Aguillaume *et al.* (2017) studied oak forests characterized by high precipitation volumes and high throughfall rates (66 - 77 %), and they found that these quantities of throughfall contributed with 15 to 23,5 kg / ha / year of N, P and K. These nutrient quantities are clearly superior to those obtained in our study.

Indeed, several researchers such as Migon *et al.* (1989); Rodrigo *et al.* (2003) and Matias *et al.* (2011) have experimentally demonstrated that biogenic inputs depend largely on precipitation and throughfall, structure and dynamics of vegetation cover and interception rates. Similarly, the investigation of Aguillaume *et al.* (2017) on

the contribution of biogenic elements by precipitation and throughfall in four green oak in Spain over three years (2011-2013) have shown that nutrient supply are highly dependent on climate, characteristics and the quality of the area.

On average, the NPK provisions by throughfall were dominated by nitrogen and potassium. Nitrogen represented 47,07 % of the NPK annual supply. Its amount fluctuated between 1,9 to 2,6 kg / ha / year (figure 1). While the potassium represented 47,54 % of the NPK annual provisions. It varied between 1,96 (2012) and 2,58 kg / ha / year(2013).

The total contributions of N element during the two years of study are lower (1,9 – 2,6 Kg / ha / year) compared to those brought by precipitation (4,3 – 6,7 Kg / ha / year).

These values are close to those of Duchesne (1999) who found 5,76 kg / ha / year of nitrogen brought by the precipitation and 4,98 kg / ha / year by the throughfall. The results of nitrogen are consistent also with several studies (Nambiar and Fife 1987; Escudro *et al.*, 1992 in Duchesne 1999; Aguilhaume *et al.*, 2017).

Other studies under various forest canopies (Nys, 1987; Chang and Matzner, 2000) have shown that nitrogen provisions by throughfall are about twice as low as in uncovered areas.

On the other hand, the results of potassium are in agreement with those of Migon *et al.* (1989) and Legoute (2008) who reported that the supply of potassium by throughfall was greater than that by rainfall. When precipitation passes through a forest cover, there is a strong enrichment in K (Duchesne, 1999).

In this study, the green oak cover enriches the soil in K four to five times more than in P. These results converge with those of Aguilhaume *et al.* (2017) who also mentioned that the effect of the green oak canopy on the potassium intake is very strong.

Regarding phosphorus, the average amount of phosphorus provided by the throughfall (0,26 kg / ha / year) in the present paper (figure 1) remains close to that reported by Duchesne (1999) (0,23 kg / ha / year).

CONCLUSION

The assessment of N, P and K supplies through precipitation and throughfall in a green oak coppice represents a first study of this kind in Algeria.

The analysis of rainfall data for 2012 and 2013 showed that the annual quantity of NPK returned to the ground by precipitation varied between 5,05 and 7,62 kg / ha / year. Throughfall contributed with quantities of NPK elements, varying between 4,08 and 5,47 kg / ha / year. The low volumes of throughfall water and the low NPK provisions induce low productivity of the Holm oak.

Throughfall water contained practically 4 to 4,5 times more potassium than precipitation water.

The fluctuations of rainfall in the Aurès may generate a shortage of nutrient supplies that can significantly influence, not only the availability of the three important elements (nitrogen, phosphorus and potassium), but also the tree resistance to drought.

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EFFECT OF CUTTING INTERVALS ON YIELD AND QUALITY OF THE GREEN FODDER *TRICHANTHERA GIGANTEA*

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ABSTRACT

This study was aimed to determine the effect of cutting intervals on leaf yield and quality of the green fodder *Trichanthera gigantea* used as feed material, mostly in poultry and rabbit diets, in order to improve farm animal products (such as meat and egg). This study included five different formulas (NT) representing five different cutting intervals, namely: NT1: 40 days, NT2: 50 days, NT3: 60 days, NT4: 70 days and NT5: 80 days of cutting intervals. All treatments were allocated in a complete block randomized design; each treatment was repeated 5 times. The other factors such as plantation density, cutting height and fertilizer dosage were similar among the treatments. The obtained results showed that from NT1 to NT5, the leaf dry matter yields were 7.34, 12.13, 12.41, 11.94 and 11.80 tons/ha/year, respectively; crude protein yields were 1.88, 3.13, 3.06, 2.78 and 2.69 tons/ha/year. When the cutting intervals increased from 40 to 80 days, the proportion of dry matter in the fresh leaves increased from 12.91% to 21.04%, crude protein proportion on dry matter decreased from 25.56% to 22.77%; crude fiber proportion on dry matter increased from 9.92% to 12.50%. Based on statistical analysis of dry matter yield and leaf chemical composition of green fodder *T. gigantea*, it is recommended that the most suitable cutting intervals for *Trichanthera gigantea* should be 50 – 60 days.

Keywords: Cutting intervals, leaf yield and quality, *Trichanthera gigantea*.

INTRODUCTION

There is a number of factors which greatly affect the quantity as well as the quality of the green fodders, for example, the plant varieties, season of the year (dry or raining season), fertilizer application, irrigation, plantation and harvesting technique etc. Of the harvesting, a cutting interval which is also called the gap between the two cuttings greatly affects the productivity and quality of green fodders. The cutting interval too short or too long may reduce the productivity of the following harvest because with a short cutting interval, the plants are not able to accumulate enough nutrients for the later regeneration, and a long cutting interval will push back the following harvest until after the dry season, causing the decrease of yield. This statement has been approved by Fadiyimu et al. (2011),

Quang et al. (2013), Hien et al. (2019) when studied on harvesting intervals of several green fodders. On the other hand, the long cutting interval will increase the proportion of mature foliage, leading to a reduction of crude protein and an increase of fiber contents in leaves, thus reduces the quality of feed (Kien et al., 2010; Nouman, 2012; Hien et al. 2013; Hien et al., 2019). Therefore, it is important to determine an appropriate cutting interval in the development of green fodder production.

MATERIALS AND METHODS

The study focused on the green fodder *Trichanthera gigantea* and it was conducted at Thai Nguyen University of Agriculture and Forestry, Thai Nguyen Province, Vietnam from March 2017 to March 2019. Meteorological data (temperature, humidity and rainfall) from April to October (raining season) was favorable for green food crops to grow and develop, the rest (dry season) was less favorable for plant development. The experimental soil was of an average fertile type.

The experiment included 5 treatments (NT), representing 5 different cutting intervals, so-called as NT1: 40, NT2: 50, NT3: 60, NT4: 70 and NT5: 80 days/cutting interval. Each treatment was carried out on an area of 24m² with 5 replicates (5 lots/treatment), and arranged in a complete randomize block design. The other factors such as plantation density, cutting height and fertilizer dosage were similar among the treatments. The monitoring indicators included the productivity and yield of biomass, fresh leaves, dry matter, crude protein and leaf chemical composition. The productivity and yield were determined following the method from Hien et al. (2002). Productivity is total biomass or fresh foliage or dry matter obtained/ha/harvest; the unit expressed as kg/ha/harvest. In this trial, the biomass productivity was determine by cut and weigh the whole biomass of each lot, then divided by 24m² to calculate the biomass productivity of 1m² and 1ha of the lot, productivity of 1 treatment was the average of 5 lots. The fresh foliage productivity was calculated by multiply biomass productivity with the percentage of fresh foliage in biomass (this ratio (y%) was determined by weighing the biomass (a), separated the leaves from the branches then weigh (b), $Y\% = b/a \times 100$). Foliage dry matter productivity was calculated by multiply foliage productivity with its dry matter content. Production yield is the total biomass or fresh foliage, dry matter, crude protein harvested within a year; expressed as ton/ha/year. Yield was calculated by adding productivity (biomass, fresh foliage, dry matter) of all harvests of production year or by multiply the average harvest productivity/year (biomass, fresh foliage, DM) with the numbers of harvest/year; these 2 calculations differed from 0 – 5%. CP yield was calculated by multiply DM yield with CP percentage in DM. The chemical composition of leaves was analyzed according to A.O.A.C (1990). Each criterion was analyzed with 5 replicates (n = 5). To assess the quality of green fodder, some of the main chemical components of *T. gigantea* leaves in different cutting intervals including dry matter (DM), crude protein (CP), crude lipid (Ether Extract - EE), crude fiber (CF), total mineral (Ash) were analyzed; Nitrogen-free extract (NFE) is calculated by $DM - (CP + EE + CF + Ash)$.

Results were statistically analyzed following the method described by Oanh and Phu (2012) using IRRISTART software 5.0.2009.

RESULTS AND DISCUSSION

Effects of cutting intervals on the productivity of T. gigantea

The average productivity of biomass, fresh leaves, dry matter per hectare per cutting of 2 experimental years are presented in Table 1.

Table 1. The productivity of *T. gigantea* at different cutting intervals (kg/ha/harvest)

Treatments	Biomass	Fresh leaves	DM
NT1 (40 days)	13,597 ^d	8,746 ^c	1,129 ^d
NT2 (50 days)	23,223 ^c	14,529 ^b	2,205 ^c
NT3 (60 days)	29,598 ^b	15,753 ^a	2,758 ^b
NT4 (70 days)	33,283 ^a	15,453 ^a	2,986 ^a
NT5 (80 days)	33,537 ^a	14,025 ^b	2,951 ^a
SEM	1103.0	563.4	99.8
P	0.000	0.000	0.000

The values with different letters are significantly different ($p \leq 0.001$) in accordance with the LSD test.

Effects of cutting intervals on biomass productivity

Biomass productivity included whole stems, branches and foliage of green fodder plants obtained per ha per harvest. This was the basis for calculating the productivity of fresh leaves and dry matter. The average biomass productivity/harvest of both years (kg/ha/harvest) increased from 13,597 (NT1) to 33,537 (NT5). The average biomass productivity of different treatments differed significantly with $P < 0.001$, except NT4 had no difference from NT5. Therefore, increasing cutting intervals from 70 to 80 days did not make a significant difference in biomass productivity. The main reason was that the long cutting intervals pushed the harvests until after the dry season, leading to low productivity. The average biomass productivity of 5 treatments of 2 years of *T. gigantea* reached 26,600 kg/ha/harvest. In previous studies, the average biomass productivity (kg/ha/harvest) of 2 years of cassava for leaf collection was 17,400 (Hien and Trung, 2016), of *L. leucocephala* was 15,100 (Hoan et al, 2017), of *S. guianensis* was 19,400 (Hien et al, 2017), of *M. oleifera* was 22,000 kg/ha/harvest (Hien et al, 2019). Thus, the average biomass productivity of *T. gigantea* in this experiment was higher than the average biomass productivity of the green forage crops commonly used to produce leaf meal in Vietnam, which were informed by the previous researchers.

Effect of cutting intervals on productivity of fresh leaves

When producing leaf meal, stems and branches of the green food plants are often removed, and only fresh leaves are used. Therefore, it is necessary to determine the productivity of fresh leaves. The foliage productivity determination was described

in the Materials and Methods (M&M) section showed that fresh foliage productivity not only depended on biomass productivity but also on ratio of fresh leaves/biomass, this ratio varies with age (cutting intervals) of plants; accordingly, when the cutting interval is short, the plants are young and the branches are small, so the ratio is high; when the cutting interval is long, the old stems and big branches cause the low rate. The weighted average percentage of fresh leaves/biomass of harvests of NT1, NT2, NT3, NT4 and NT5 were determined as 61.32%; 62.56%, 53.24%, 46.43% and 41.82% respectively. Fresh leaf productivity did not follow the rules of biomass productivity. It did not increase steadily when the cutting intervals increased, but the average productivity of fresh leaves/harvest/2 years increased from NT1 to NT3 from 8,746 to 15,753 kg/ha/harvest. After that, it gradually reduced to 14,025 kg/ha/harvest in NT5 because the increase of cutting intervals resulted in the decrease of the rate of fresh leaves/biomass as explained above. The average productivity of fresh leaves/ harvest/2 years was significantly different with $p < 0.001$; however, there was no significant difference between NT3 and NT4 and between NT2 and NT5.

Effect of cutting intervals on productivity of dry matter

After the fresh leaf productivity was defined, the dry matter (DM) productivity was calculated. The DM productivity which previously described in M&M section showed that DM productivity not only depended on fresh foliage productivity but also on DM content in fresh foligae, this ration also changed in accordance with cutting intervals; It was low when the cutting interval was short because young leaves had a high rate of water, low rate of DM and vice versa. The rate of DM/fresh leaves from intervals of 40 to 80 days were determined as 12.91%; 15.18%; 17.51%; 19.32% and 21.04%, respectively.

The productivity of DM was similar to that of biomass but there was a difference that when cutting intervals increased, the average productivity/harvest/2 years increased sharply from NT1 to NT3 (from 1129 to 2758 kg/ha/harvest) but only slightly increased in the later treatments. The productivity of DM was significantly different ($p < 0.001$) among treatments, except NT4 compared with NT5.

The influence of the cutting intervals on the productivity of green food crops had been studied by many scientists who concluded that too short intervals (too early harvest) would give low productivity/harvest; lengthening cutting intervals could increase productivity/harvest but when the intervals were too long, the productivity did not increase much, sometimes even decreased (Kien et al. 2010; Fadiyimu 2011; Quang et al. 2013; Hien et al. 2019).

Effect of cutting intervals on yield of *T. gigantea*

Yield is the total volume of biomass or fresh leaves, dry matter, crude protein obtained per hectare/year. Cách tính the yield of biomass, fresh leaves, dry matter and the crude protein yield which described in the M&M section. The average yields of biomass, fresh leaves, DM and crude protein per hectare per year of two experimental years are presented in Table 2.

Table 2. Yield of *T. gigantea* in different cutting intervals (tons/ha/year)

Treatments	Biomass	Fresh leaves	DM	Crude protein
NT1 (40 days)	88.383 ^b	56.848 ^d	7.339 ^b	1.876 ^c
NT2 (50 days)	127.729 ^a	79.907 ^a	12.130 ^a	3.125 ^a
NT3 (60 days)	133.147 ^a	70.887 ^b	12.412 ^a	3.062 ^a
NT4 (70 days)	133.133 ^a	61.813 ^c	11.942 ^a	2.781 ^b
NT5 (80 days)	136.146 ^a	56.100 ^d	11.803 ^a	2.688 ^b
SEM	5.046	2.711	0.457	0.111
P	0.000	0.000	0.000	0.000

The values with different letters are significantly different ($p \leq 0.001$) in accordance with the LSD test.

Although biomass productivity increased sharply from NT1 to NT5, biomass yield increased only from NT1 to NT3, and then hardly increased in the next treatments. The reason is that NT4 and NT5 had higher productivity of biomass/harvest, but had fewer harvests than NT1, NT2 and NT3. Biomass yields of NT2 - NT5 were significantly different from NT1 ($p < 0.001$) but there was no significant difference among them ($p > 0.05$).

The yield of fresh leaves increased from NT1 to NT2, then decreased gradually. Fresh leaf yield of NT5 was only equivalent to NT1 because the increase of cutting intervals caused the development of stems and branches, leading to a reduction in the ratio of fresh leaves/ biomass from NT1 to NT5 (from 64.32% to 46.43%). The fresh leaf yield of different treatments differed significantly with $p < 0.001$.

Dry matter yield increased sharply from NT1 to NT2, slightly from NT2 to NT3, then decreased gradually in NT4 and NT5. The DM yields of NT2 to NT5 were not significantly different ($p > 0.05$) but they were significantly different from that of NT1. Thus, based on DM yield, *T. gigantea* should not be harvested in the cutting interval of 40 days.

The crude protein yield depends on two factors, namely, DM yield and ratio of crude protein in DM; this ratio of NT1 to NT5 were 25.56%; 25.76%; 24.67%; 23.29% and 22.77% respectively. Thus, the percentage of crude protein/DM was high in short intervals and low in long intervals (i.e. 25.56% with interval of 40 days and 22.77% with interval of 80 days). Therefore, the change of crude protein yield among the treatments was similar to DM yield, which increased from NT1 to NT2 and then gradually decreased in NT3, NT4 and NT5. The crude protein yields of the treatments were significantly different ($p < 0.001$), except for NT2 compared to NT3 and NT4 compared to NT5. Thus, based on crude protein yield, *T. gigantea* should be harvested in cutting intervals of 50 or 60 days, not in intervals of 40 or 70, 80 days.

Kien et al. (2010), Fadiyimu et al. (2011), Nouman (2012), Quang et al. (2013), Hien et al. (2013), and Hien et al. (2019) studied the effect of cutting intervals on the yield of different food crops. Their research results showed that increasing cutting intervals made the yield of green matter, DM and crude protein grow up,

but the interval that was too long made the yield increase unremarkably and even decrease. In general, the selection of long or short cutting intervals depends on meteorology and soil nutrition, and has to ensure that the plants accumulate enough nutrients for later regeneration (Assefa, 1998; Latt et al., 2000).

*Effect of cutting intervals on quality of *T. gigantea**

Results of foliage chemical composition are presented in Table 3.

Table 3. Chemical composition of *T. gigantea* leaves in different cutting intervals

Intervals (days)	DM in fresh leaves (%)	% DM				
		CP	EE	CF	Ash	NFE
40	12.91 ^f	25.56 ^{ab}	2.48 ^d	9.92 ^c	24.63 ^a	37.41 ^a
50	15.18 ^d	25.76 ^a	2.57 ^{cd}	10.01 ^c	23.72 ^b	37.94 ^a
60	17.51 ^c	24.67 ^b	2.80 ^c	11.19 ^b	22.90 ^c	38.44 ^a
70	19.32 ^b	23.29 ^c	3.36 ^b	11.96 ^a	22.00 ^d	39.39 ^a
80	21.04 ^a	22.77 ^c	4.18 ^a	12.50 ^a	20.94 ^f	39.61 ^a
SEM	0.0171	0.0088	0.0116	0.0087	0.0101	0.0206
P	0.0038	0.0019	0.0026	0.0019	0.0023	0.0046

The values with different letters are significantly different ($p \leq 0.01$) in accordance with the LSD test.

As shown in Table 3, when cutting intervals increased from 40 to 80 days, the rate of DM in fresh leaves increased by 8.13%, from 12.91% to 21.04%. This rate of five treatments had a significant difference with $P < 0.01$. The rate of DM/fresh leaves remarkably affected DM yield, which was the main indicator of assessment on production capacity of green fodders. The rate of DM/fresh leaves in the interval of 40 days was the lowest (12.91%), which is one of the two main causes of low DM yield of this treatment and therefore it should not be selected for green fodder production.

The crude protein ratio in DM increased from the intervals of 40 days to 50 days, and then decreased at the cutting intervals of 60; 70 and 80 days (from NT2 to NT5 decreased by 2.99%). The crude protein rates in DM of five treatments had relatively remarkable differences ($p < 0.01$), except for NT1 compared to NT2, NT3. The 50-day and 60-day cutting intervals had high DM yield and high protein/fresh leaf ratio, so the protein yields of these intervals were significantly higher than the remaining intervals. This is the factor that should be considered when choosing appropriate cutting intervals.

When cutting intervals increased from 40 to 80 days, the fiber ratio in DM increased sharply, from 9.92% to 12.50%. This rate was relatively different among treatments with $p < 0.01$, except for NT1 compared to NT2. The high rate of fiber in feed will affect the amount of consumed feed and the rate of feed digestion of livestock. Therefore, to obtain good quality leaf meal, *T. gigantea* should not be

harvested in long cutting intervals (70, 80 days). The 40-day cutting interval had the lowest fiber/DM ratio (9.92%), but it had significantly lower DM and crude protein yield than the intervals of 50 and 60 days, so it should not be selected.

The rate of ash in DM decreased, while lipid and nitrogen-free extract in DM increased when cutting intervals increased. It was significant different among treatments ($p < 0.01$).

The cutting intervals have a great influence on the quality of green fodder, so it has been paid attention by many scientists. For example, Kien (2010) studied cutting intervals for grass *P. atratum* and *B. brizantha*; Fadiyimu et al. (2011), Nouman (2012), Hien (2019) studied intervals for *M. oleifera*; Hien et al. (2013) studied intervals of cutting on grass *B. decumbens*; Quang et al. (2013) had research on *S. guianensis*. These authors all pointed out that the raise of cutting intervals increased the rate of DM, fiber and reduced protein ratio. The longer the cutting intervals are, the more sharply the above rates grow up and down. This feature should be taken into account when producing green feed.

CONCLUSION

The experimental results with cutting intervals of 40, 50, 60, 70 and 80 days/harvest for green fodder *Trichanthera gigantea* showed that the yields of DM /ha/year of the intervals from 50 to 80 days had no significant difference but they were remarkably higher than that of the 40-day interval. The yields of crude protein/ha/year of the 50-day and 60-day intervals were higher with significant differences compared to the remaining intervals; 70 and 80-day cutting intervals had a significantly higher rate of fiber and remarkably lower rate of crude protein in DM than the shorter cutting intervals. These results allow to exclude the intervals of 40, 70 and 80 days, so the cutting intervals of 50 and 60 days are appropriate.

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EFFECT OF OMEGA 3 ON THE REPRODUCTIVE PERFORMANCE OF THE ALGERIAN SYNTHETIC RABBIT IN ARTIFICIAL INSEMINATION

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ABSTRACT

In the present work of the pubescent and immature rabbit does of the Algerian synthetic strain (ITELV 2006), the animals received a supplement of omega 3 of animal origin (fish oil) or vegetable origin (linseed) for 3 months (2 months before AI and 1 month during pregnancy). The females were followed until parturition in order to study the effect of omega 3 on their reproductive performance (fertility, prolificacy and stillbirth). Comparison of data between the six lots (Control puberts (CP), Control peripubertal (CPE), Linen grains pubertal (LGP), Linen grains peripubertal (LGPE), Fish oil puberts (FOP) and Fish oil peripubertal (FOPE)) for parameters of born deaths (BD), fertility and stillbirth rates showed no significant difference ($P>0.05$). Whereas for total births (TB), live births (LB) and weaner births (WB), the differences are significant ($P<0.05$). A very marked improvement in prolificacy has been achieved by the incorporation of fish oil and flaxseed into the feed of the rabbits. In fact, the females of these two lots recorded the highest values (10.37 TB, 9.87LB, 9.3 WB and 10.44 TB, 9.77LB, 8.77WB respectively for FOPE and LGPE), as opposed to the unpunished rabbits of the control lot which gave the lowest numbers (7.14TB, 6.57LB and 6.57WB).

Keywords: *Fish oil, linseed, fertility, prolificacy, stillbirth.*

INTRODUCTION

In Algeria, numerous scientific research axes have been drawn up by several institutions (Institutes, universities, National School of Agricultural Sciences) in order to carry out work on the synthetic strain ITELV 2006. The majority of this work focused on describing characteristics from characterization work at experimental and research stations, such as Zerrouki and al. (2005); Mefti and al. (2010), Cherfaoui and al. (2013). This work on characterizing the reproductive

performance of this strain has revealed a relatively high level (Gacem and al. 2009; Bolet and al., 2012; Sid and al. 2018). Nevertheless, a minority of scientific work had focused on the use of different biotechnologies for this strain. Within this framework, the research project carried out by the laboratory of natural bio-resources of the University Hassiba Benbouali of Chlef which deals with biotechnologies applied to livestock farming and in which the present study. To enable the rabbit to express its performance, it is necessary to control its conduct and optimize the conditions of its rearing, in particular feeding and reproduction. The management of the reproduction has changed from natural projection to artificial insemination and the conduct in strip, thus facilitating the management of the farms and ensuring a better profitability (Lebas, 2002; Theau-Clément 2005 and Theau-Clément 2008). At the same time, the control of AI has enabled the establishment of a new production system which is defined by the «duct en bande» and a better organization of the farms. As in other animals, feeding can have multiple influences on rabbit performance. Changes in these may be achieved by changing the composition of the food (Lebas, 2010). Several authors have studied the effects of increasing levels of omega-3 fatty acid in foods on the quality of rabbit meat both qualitatively and quantitatively (Colin et al, 2005; Benatmane F., 2012; Lebas F, 2007). However, little work has been done on the effect of omega-3 fatty acid supplementation on reproductive performance in this animal. The objective of our work is to study the comparative effect of supplementation of Omega-3 fatty acids of animal (fish oil) or vegetable (extruded flaxseed) on reproductive performance (receptivity, fertility, prolificacy and embryonic mortality) of pre-pubescent and pubescent rabbits conducted in AI.

MATERIALS AND METHODS

The experiment was carried out on pubic nulliparous females aged 4 to 5 months and peripubertal aged 2 months. Three males of the same 7-month-old strain used for semen collection are used in the experiment. All females are housed in a hard-built building, have windows providing ventilation and natural lighting and conducted 2 extractors for ventilation.

A cooling system is insta. The rabbit cages, made of wire mesh, are 100 cm long by 43 cm wide and 31 cm high. All cages are equipped with a feeder and a semi-automatic water trough in the form of a nipple.

During the experimental period, all females receive 150g/d of commercial standard feed in the form of pellets, containing alfalfa bran, forage wheat, corn, soybean meal, molasses, anticoccidien, phosphate, amino acid, trace elements and salt. The chemical composition of the food is given in Table 1. For the experimental lots, the basic ration is supplemented by flaxseed or fish oil. Females receive omega-3s for 3 months (2 months before AI and 1 month during gestation).

Table1. Chemical composition of standard food

The	Dry matter DM (%)	91,42
	Minerals matter MM (%)	7,51
	Crude protein CP (%)	14,5
	Crude cellulose CC (%)	9,49
	Fat matter FM (%)	3.38
	Calcium (%)	0,89
	Phosphorus (%)	0,6

sixty-six rabbits used in the study were divided into 6 homogeneous lots (n=11) with 2 pubic (P) and peripubertal (PE) control groups and 4 groups for which the diet is enriched either with fish oil, or with extruded flaxseed for P and PE females for the supply of polyunsaturated fatty acids. Thus the 66 rabbits are distributed as follows:

Lots CP and CPE (control puberts, n=11 and control peripubertal, n=11) receive the basic ration of 150g/d of the standard feed.

Lots LGP and LGPE (flaxseed pubères, n=11 and flaxseed peripubertal, n=11) receive a basic ration of 150 g/d to which 3% flaxseed per day was added.

The FOP and FOPE batches (puberts fish oil, n=11 and peripubertal fish oil, n=11) received a basic ration of 150 g/d to which was added 2% fish oil per day.

After two months, the rabbits of the six lots were artificially inseminated with semen collected and analysed at the laboratory level. The gestation diagnosis was made by abdominal palpation, performed on the 11th day of AI.

The reproductive parameters of the rabbits in the six lots, based on the diet and age of the females, were evaluated using fertility, birth and weaning prolificity and stillbirth rates. The means and standard deviations of the identified reproduction parameters were calculated using the Excel software (descriptive statistics). Comparison between batches for reproduction performance was done by variance analysis using the Xlstat 2016 software.

RESULTS AND DISCUSSION

Overall and far from the effect of n-3 fatty acid supplementation, the three treatments studied allow for consistent performance with those reported by the bibliography for rabbit of the Algerian synthetic strain (Chibah, 2016; Sid et al., 2018).

Comparison of the data for the six lots for fertility and stillbirth rates showed no significant differences ($P > 0.05$). While for total born (TB), live born (LB) and weaned born (WB), the differences are significant (table 2).

Table 2. Reproductive performance of rabbits in the 6 lots (mean standard deviation)

	CP	CPE	LGP	LGPE	FOP	FOPE	p
Fertility rate (%)	54.54 (n=6)	63.63 (n=7)	54.54 (n=6)	81.81 (n=9)	63.63 (n=7)	72.72 (n=8)	0.74
Stillbirth rate (%)	4.23 ±6.05 (n=6)	8.84 ±14.04 (n=7)	6.11 ±8.69 (n=6)	5.42 ±7.37 (n=9)	6.71 ±6.82 (n=7)	4.96 ±6.55 (n=8)	0.96
Number of total births (TB)	7.33 [©] ±1.49 (n=6)	7.14 [©] ±2.03 (n=7)	8.00 [©] ±2.30 (n=6)	10.44 ^(a) ±1.57 (n=9)	8.43 ^(b,c) ±1.59 (n=7)	10.37 ^(a,b) ±1.93 (n=8)	0.004
Number of live births (LB)	7 ^(b) ±1.41 (n=6)	6.57 ^(b) ±2.38 (n=7)	7.50 ^(b) ±2.06 (n=6)	9.77 ^(a) ±0.91 (n=9)	8.00 ^(a,b) ±1.85 (n=7)	9.87 ^(a) ±1.96 (n=8)	0.006
Number of deaths born (DB)	0.33 ±0.47 (n=6)	0.57 ±0.90 (n=7)	0.5 ±0.76 (n=6)	0.66 ±0.94 (n=9)	0.43 ±0.49 (n=7)	0.5 ±0.70 (n=8)	0.98
Number of born weaned (BW)	6.66 ^(b,c) ±1.97 (n=6)	6.57 [©] ±2.38 (n=6)	6.5 [©] ±1.89 (n=6)	8.77 ^(a,b) ±1.22 (n=9)	7 ^(b,c) ±1.77 (n=7)	9.37 ^(a) ±1.79 (n=7)	0.02

CP: Control puberts. CPE: Control peripubertal. LGP: Linen grains pubères, LGPE: Linen grains peripubertal, FOP : Fish oil puberts, FOPE : and Fish oil peripubertal. p: statistical significance. On each line, the numbers affected by different letters (a,b,c,) are significantly different at the 5% threshold.

We find that the fertility rate has been improved by the addition of omega-3 in the diet of the peripubertal rabbits for both the diet enriched with flaxseed (81.81%) and the diet enriched with fish oil (72.72), although the statistical analysis showed no significant differences between the six treatments ($P>0.05$).

Colin et al. (2012) show improved fertility through incorporation of flaxseed extruded into food in a synthesis of work on 2179 rabbits. These same authors note that this improvement was achieved with low fertility levels in the control diet. In our study the control lots have the lowest fertility rates, 54.54% for CP).

For the birth mortality rate, no statistically significant differences were found ($P>0.05$). The diet enriched with polyunsaturated fatty acids (PUFA) does not result in any difference for rabbits in the six lots. Overall and apart from the effect of the incorporation of n-3 fatty acids in the food, our animals have very satisfactory stillbirth rates and much lower than the value of 17.5 found by Moumen in 2017 on rabbits of the local population of the region of Aurès, Algeria.

Sid et al. (2018) reported slightly higher in ours (9.8%) for the same synthetic strain but a much higher rate for the white population (18.2%).

A very clear improvement on the components of prolificity was achieved by incorporating fish oil and flaxseed into the food. In fact, the diet enriched with omega 3 of animal origin allowed, in young and adult females, the most important means for the majority of the prolificity parameters studied: 8LB and 7BW for elderly females; 9.87LB and 9.36BW for young females).

Our results are consistent with those of Colin et al. (2012), which showed an improvement in prolificity through extruded flaxseed supplementation in food in a synthesis of work on 2179 rabbits.

Overall, the prolificity results obtained in this study are close to those of the bibliography for the synthetic strain ITLV 2006, indeed, Zerrouki et al. (2014) published comparable values for rabbits reared at two stations: Baba Ali (8.76) and Lamtar (8.02).

In terms of LB, the results recorded during the study show a response of the rabbits to the diets tested. This finding is consistent with that of Colin et al. (2005) who confirm that the incorporation of 7% omega-3, in the form of flaxseed extruded into the food, significantly improves the number of live rabbits born per litter. For infant deaths, statistical analyses showed no significant difference ($P > 0.05$) between the six lots.

The number of DB ranges from 0.33 to 0.66. This finding is consistent with that of Gacem et al. (2009), which reported a value of 0.58 for the white population and 0.7 for the synthetic strain. Conversely, Sid et al. (2018) report higher values for the synthetic strain (0.8) and the white population (1.3).

The highest number of weaned lapereaux (9,37) is obtained in unpunished rabbits receiving the feed containing fish oil, followed by the unpunished rabbits receiving the feed enriched with flaxseed (8,77). I assumed that the lowest value is 6.5 at the level of the pubic lot receiving the feed with the flaxseed and the impudent lot checking. The withdrawal prolificity values obtained in the pubic lots receiving flaxseed in the diet and control lots for young and adult rabbits are very close to those recorded by Zerrouki et al. (2014) for the same strain are: 6.85 at Baba Ali and 6.61 at Lamtar. The improvement in the number of pupae weaned following the incorporation of omega-3s in the food, highlighted in this experiment, was reported by Colin et al. (2017), which confirm that the incorporation of algae rich in docosahexaenoic acid (DHA) into food significantly improves the viability of rabbits. This is explained, according to the same authors, by the fact that the level of omega 3 fatty acids in the milk of rabbits receiving food containing extruded flaxseed is 2 to 3 times higher than that of control rabbits. This result is very interesting since omega-3s play a very important role in immune development. However, Maertens et al. (2005) indicate that the performance of the control and extruded flaxseed concentrate rabbits was not significantly different between the two diets, but overall the females in lot omega-3 weaned 3.5 more pups during the experimental period. The Omega 3 feed produced higher milk fat (+1.3%; $P > 0.05$) and the dietary profile of Pufas was very well reflected in the milk.

CONCLUSIONS

In this study, we investigated whether an increase in omega 3 fatty acid content in the diet of breeding rabbits, either by the addition of extruded flaxseed or fish oil could improve reproductive performance. Our results suggest a significant improvement in reproductive performance due to the addition of flaxseed and fish oil. There was no significant improvement in fertility or stillbirth rates in the experimental lots compared to the control lot. Nevertheless, it was clear, although not significant, that the addition of fish oil or flaxseed resulted in better rates than the control lots. It should be noted that the standard feed constituting the basic ration for the control lot contains a significant amount of dehydrated alfalfa high in n-3 GA. The enrichment of the food by Agpin-3 made it possible to obtain, in young females (impubeers), better fertility rates and litter sizes at birth and weaning compared to adult females. These preliminary results point us towards an interest in studying young rabbits of this very prolific strain and preparing them to ensure better productivity with better body condition.

It should be noted that in our study, the incorporation rates are minimum, 3% flaxseed and 2% fish oil. It would be interesting, therefore to start trials with higher levels of omega 3, with a better balanced food and a larger number of females that will be monitored over a higher number of breeding cycles.

It is interesting to conduct studies with diets with a low intake of omega 3, so that the effects of n-3 PUFA are more marked. Indeed, in the absence of information indicating the exact levels of the food marketed in omega-3 fatty acids, the effect of the intake must be confirmed by in-depth analyses determining the quantity and quality of omega-3 fatty acids in the standard food.

The results obtained, at the end of this modest work, show that AI provides encouraging fertility and prolificacy rates for the synthetic strain.

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ALTERNATIVE PECTIN PRODUCTION METHODS AND SOURCES

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ABSTRACT

Pectin is a polysaccharide, found in the cell wall of high plants that imparts flexibility and mechanical strength to plants by interacting with other cell wall elements. It is widely used in the food, cosmetic and pharmaceutical industries, as thickener, texturizing, emulsifying, stabilizing and gelling agent. The most commonly used method for pectin production is the acid extraction method. Due to the low extraction efficiency with limited yield, many methods have been developed such as enzyme, microwave and ultrasound-assisted extractions and subcritical water extraction. Pectin is commercially produced from mainly citrus peels followed by apple pomace, sunflower head and sugar beet pulps and the properties of the pectin depend on the source that are isolated from. Finding alternative sources methods are necessary that can compete with the production cost and properties of the commercial pectin sources. In this study, alternative pectin production methods, pectin sources and possibilities for the industrial use of the pectin produced with them were reviewed.

Keywords: *Extraction methods, Pectin sources, Food waste, Pectin properties.*

INTRODUCTION

The pectic components found in plants were first identified by French chemist Louis Nicolas Vauquelin in 1790 and isolated in 1825 by French chemist Henri Braconnot. Pectin is a multifunctional component of a cell wall, a high-value functional food component used as a gelling and stabilizing agent (Georgiev *et al.*, 2012) It is composed mainly of an α -1,4-D-galacturonic acid residue. It is water-soluble and can form a gel with sugar and acid under favorable conditions. It is present in different fruits and vegetables in different qualities and amounts (Arslan, 1994) and the properties of the pectin depend on the source that are isolated from. This study covers alternative pectin production methods, pectin sources and possibilities for the industrial use of the pectin produced with them.

Pectin and Structure

Pectin is a structural heteropolysaccharide that is naturally found in the cell walls and intercellular regions of plant tissues. It plays an important role in the growth and development of the plant and provides mechanical resistance to the plant (Zhang *et al.*, 2013). It coexists with hemicellulose and cellulose in the primary cell wall of plants (Buggenhout *et al.*, 2009) (Figure 1).

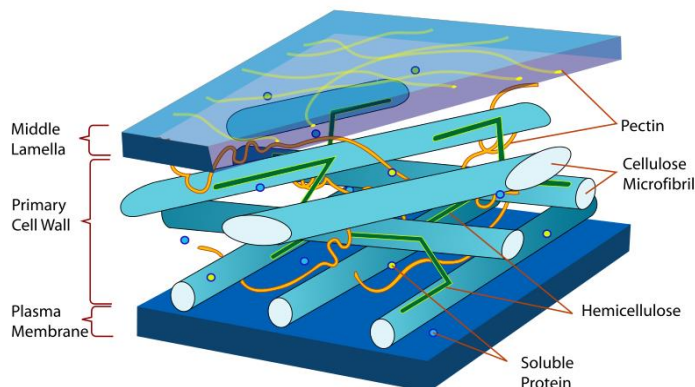


Figure 1. The position of pectin in the primary cell wall model (Anonymous, 2019).

The pectin molecule consists of four basic structures: homogalacturonan, ramnogalacturonan I, ramnogalacturonan II and xylogalacturon (Willats *et al.*, 2001) (Fig. 2). The galacturonic acid units of pectin are partly esterified with methanol. Amount with less than 50% is named as low methoxyl pectin and above 50% is named as high methoxyl pectin. The gelling rate of pectin depends on the degree of esterification, and as the degree of esterification increases, the rate of gelling increases. Gelling rate is an important parameter affecting the texture of the food product. High methoxylated pectin forms gel with high amount sugars (more than 50%) and acid, while low methoxylated pectins form gel with multivalent cations (such as Ca^{+2} , Mg^{+2}) at low sugar concentrations (Arslan, 1994).

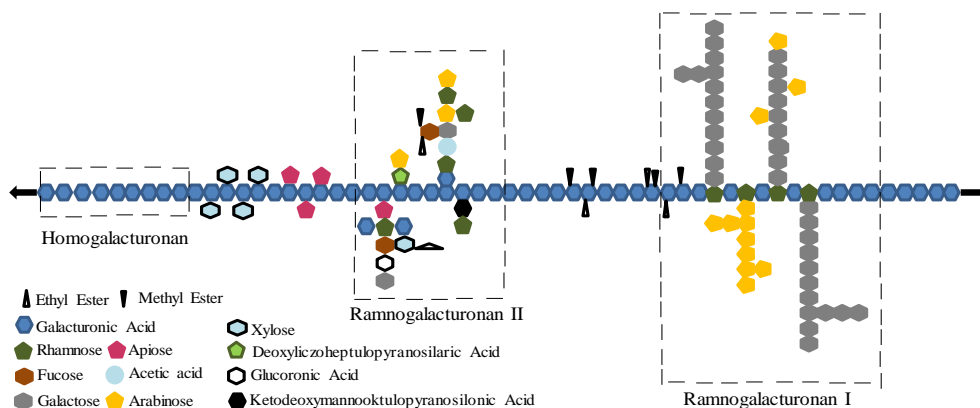


Figure 2. Structure of pectin (Harholt *et al.*, 2010)

Pectin Resources

Pectin is found in the most of plant tissues, but the amount for the production of it is not sufficient for all plants. In some plants, it is found in high amount, but pectin is not suitable for food use. The most important pectin sources are apple pomace, citrus peels, sunflower head and sugar beet pulp. Among them citrus peels are mostly used as a raw material in pectin production due to its high quality, high yield and widespread availability (Yıldırım, 2013). However, alternative sources; cocoa husks (Chan and Choo, 2013), mulberry branch bark (Liu *et al.*, 2011), sisal wastes (Santos *et al.*, 2015), watermelon peel (Prakash *et al.*, 2014), orange, apple, pomegranate, melon and kiwifruit peels (Güzel and Akpınar, 2019), pumpkin (Ptichkina *et al.*, 2008), banana peels (Oliveira *et al.*, 2016), potato pulp (Yang *et al.*, 2018), wolf apple (*Solanum lycocarpum*) (Torralbo *et al.*, 2012) and carrot pulp (Wikiera *et al.*, 2015; Jafari *et al.*, 2017) are also being investigated for pectin production. The pectin yields obtained from different sources are summarized in Table 1.

Table 1. Pectin contents of some fruits and vegetables

Source	Pectin (%)	References
Orange peel	2.95, 11.46, 28.27	Georgiev <i>et al.</i> , 2012; Güzel and Akpınar, 2019; Hosseini <i>et al.</i> , 2019
Apple	14.5	Wikiera <i>et al.</i> , 2015
Banana	5.2-12.2	Oliveira <i>et al.</i> , 2016
Sugar beet	22.4	Mesbahı <i>et al.</i> , 2005
Pear	0.9-1.4	Çelik, 2007; Baker, 1997
Tomato	2.4-4.8	Çelik, 2007; Baker, 1997
Strawberry	0.6-0.7	Çelik, 2007; Baker, 1997
Carrot	5-15.2	Jafari <i>et al.</i> , 2017
Melon rind	6.54	Güzel and Akpınar, 2019
Kiwifruit peel	8.03	Güzel and Akpınar, 2019
Grapefruit peel	20.93-27.51	Wang <i>et al.</i> , 2015; Taşan, 2018
Pomegranate peel	3.92 -11.18	Pereira <i>et al.</i> , 2016; Güzel and Akpınar, 2019
Artichoke (<i>Cynara scolymus L.</i>)	22.14	Sabater <i>et al.</i> , 2018
Pomelo (<i>Citrus grandis(L.) Osbeck</i>)	19.6	Liew <i>et al.</i> , 2018

Pectin Production Methods

Pectin production consists of the extraction of it with the acid and precipitation of it with alcohol followed by filtration, purification, drying and grinding (Yıldırım, 2013). The most important factor affecting the yield and quality of pectin is the extraction stage, especially acid type, pH, time, temperature, solvent/solid ratio, solvent type, raw material and particle size (Perussello *et al.*, 2017). In the

conventional acid extraction method, pectin is extracted using different acids (sulfuric, nitric, citric, phosphoric, acetic or hydrochloric acid) at an extraction temperature of 80-100°C and concentrations of 0.05-2M (Georgiev *et al.*, 2012). Although acid extraction is economical, the acids used in the extract can damage the pectin structure and cause environmental problems. In addition, during pectin extraction, the yield and quality of pectin decrease depending on time and temperature (Adetunji *et al.*, 2017). Pectin depolymerization is occurred more in extraction of it with mineral acid than extraction with organic acid. For this reason, different extraction methods are investigated to isolate the pectin with high yield at low temperatures and in short time with less or no acidic solvent use (Min *et al.*, 2011). Ultrasound-assisted extraction, sub-critical water extraction, microwave-assisted extraction, enzymatic extraction are some of them.

Enzymatic extraction of pectin has become research interest in the last years (Puri *et al.*, 2012). There are two approaches for the enzymatic extraction of pectin. These are the isolation of pectin by the use of pectin degrading enzymes, and the isolation of pectin by cell wall degrading enzymes such as cellulases, amylases, hemicellulases and arabanases. However, the second approach is more common for the enzymatic pectin extraction. Enzymatic extraction is an environmentally safe method. It produces less waste problems than the conventional method, enzyme are specific and, the structural and functional properties of the extracted polysaccharides are retained better. The molecular weight of the released polymer is higher than the pectin obtained in the classical method. It also reduces the need for specific pre-treatment steps in (eg removal of sugars and color pigments) (Adetunji *et al.*, 2017). There are some problems for the industrial use of enzymes in the pectin production. The first is the cost of enzymes. The other one is the difficulty of the scale up the extraction process because different enzymes have different responses to environmental conditions such as temperature and food matrix. In addition, the extraction process is longer than the classical method (Adetunji *et al.*, 2017). In previous studies, it was found that pectins extracted by enzymatic method had more galacturonic acid than pectins extracted with acids, had higher methylation degree (Wikiera *et al.*, 2015) and had higher yields (Sabater *et al.*, 2018). In other studies (it was determined that pectins with high yields and superior properties were obtained by enzymatic extraction Ptichkina *et al.*, 2008; Min *et al.*, 2011; Yang *et al.*, 2018).

Subcritical water is liquid water at high pressure, which can reach temperatures higher than the normal boiling point without a change phase. Subcritical water extraction is also known as pressurized hot water extraction. High temperatures help to break down analyte-sample matrix interactions such as van der Waals forces, hydrogen bonding and dipole attraction, and increase extraction by accelerating extraction kinetics (Adetunji *et al.*, 2017). The disadvantages of this method are the hydrolysis of the pectin chain during extraction, the difficulty to control the process conditions, the dependence of the yield on the matrix and the high process costs (Adetunji *et al.*, 2017). However the method is fast and environmentally friendly. It was reported that the pectin yields by this method were

higher than by conventional and microwave pectin extraction methods and the pectins had better physicochemical, rheological and gelling properties than the others (Wang *et al.*, 2014).

Ultrasound assisted extraction method provides faster heat-mass transfer and low solvent usage. In addition, this process has many advantages such as low energy consumption, low extraction temperature, selective extraction, small equipment size, faster operation and elimination of some process steps used in conventional extraction steps. However, ultrasound assisted pectin extraction is an expensive system and the yield varies according to the materials used. Although ultrasound has started to be used in many fields, it is not widely used in the food industry due to its high investment costs (Adetunji *et al.*, 2017). In studies, it was determined that non-continuous ultrasound application provided higher efficiency than continuous ultrasound application (Bagherian *et al.*, 2011), this method increased the yield of pectin compared to the classical method and reduced extraction time without changing the pectin microstructures (Wang *et al.*, 2015).

Microwave assisted pectin extraction is a method applied in electromagnetic waves ranging from 0.3–300 GHz (Wang *et al.*, 2016). During microwave assisted extraction, microwaves pass through the plant tissue, the absorbed energy produces volumetric heating from the dipole rotation of polar molecules such as water, which causes vibration as there is molecular collision, leading to heat generation inside the plant tissue (Kute *et al.*, 2015). The most important advantages of this method are less solvent usage, less extraction time, high yield and lower energy consumption (Maran *et al.*, 2013). In this method, pectin extraction is affected by many parameters such as plant material, solvent type and volume, pH, microwave power, temperature, time (Košťálová *et al.*, 2016). When the studies were examined, it was determined that the extraction time was shorter compared to other methods and the increase in microwave power increased the pectin yields. In the studies, it was founded that the yields decreased at microwave power higher than 420 W (Maran *et al.*, 2015). It was also stated that during this method there was a risk that other polysaccharides could be extracted, so the method had to be improved (Kazemi *et al.*, 2019).

CONCLUSIONS

Commercially the most important pectin sources are citrus peels, apple pomace, sunflower heads and sugar beet pulps. Studies have also showed that high amount of pectin can be extracted from different food wastes such as fruit and vegetable peels. The use of food waste as a pectin source can reduce the pectin production cost and the disposal of the waste. Recently alternative pectin production methods have been developed for the shortening the process time and reducing the chemicals used in the extraction. Among them microwave and enzymatic assisted extractions are the most promising methods due to high pectin yield, less solvent, temperature and energy requirement, low extraction time and consequently less damage to pectin structure.

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UPTAKE AND EXPENSE OF NITROGEN, PHOSPHORUS AND POTASSIUM IN GRAIN SORGHUM DEPENDS ON NITROGEN FERTILIZATION

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ABSTRACT

The uptake and expense of nitrogen, phosphorus and potassium in grain sorghum was studied in a field experiment during the period 2017-2018. Hybrid EC Alize was grown under non-irrigated conditions. The applied nitrogen fertilization was in rates 0, 60, 120, 180, 240 and 300 kg N.ha⁻¹. It was established that application of N₂₄₀ and N₃₀₀ led to high average uptake of nitrogen (212.0 kg N.ha⁻¹) and phosphorus (125.2 kg P₂O₅.ha⁻¹) in maturity. The higher removal of 159.9 kg K₂O.ha⁻¹ on average was observed at N₁₈₀ rate. The expense of nitrogen for production of 1 t of grain increased in parallel with the nitrogen fertilization. The highest nitrogen expense of 39.7 - 45.3 kg N.t⁻¹ grain was established when sorghum received 300 kg N.ha⁻¹ and it exceeded the control by 38.8 in 2017 and by 53.6% in 2018. Sorghum plants used 15.5 - 16.6 kg P₂O₅ on average to form 1 t of grain and nitrogen fertilization in rates N₆₀-N₃₀₀ slightly affected the phosphorus expense. Nitrogen fertilization proven increased the expense of potassium for production of 1 t of grain compared to N₀ control plants. The increase was by 8.3 - 20.0% in 2017 and by 8.0 - 34.0% in 2018. Sorghum plants expensed 23.2 - 24.2 kg K₂O on average to form 1 t of grain at nitrogen rates N₁₈₀-N₃₀₀. The strong positive correlation was established between nitrogen fertilization with N uptake (0.966**) and N expense (0.997**) and K uptake (0.820*) and K expense (0.870*).

Keywords: *Uptake, Expense, Nutrients, Grain sorghum.*

INTRODUCTION

Nitrogen is the main nutrient for the growth and productivity of sorghum and, in the absence of another limiting factor, most strongly affected the yields (Gerik et al., 2014). It involves high energy and production costs in agriculture, it is easily mobile and, its inappropriate use can cause environmental pollution. Effective use of nitrogen is important from an economic and environmental point of view, and must be taken into account in good agricultural practices (Dobermann et al., 2005). The current average nitrogen utilization index of fertilizers for cereal crops,

including sorghum, is 30-50% (Fixen, 2009). Rates of nitrogen fertilization for grain sorghum vary and they are most often in the range of 60 to 320 kg N.ha⁻¹, depending on the region and the growing conditions. In dry conditions of Africa and lack of irrigation ability, the fertilization doses are 50-80 kg N.ha⁻¹ (Stoorvogel and Smaling, 1990). Most often fertilization rates of sorghum grown in non-irrigated conditions are 100-120 kg N.ha⁻¹, but under irrigation or humid conditions fertilization norms are 150-240 kg N.ha⁻¹ (Gorbanov, 2010). According to Kissel (2008), yields higher than 6700 kg N.ha⁻¹ require nitrogen fertilization higher than 150 kg N.ha⁻¹. In the United States, grain sorghum fertilization rates are typically 90-120 kg N.ha⁻¹ (Diaz, 2014, Ciampitti et al., 2014). The yield difference of properly fertilized and unfertilized sorghum may be more than 50% (Paul, 2009). A key factor for sustainable agricultural production, the obtaining of high and stable yields and the preservation of soil fertility is the maintenance of a non-deficit balance of the nutrients in the soil (Fixen, 2009). Nutrients uptake of sorghum is the main source of information for optimization of the fertilization and depends on various factors: weather conditions, soil reserves, nitrogen rates, the amount of dry biomass formed, and others (Ladha et al., 2005). Average removal of main nutrients of sorghum crop is within limits 40–250 kg N.ha⁻¹, 20-60 kg P₂O₅.ha⁻¹, and 40-250 kg K₂O.ha⁻¹ for one vegetation period (Stewart, 2012). The consumption of nitrogen, phosphorus and potassium to form one tone of grain and the corresponding side production is a basic indicator for the efficiency of mineral nutrition. In Bulgaria there is insufficient scientific information related to the total uptake of nutrients of different grain sorghum hybrids. The objective of this study was to investigate the effect of nitrogen rates on the uptake and expense of nitrogen, phosphorus and potassium in grain sorghum.

MATERIAL AND METHODS

The field experiment was conducted during the period 2017-2018 on the experimental field of Agricultural University of Plovdiv, Bulgaria. Grain sorghum hybrid EC Alize was grown under non-irrigated conditions. The applied nitrogen fertilization was in rates 0, 60, 120, 180, 240 and 300 kg N.ha⁻¹. Total nitrogen as NH₄NO₃ was applied as pre-sowing fertilization on the background P₅₀K₅₀ fertilization as triple superphosphate and potassium chloride, respectively. The experimental design was a randomized, complete block design with four replications and a size of experimental plots of 20 m² after wheat as predecessor. Standard farming practices for the region of Southern Bulgaria were applied.

Table 1. Content of available nitrogen, phosphorus and potassium in the soil layers 0-30 and 30-60 cm.

Year	Nmin, mg.kg ⁻¹		P ₂ O ₅ , mg.100 g ⁻¹		K ₂ O, mg.100 g ⁻¹	
	0-30 cm	30-60 cm	0-30 cm	30-60 cm	0-30 cm	30-60 cm
2017	27.6	22.1	15.8	13.9	21.0	24.0
2018	33.8	20.4	17.3	14.1	23.1	22.9

The soil type of the experimental field is alluvial-meadow *Mollic Fluvisols* (FAO, 2006) with slightly alkaline reaction $\text{pH}_{\text{H}_2\text{O}}=7.80$ and content of organic matter 1.3% (Popova et al., 2012). The content of available nutrients in the soil before sowing of the sorghum was determined in soil layers 0-30 and 30-60 cm (Table 1). The soil had low content of mineral nitrogen and it was good supplied with available phosphorus according (Egner-Ream method) and exchangeable potassium (extracted by 2N HCL).

Table 1. Hydro-thermal conditions during sorghum vegetation period.

Year	April	May	June	July	August
Temperature, °C					
2017	12.7	17.6	23.7	25.1	25.4
2018	16.4	19.2	28.8	30.5	24.2
Long-term norm	12.2	17.2	20.9	23.2	22.7
Precipitation, L.m ⁻¹					
2017	26.1	52.7	15.4	29.8	9.2
2018	25.0	112.3	118.9	94.7	35.1
Long-term norm	45.0	65.0	63.0	49.0	31.0

The values of temperature and precipitations during the vegetation period of sorghum characterized hydro-thermal conditions of 2017 as warm and dry (Table 1). In contrast, the months of May, June and July of 2018 were characterized as extremely humid. The amount of precipitation exceeded nearly twice the values of the long-term norm for the region. The concentrations of nitrogen, phosphorus and potassium were analyzed in sorghum aboveground parts in maturity after wet digestion by H_2SO_4 and H_2O_2 as a catalyst (Mineev, 2001). The concentrations of nitrogen and phosphorus were determined by colorimetric methods and potassium concentration was analyzed by the flame photometer model PFP-7. The uptake of nitrogen, phosphorus and potassium was obtained by multiplying the dry mass of aboveground parts of sorghum ($\text{kg} \cdot \text{ha}^{-1}$) by the concentration (%) of each nutrient and divided by 100. An overall analysis of variance (ANOVA) was performed to evaluate the effect of the experimental treatments on the referred variables. In order to establish the difference among the means Duncan's multiple range test at level of significance $p \leq 0.05$ was used. Correlation test with significance level reported ($p < 0.05$ or $p < 0.01$) was based on Pearson's correlation coefficient.

RESULTS AND DISCUSSION

In maturity sorghum plants removed in its above-ground dry biomass an average of $180.7 \text{ kg N} \cdot \text{ha}^{-1}$ in 2017 and $227.5 \text{ kg N} \cdot \text{ha}^{-1}$ in 2018 (Table 2). The average uptake of phosphorus and potassium during the two experimental years was within limits $79.9 - 99.9 \text{ kg P}_2\text{O}_5 \cdot \text{ha}^{-1}$ and $106.8 - 146.8 \text{ kg K}_2\text{O} \cdot \text{ha}^{-1}$, respectively.

Table 2. Effect of nitrogen fertilization on the uptake of nitrogen, phosphorus and potassium in sorghum grain and stover.

Fertilization	2017	% to N ₀	2018	% to N ₀	2017-2018	% to N ₀
kg N.ha ⁻¹						
N ₀	130.9 e	100	148.0 e	100	119.7	100
N ₆₀	147.6 d	112.8	175.0 d	118.2	138.4	115.6
N ₁₂₀	182.4 c	139.3	218.1 c	147.4	171.8	143.5
N ₁₈₀	202.9 b	155.0	256.5 b	173.3	196.9	164.5
N ₂₄₀	207.7 ab	158.7	287.4 a	194.2	212.0	177.1
N ₃₀₀	212.5 a	162.3	279.7 a	189.0	210.9	176.2
<i>Average</i>	<i>180.7</i>		<i>227.5</i>		<i>175.0</i>	
kg P ₂ O ₅ .ha ⁻¹						
N ₀	65.4 b	100	72.6 c	100	84.5	100
N ₆₀	77.8 ab	119.0	86.5 c	119.1	100.6	119.1
N ₁₂₀	87.2 a	133.3	102.9 b	141.7	116.3	137.6
N ₁₈₀	85.6 a	130.9	109.2 b	150.4	119.0	140.9
N ₂₄₀	80.5 a	123.1	125.0 a	172.2	125.2	148.2
N ₃₀₀	82.8 a	126.6	103.1 b	142.0	113.6	134.5
<i>Average</i>	<i>79.9</i>		<i>99.9</i>		<i>109.9</i>	
kg K ₂ O.ha ⁻¹						
N ₀	82.5 e	100	100.3 e	100	95.7	100
N ₆₀	95.5 d	115.8	117.5 d	117.1	111.5	116.5
N ₁₂₀	106.9 c	129.6	144.9 c	144.5	131.5	137.4
N ₁₈₀	124.4 a	150.8	182.5 a	182.0	159.9	167.1
N ₂₄₀	117.6 ab	142.5	180.6 a	180.1	155.2	162.2
N ₃₀₀	114.1 bc	138.3	155.2 b	154.7	140.6	146.9
<i>Average</i>	<i>106.8</i>		<i>146.8</i>		<i>132.4</i>	

*Values with identical letters within each column are not significantly different at $p < 0.05$ according to Duncan's multiple range test.

The total removal of the three nutrients depended on the hydro-thermal conditions of the sorghum growing period and the obtained yields of grain and stover. As a result of the wet growing conditions of 2018 and higher productivity of grain and stover, the average uptake of nutrients exceeded by 46.8 kg N.ha⁻¹, 20.0 kg P₂O₅.ha⁻¹ and 40.0 kg K₂O.ha⁻¹ their average values in experimental 2017. Expressed as a percentage, this increase was by 25.9% for nitrogen, 20.0% for phosphorus and 37.4% for potassium. Applied nitrogen in rates 0-300 kg N.ha⁻¹ increased the total removal of nitrogen in maturity by 12.8 - 62.3% in 2017 and by 18.2 - 94.2% in 2018. The established differences were mathematically proven compared to the control without nitrogen. In 2017, the amount of nitrogen accumulated in the above-ground plant parts in maturity increased along with the amount of applied nitrogen fertilization up to N₃₀₀ rate. In 2018, the greatest nitrogen removal was established at the higher N₂₄₀ and N₃₀₀ rates and it reached 279.7 - 287.4 kg N.ha⁻¹.

Without nitrogen fertilization, sorghum plants accumulated in the above-ground dry mass 65.4 - 72.6 kg $P_2O_5 \cdot ha^{-1}$. Our results showed no proven differences in the phosphorus uptake between the control variant and the low N_{60} fertilizer variant. In 2017, nitrogen-fertilized plants exported from 19.0 to 33.3% more phosphorus than the control plants. There was a slight effect of nitrogen fertilization in rates N_{60} - N_{300} on the total accumulated phosphorus of sorghum. The values varied from 77.8 kg $P_2O_5 \cdot ha^{-1}$ at N_{60} to 87.2 kg $P_2O_5 \cdot ha^{-1}$ at N_{120} .

The application of 120-300 kg $N \cdot ha^{-1}$ increased the phosphorus removal with 41.7 to 72.2% compared to the nitrogen-free control in 2018. During the same experimental year, sorghum exported the highest amount of phosphorus 125.0 kg $P_2O_5 \cdot ha^{-1}$ when plants were fertilized with 240 kg $N \cdot ha^{-1}$, and the differences were proven against all other variants in the study.

Total potassium uptake of sorghum was higher in the wet vegetation period of 2018 experimental year. This was observed in regard to the control and to all studied nitrogen rates. The influence of applied nitrogen in rates 60-300 kg $N \cdot ha^{-1}$ on the total potassium absorption in maturity was positive and proven against the control variant in both experimental years. Nitrogen fertilization increased the potassium removal by 15.8-50.8% in 2017 and by 17.1-82.0% in 2018. Sorghum accumulated most potassium in the above-ground biomass when plants received 180 and 240 kg $N \cdot ha^{-1}$. The highest rate of N_{300} reduced potassium uptake, compared to variants fertilized with N_{180} - N_{240} .

On average for the period 2017-2018, the application of N_{60} rate increased the amount of nutrients of the above-ground dry biomass in maturity by 15.6% for nitrogen, 19.1% for phosphorus and 16.5% for potassium. The fertilization of the sorghum with higher levels of N_{240} and N_{300} resulted in high average nitrogen and phosphorus removal which reached 212.0 kg $N \cdot ha^{-1}$ and 125.2 kg $P_2O_5 \cdot ha^{-1}$, respectively. The application of N_{180} to sorghum led to a high potassium intake of 159.9 kg $K_2O \cdot ha^{-1}$ on average over the studied period.

The expense of nutrients to form 1 t of sorghum grain and the corresponding additional production was higher in all studied variants during the wet 2018 year (Table 3). The average expense of the nutrients in 2018 exceeded the expense in 2017 by 7.9% for nitrogen, 8.0% for phosphorus and 17.4% for potassium. At a unit phosphorus used for grain formation and corresponding additional production, sorghum plants consumed 2.26 units of nitrogen and 1.34 - 1.46 units of potassium. The amount of nitrogen to form 1 t of sorghum grain increased in parallel with the magnitude of the nitrogen rate. This was established over the period 2017 - 2018. The expense of nitrogen for producing 1 t of grain at the high N_{300} rate was 39.7 kg N in experimental 2017 and 45.3 kg N in 2018. These values exceeded the control plants by 38.8% and 53.6%, respectively. Fertilization rates N_{240} and N_{300} showed higher nitrogen consumption to form 1 t of grain and they were less efficient from an agrochemical point of view. The slight effect of nitrogen fertilization on the expense of phosphorus was obtained in 2017. In 2018, a proven difference was established only between the control plants and the plants received N_{240} .

Table 3. Expense of nitrogen, phosphorus and potassium for formation of one ton of sorghum grain and corresponding additional production depends on nitrogen fertilization.

Fertilization	2017	% to N ₀	2018	% to N ₀	2017-2018	% to N ₀
kg N.t ⁻¹						
N ₀	28.6 d	100	29.5 e	100	29.1	100
N ₆₀	30.1 cd	105.2	32.2 d	109.2	31.2	107.0
N ₁₂₀	33.9 c	118.5	35.8 cd	121.4	34.9	119.8
N ₁₈₀	35.3 bc	123.4	37.7 c	127.8	36.5	125.4
N ₂₄₀	38.1 ab	133.2	41.4 b	140.3	39.8	136.6
N ₃₀₀	39.7 a	138.8	45.3 a	153.6	42.5	146.0
<i>Average</i>	<i>34.3</i>		<i>37.0</i>			
kg P ₂ O ₅ .t ⁻¹						
N ₀	14.3 ns	100	14.5 b	100	14.4	100
N ₆₀	15.9	111.2	15.9 ab	109.7	15.9	110.4
N ₁₂₀	16.2	113.3	16.9 ab	116.6	16.6	114.9
N ₁₈₀	14.9	104.2	16.1 ab	111.0	15.5	107.6
N ₂₄₀	14.7	102.8	18.0 a	124.1	16.4	113.5
N ₃₀₀	15.4	107.7	16.7 ab	115.2	16.1	111.5
<i>Average</i>	<i>15.2</i>		<i>16.4</i>			
kg K ₂ O.t ⁻¹						
N ₀	18.0 c	100	20.0 e	100	19.0	100
N ₆₀	19.5 b	108.3	21.6 d	108.0	20.6	108.2
N ₁₂₀	19.9 b	110.6	23.8 c	119.1	21.9	115.0
N ₁₈₀	21.6 a	120.0	26.8 a	134.0	24.2	127.4
N ₂₄₀	21.6 a	120.0	26.0 ab	130.0	23.8	125.3
N ₃₀₀	21.3 a	118.3	25.1 bc	125.5	23.2	122.1
<i>Average</i>	<i>20.3</i>		<i>23.9</i>			

*Values with identical letters within each column are not significantly different at $p < 0.05$ according to Duncan's multiple range test.

Sorghum spent an average of 15.5 – 16.6 kg P₂O₅ to form one ton of grain and corresponding additional production when plants received nitrogen in rates 60-300 kg N.ha⁻¹.

Without nitrogen fertilization, sorghum expended 18.0 - 20.0 kg K₂O to form 1 t of grain. Nitrogen fertilization proven increased the potassium expense by 8.3 - 21.6% in 2017 and by 8.0 - 34.0% in 2018, compared to the control plants. Higher N₁₈₀₋₃₀₀ rates demonstrated higher potassium expense for grain formation 23.2-24.2 kg K₂O.t⁻¹ on average for the period 2017-2018.

Table 4. Correlation of nitrogen fertilization, uptake and expense of nitrogen, phosphorus and potassium in grain sorghum average for the period 2017-2018.

Parameters	N uptake	P ₂ O ₅ uptake	K ₂ O uptake	N expense	P ₂ O ₅ expense	K ₂ O expense
N fertilization	0.966**	0.801	0.820*	0.997**	0.600	0.870*
N uptake		0.910*	0.934**	0.962**	0.633	0.956*
P ₂ O ₅ uptake			0.942**	0.798	0.801	0.937**
K ₂ O uptake				0.802	0.567	0.992**
N expense					0.618	0.851*
P ₂ O ₅ expense						0.592

**Correlation is significant at the 0.01 level

*Correlation is significant at the 0.05 level

Nitrogen fertilization of the sorghum was in a strong positive correlation with N uptake (0.966**) and N expense (0.997**) and K uptake (0.820*) and K expense (0.870*) (Table 4). Proven positive relations were established among uptake of nitrogen, phosphorus and potassium. Expense of nitrogen for formation of one ton of sorghum grain and corresponding additional production strongly and positively correlated with the expense of phosphorus.

CONCLUSIONS

Application of N₂₄₀ and N₃₀₀ rates in grain sorghum let to high average uptake of nitrogen (212.0 kg N.ha⁻¹) and phosphorus (125.2 kg P₂O₅.ha⁻¹) in maturity. The higher removal of 159.9 kg K₂O.ha⁻¹ on average was observed at N₁₈₀ rate. The expense of nitrogen for production of 1 t of grain increased in parallel with the nitrogen fertilization. The highest nitrogen expense of 39.7 - 45.3 kg N.t⁻¹ grain was established when sorghum received 300 kg N.ha⁻¹ and it was exceeded the control without nitrogen fertilization by 38.8 in 2017 and by 53.6% in 2018. Sorghum plants used 15.5 - 16.6 kg P₂O₅ on average to form 1 t of grain and nitrogen fertilization in rates N₆₀-N₃₀₀ slightly affected the phosphorus expense. Nitrogen fertilization proven increased the expense of potassium for production of 1 t of grain compared to N₀ control plants. The increased was by 8.3 - 20.0% in 2017 and by 8.0 - 34.0% in 2018. Sorghum plants expensed 23.2 - 24.2 kg K₂O on average to form 1 t of grain at nitrogen rates N₁₈₀-N₃₀₀. The strong positive correlation was established between nitrogen fertilization with N uptake (0.966**) and N expense (0.997**) and K uptake (0.820*) and K expense (0.870*).

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**BIOLOGY, ECOLOGY AND CONTROL OF THE PLUM SEED
WASP [*EURYTOMA SCHREINERI* SCHREINER (HYMENOPTERA:
EURYTOMIDAE)]**

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ABSTRACT

The plum seed wasp, *Eurytoma schreineri* Schr. is a new pest on plum trees in Bulgaria. It is a serious pest for plums in northeastern Bulgaria. This wasp attacks the fruits of various plum cultivars. Damage by *E. schreineri* on plums ranges from 26-92%. The damage percent depends upon bioecological conditions and on the susceptibility of the plum varieties. Late-flowering cultivars are the most sensitive, where the attack can reach up to 90-92% of Stanley cultivar. This is univoltine and overwinters as a fully developed larva within stones of the fallow fruit under the plum trees. During the spring, usually in early May, the adults go out of the fallen mummified fruits and after mating the females oviposit inside the newly formed plum fruit. The egg is inserted into the endosperm of the fruit before the formation of the stone. Incubation lasts about 20-22 days, and hatch begins about the time that the plum seed embryo becomes visible. Larva development is completed by the end of June or early July, then the larvae enter diapause and remain in this state for 1-3 winters. Locally penetrating insecticides, applied when the larvae begin to hatch, provide a significant degree of larval control.

Keywords: *Prunus domestica*, plum tree wasp, *Eurytoma schreineri*, adult emergence, northeast Bulgaria.

INTRODUCTION

The plum seed wasp, *Eurytoma schreineri* Schr., was first described in Russia by Schreiner (1908) as a pest fruits of plum (*Prunus domestica* L.) in the Astrakhan region (Georgescu, 2006). Initially, the area of spread of the pest covered the southern parts of the European part of Russia, Western Siberia, the southern parts of the Ukraine, Armenia and Georgia. Until the research of Nikolskaya (1961), this species has been identified as almond seed wasp, *Eurytoma amygdali* End., which damages the almonds and is found in Russia only in the Caucasus. In the next half of the 20th century it spread to Moldova (Perju and Peiu, 1980), Wallachia (Copăescu, 1988) and Cluj-Napoca (Perju, 1995), Romania, and Turkey (Özbek et al., 1996). It is reported in Greece (Koveos et al., 2002), but it is also spread in the

Slovak Republic (2011), Moravia (2012) and Bohemia (2013) in the Czech Republic (Pultar, 2014).

The plum seed wasp, *E. schreineri* was detected in Bulgaria for the first time in 2013 (Arnaudov, et al. 2017) in plum orchards in the vicinity of Dobrich and Silistra, northeastern Bulgaria. After 2014 it spread widely in the northeastern parts of the country, causing serious damage to plum production. According to our previous studies, damage from *Eurytoma schreineri* varies from 26 to 92% depending on the location and variety of the plum orchards. At present *E. schreineri* is considered to be one of the most important pests of plum trees in northeastern Bulgaria.

Eurytoma schreineri belongs to order Hymenoptera, subdivision of Clistogastra, suprafamily Chalcidoidea, family Eurytomidae.

This species is oligophagous and attacks the kernel of the forming fruits, mainly of plums (*Prunus domestica*), *P. domestica* ssp. *Insititia* and mirabelle plums (*P. domestica* ssp. *Syriaca*). Among the preferred species are also cherry plum /myrobalan (*P. cerasifera*) and apricot (*P. armeniaca*). The appearance of this pest on sweet cherry (*P. avium*) and sour cherry (*P. cerasus*) is very rare. Blackthorn (*P. spinosa*) is less attacked, while the almond (*P. dulcis*) is not mentioned as a host (Pultar, 2014).

The pest hibernate as mature larva in the seeds of infested host plants. In late April, when ambient temperature exceeds 10°C, larvae turns into pupae and when the temperature exceeds 15.6°C developed into adult. In the adult stage, it lives only 6-9 days, maximum 15-18 (Gatina, 1989; Kudreavtseva, 1985). Before leaving the pits of infected fruits, adults make round holes in the stone walls with a diameter of 1.0-1.8 mm. After the copulation, the female pierces with her egg-laying the pulp of the fetus and lay some eggs in the not yet hardened stone. The larva feeds on the seed until all or almost all of the embryo is consumed. Only one larva develops in a fruit. The attacked fruits can not be distinguished from the healthy until they fall on the ground, until their skin becomes dry and does stick tightly to the stone (mummified fruits). The larvae, which have developed, enters into summer diapause and then hibernate in the fallen fruit, protected by strong walls of stones, until the following spring (Perju, 2002).

The aim of this study was to investigate some aspects of *E. schreineri* biology, associated with determining adult onset and biology of the immature stages.

MATERIALS AND METHODS

The studies were conducted in commercial plum orchards, located in the region of Shumen (43.27 N/26.92 E) and Novi Pazar (43.35 N/27.20 E), during 2018 and 2019. All observations, unless otherwise stated, were made on the Stanley plum variety. In addition, temperature, humidity and rainfall were recorded at the two forecast and warning stations in Shumen and Novi Pazar throughout the study period. Periodically in winter, samples of infected plum fruits were collected under the trees and classified according to the year of production. The pits of infested plum fruits were broken and the developmental stage of *E. schreineri* was

determined. To determine the presence of exit holes and determine the period of emergence of adults, infested plum fruits were put in cages (700 pieces per cage/plum orchard) on the soil surface near the stem of the tree. In spring 2019, the number of wasps emerging from the endocarps was recorded daily. Imaginary adults were collected daily and examined in laboratory to determine the sex of individuals. During spring and early summer, infested plum fruits were sampled also to observe development of the pest. In order to determine the appropriate moment for treatment, the initial appearance of adults, in relation to temperature, biological characteristics of the pest and phenological development of the culture, were monitored daily. Insecticide tests: One contact insecticide, Karate® Zeon (active ingredient, lambda-cyhalothrine) was tested in dose 200 ml/ha. The two strategies have been tested. The first with a single treatment applied only at the beginning of the emergence and the second strategy with a second treatment applied two weeks after the first. At the harvest, the number of infested fruits was counted.

RESULTS AND DISCUSSION

The results from the field investigations were analyzed and summarized in Table 1. The plum seed wasp hibernates as mature larva in the seeds of infested host. In 2019 the first hialine pupe in the Shumen region was observed on 11.04., when the plum trees were in the phenophase 'white bud'. The end of this nymphal stage was recorded 15 days later, on 25.04. At the end of April some individuals began to turn from the stage of hyaline pupae into the black pupa stage. This process lasted until 22.05. At this nymphal stage the antennae, legs and wings of the insect were already clearly visible. The appearance of the first adults was recorded a few days after the end of the last nymphal stage, which coincides with the 'Beginning of fruit growth' (first fruits visible at raceme base) phenophase (10 days after the 'Petal fall' phenophase). Adult flight was relatively short with a duration of about 20 days. The peak of adult flight activity was observed at the end of first decade May until the mid-May. Fig. 1.

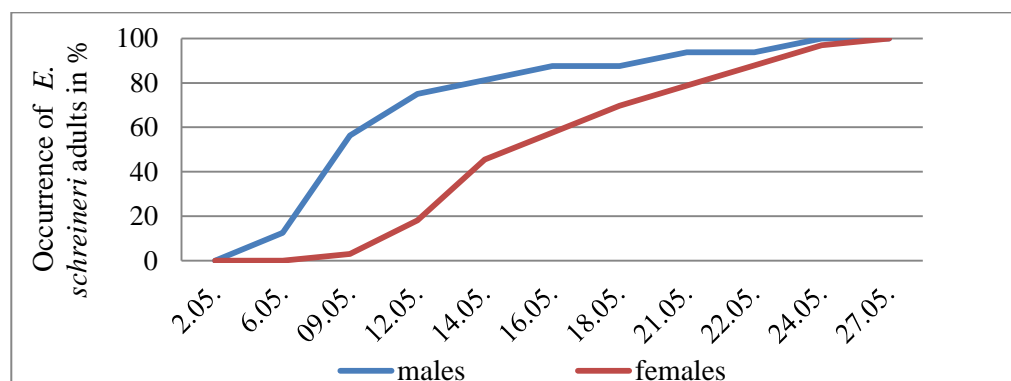


Fig. 1. Adult occurrence of *E. schreineri*, in spring 2019, in the area of Shumen.

From the data in Table 1 it can be seen that the number of attacked seeds in the samples is 64.8%, which indicate the high damage this pest can cause. It should be noted that the percent of larval and adult mortality is 14.8% and 32.1%, respectively. The lack of snow cover during the winter and the lack of enough rainfall in the spring (Fig. 2 and 3), we consider as the main causes of the high mortality of the wintering generation, although some authors believe that other factors may be responsible for this (fungi, nematodes and others) (Tamas et al., 2009). These assumptions fully correspond to Kudryvtseva's view that the fruits that have fallen on the dry soil are very dry and in such dry stones the adult dies because it is unable to make round holes in the stone walls of the stone (Kudryvtseva, 1985).

Table 1. Observations on the biology of *Eurytoma schreineri*, Shumen, 2019

№	Date	Phenophase	Damage seeds (%)	Vitality of the developing stages			Development stage			
				Dead larvae (%)	Dead adults (%)	Viable individuals (%)	Larvae (%)	White Pupae (%)	Black Pupae (%)	Seeds abandoned (%)
1	11.04	White bud	72	36	0	64	43	57	-	-
2	15.04	Bloom	60	34	0	66	14	86	-	-
3	25.04	Petal fall	68	36	0	64	-	100	-	-
4	30.04.		65	21	18	61	-	78	22	-
5	06.05.	Beginning of fruit growth	76	10	25	65	-	57	36	7
6	09.05.		58	7	44	49	-	43	43	14
7	13.05.		59	4	56	40	-	25	32	43
8	17.05.		61	0	63	47	-	11	18	71
9	22.05.		62	0	61	39	-	4	9	87
10	27.05.		67	0	54	36	-	-	-	100
			64,8	14,8	32,1	53,1				

The appearance of the first males was registered on 6.05., and the first female on 9.05. The male emergence preceded the female emergence of 3 to 4 days. Adults were observed in order to check the sex ratio. The results are shown in Table 2 and Fig 1.

Table 2. Sex ratio of male and female to *Eurytoma schreineri*.

Plum orchard	Number of insects examined					Sex ratio	
	Nr. total	Nr. male	Male %	Nr. Female	Female %	male	female
1	780	291	37,3	489	62,7	1	1.7
2	650	186	28,6	464	71,4	1	2,5
3	830	282	34,0	548	66,0	1	1,9
Total / Average						1	2.03

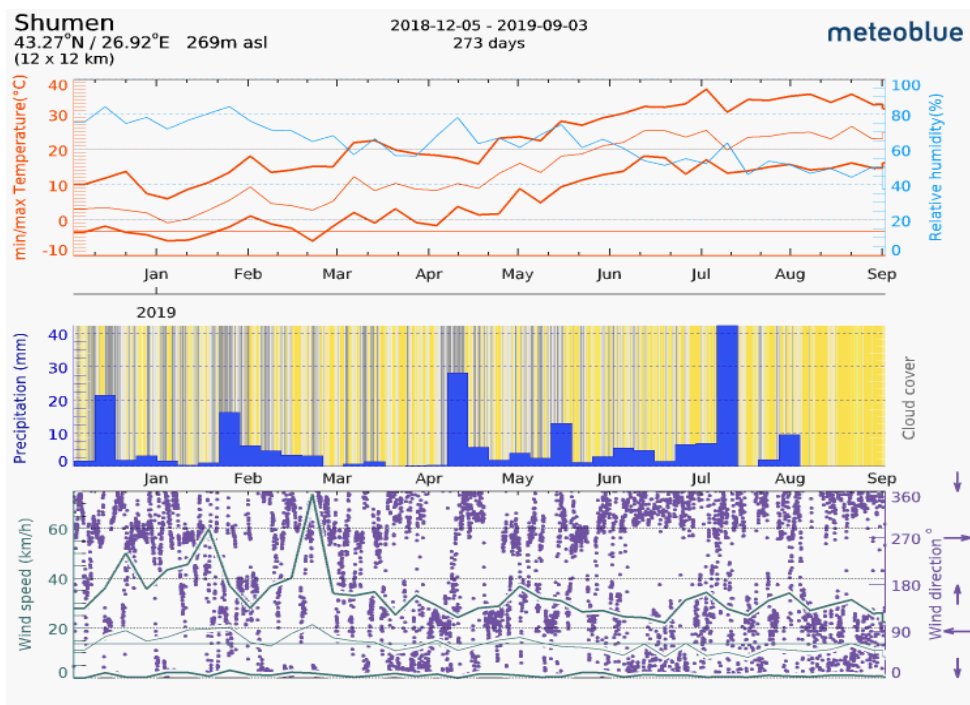


Fig. 2. Climatic conditions (temperature, humidity and precipitation) in the region of Shumen in 2019.

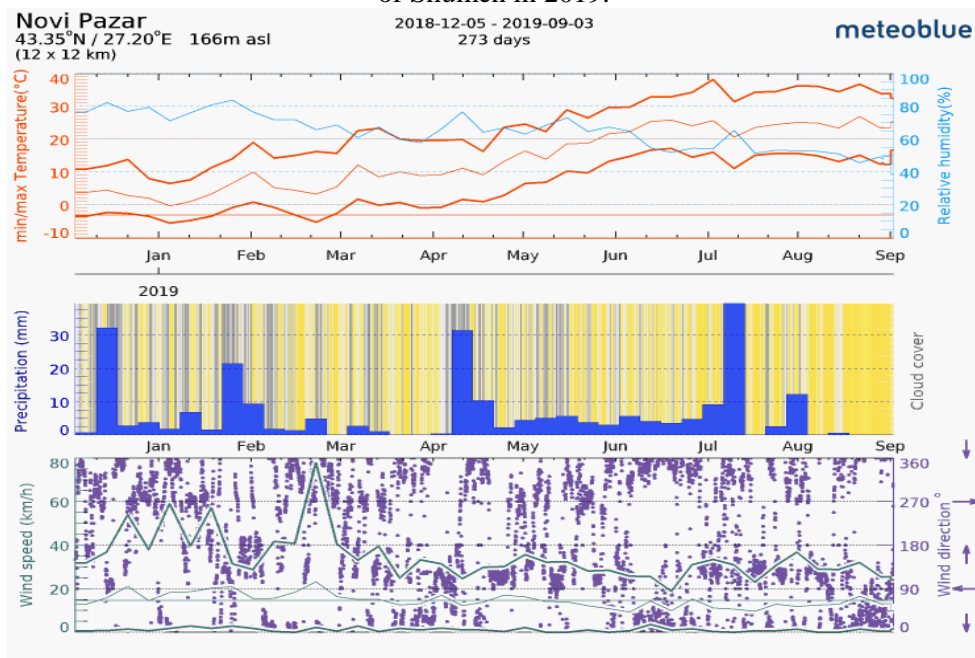


Fig. 3. Climatic conditions (temperature, humidity and precipitation) in the region of Novi Pazar in 2019.

The results from this study showed that, despite the variations between different plum gardens, the sex ratio male:female was about one male for two females and is similar to the observed ratio in the other countries (Panuta, 2008).vAfter mating, each female oviposit inside the newly formed plum fruit. The egg is inserted into the endosperm of the fruit before the formation of the stone. Incubation lasts about 20-22 days, and hatching begins about the time when the plum seed embryo becomes visible, usually at the end of May. Larval development is completed by the end of June or early July, and then the larvae enter diapause and remain in this state for 1-3 winters. Preliminary tests of Karate® Zeon showed their high effectiveness in adult control of *E. schreineri*. The results of the experiments in fields are presented in Table 3. The both applied strategies showed very good effectiveness with a low rate of infestation. The chemical control with a single treatment is cheaper and more advisable, but the optimal time for spraying at the first emergence has to be right.

Table 3. Percentage of infested fruits in plum orchards treated with one and two sprays of Karate® Zeon.

	Novi Pazar	Matnitsa	Shumen
Karate® Zeon, one spray	2,8%	2,5%	1,9%
Karate® Zeon, two sprays	1,2 %	1.0%	0.6%
Untreated control	78%	63%	42%

Locally penetrating insecticides such as thiacloprid and thiomethoxam, applied when the larvae begin to hatch, can also provide good larval control.

CONCLUSIONS

The plum seed wasp, *E. schreineri* has one generation per year in the climatic conditions of Bulgaria. This pest overwinters as mature larva in the seeds of infested host. The appearance of the first males was registered on 6.05., and the first female on 9.05. The peak of adult flight activity was observed at the end of first decade May until the mid-May. The absence of precipitation during the pupae stage leads to the death of the larvae and the adults in the pits. The male emergence preceded the female emergence of 3 to 4 days and the ratio male:female was about one male for two females. Our data shows that a protection of the plum orchards against *E. schreineri* with a single treatment of the contact insecticide Karate® Zeon is satisfactory. However, growers have to be trained to detect the first adult emergence with field cages, in order to apply the treatment at the optimal time at the first adult emergence.

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THE EFFECT OF THE ORIGIN OF THE QUEEN BEES AND THEIR INTERACTION WITH SURROUNDINGS ON THE DEGREE OF VARROA INFESTATION OF A BEE COLONY

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ABSTRACT

Honey bee endures significant losses due to the presence of *Varroa destructor* mite in bee colony. Because of its wide-spread presence in bee colony it can cause its complete destruction. Different breeding programmes regarding honey bee pay a great attention to bee resistance to varroa. The trial was conducted in 27 bee colonies. Three groups of bee swarms were formed and in each there were nine queen bees originating from three mutually distant producers. Then, in three distant apiaries the queen bees were placed in bee swarms so that in every apiary the queen bees of three different genotypes were represented. During 2017 and 2018, during six different periods, by a powdered sugar method the infestation of bee colonies by varroa mite was inspected. The degree of varroa infestation in relation to origin of queen bees ranged from 0.269 to 0.327 and difference determined was not statistically significant ($P > 0.05$). In relation to a location, the least average infestation of societies accounting for 0.140 was observed in an apiary in north-eastern Serbia, while the greatest infestation accounting for 0.452 was observed in colonies placed in western Serbia. Determined difference in varroa infestation in relation to a location of an apiary was statistically significant ($P < 0.05$). Continual monitoring of the varroa infested colonies by use of powdered sugar method indicated the differences between examined groups and reduced damage threshold for bees.

Keywords: *Honeybee, Queen bees, Varroa infestation, Powdered sugar method.*

INTRODUCTION

Honey bee (*Apis mellifera* L.) is the most useful insect in the world and its social and economic benefits for man are great. By honey bee breeding we can make profit realised from direct bee products. On the other hand, through bee pollinating activity a considerably greater indirect profit is realised estimated to be more than €150 billion on the world scale. This sum represents 9.5% of the value of global agricultural production (Gallai *et al.*, 2009).

Honey bee is exposed to various negative factors which either separately or interactively may contribute to substantial loss in this most important insect

pollinator (Meixner *et al.*, 2010; Jacques *et al.*, 2017). One of the most significant factors referred as the cause of bee losses is ectoparasite *Varroa destructor*. This mite causes both direct damage by feeding itself on the fat body of the bee brood and adult bees and an indirect damage as a vector of different viruses (Ramsey *et al.*, 2019). Beekeepers worldwide most often try to suppress varroa by adding a chemically synthesized acaricides to bee colony which without adequate rotation contribute to varroa resistance (Gregorc *et al.*, 2018). However, the use of chemical treatments has a negative consequence of incidence of residuals in bee products (Buchler *et al.*, 2010). In such conditions honey bee seems unable to manifest its natural resistance potential to varroa. The European Union has taken steps to find new approaches through different projects like FP7-KBBE.2013.1.3-02 (SMARTBEES) to focus on identification, breeding and propagation of locally adapted honey bees with high performance and resistance traits to *Varroa destructor* (Uzunov *et al.*, 2015). To include and improve desirable traits is the aim of many breeding programmes in bee breeding (Nedić *et al.*, 2005; Uzunov *et al.*, 2017). Slow and limited varroa mite population growth is a fundamental criterion of resistant stock which can be used as a character for selective breeding on mite resistance (Buchler *et al.*, 2010).

Therefore, the goal of this pilot research was to study mite infestation level in three different honey bee genotypes.

MATERIAL AND METHODS

The trial was carried out in three mutually remote bee farms chosen previously among bee keepers. These bee farms were testing bee farms while records were monitored according to recommendations of and cooperation with SMARTBEES FP7.KBBE programme.2013.1.3-02/WP6 "Field testing and selection of local bee populations". The first testing bee farm was situated in Bela Crkva (BC) in the far east of Serbia where local queen bees of known origin were bred and they represented the first genotype (G1). The second beehive was located in Bajina Bašta (BB) in the far west of Serbia where queen bees of the second genotype were bred (G2). On the third beehive located in Lapovo (LA), in central Serbia, the queen bees of the third genotype were bred (G3). In the first stage of the research during the month of June, 2017, 9 standard bee swarms were formed on all three bee farms according to performance testing protocol (Uzunov *et al.*, 2015). After that the queen bees were exchanged among the bee keepers in such a way that on each testing farm the three queen bees of different genotypes were present but on each bee farm a group of queen bees which originated from the breeder's population remained. Formed and stabilized swarms in all three testing bee farms were in the beginning treated against varroa by the same chemical treatment. During further period of monitoring no treatment was applied against varroa on bee farms. The colony mite infestation level was monitored by means of "powdered sugar method" (Uzunov *et al.*, 2015). For calculation of the infestation levels they were expressed as the number of mites in 10 g of bees - about 100 bees by using the following formula: total number of mites x 10 / bees net weight (g). The level

of infestation during 2017 and 2018 in six control examinations in different time periods during the course of the year was carried out. The results of the research were collected and statistically processed. Two way ANOVA with a descriptive statistical analysis were carried out and comparisons between different genotypes and locations were determined by Tukey (HSD) test.

RESULTS AND DISCUSSION

The results of the variance analysis of varroa mite infestation of bee colonies depending on genotype and location are shown in Table 1.

Table 1. Results of the ANOVA of varroa presence depending on genotype and location

Factors	df	Mean Square	F	p-value
Genotype	2	0.049	0.44	0.646
Location	2	1.316	11.73	0.000
Genotype*Location	4	0.064	0.57	0.682

Descriptive statistical values for varroa mite infestation of bee colonies depending on genotype are displayed in Table 2.

Table 2. Descriptive statistical values of mite infestation level depending on genotype

Genotype	Mean	N	SD	Min.	Max.
G1	0,269 ^{a*}	54	0,30	0	1,20
G2	0,327 ^a	54	0,42	0	1,80
G3	0,283 ^a	54	0,34	0	1,11

*Means followed by same letter within genotype are non significantly different according to ANOVA

Descriptive statistical values for bee colonies mite infestation level depending on locations are displayed in Table 3.

Table 3. Descriptive statistical values of mite infestation level depending on location

Location	Mean	N	SD	Min.	Max.
BC	0,140 ^a	54	0,26	0	1,11
BB	0,288 ^a	54	0,22	0	1,00
LA	0,452 ^b	54	0,46	0	1,80

*Means for the same characteristics followed by different letters within locations are significantly different ($P < 0.05$).

The lowest varroa infestation level was established in bee colonies of genotype 1 (0.269) while the highest average varroa mite infestation was found in bee colonies of genotype 2 (0.327). The genotype did not statistically significantly affect ($P>0.05$) varroa mite infestation level of bee colonies (Table 2). This result can be considered in the context of bee-keeping management. Technology of bee-keeping in Serbia includes treating the bees against varroa after the last melliferous pasture. In early August, due to simple application, relatively low prices and good efficiency in majority of bee colonies a chemical treatment against varroa is applied. During winter period a single treatment by oxalic acid is applied. A practice that queen bees should be changed after every two or possibly three years in production should be observed as well. Under such long-term impact the bees in modern bee-keeping had no chance to develop resistance to varroa (Buchler *et al.*, 2010), while on the other hand varroa surviving bees (VSB) were identified in untreated populations on some locations in Europe and America (LeConte *et al.*, 2007; Seeley, 2007.).

The effect of location of apiary significantly affected ($P<0.05$) the average number of varroa in bee colony (Table 1). An average varroa mite infestation of bee colonies on location LA was significantly higher compared to bees on locations BC and BB (Table 3). The effect of the location of apiary on level of varroa presence in bee colony can be regarded in the light of environment conditions. The research of Correia-Oliveira *et al.* (2018) reported that colonies of Africanized honey bees located in areas with lower altitude and greater rainfall had higher level of varroa mite infestation compared to warm, higher altitudes. In our research the altitudes of locations on which the testing bee hives were situated were: BC (90 m), BB (257 m) and LA (96 m). Testing beehives in locations BC and LA were placed on almost same altitudes but with significantly different varroa infestation. For this reason the altitude in this case cannot be taken as a reason of established differences in the level of infestation. The effect of bee hive location on the presence of varroa in bee colonies can be a consequence of density of population, i.e. number of colonies in surrounding areas (up to 1.5 km). It is possible that drifting foragers, mite carriers, can contribute to their migration and increased infestation among colonies (DeGrandi-Hoffman *et al.*, 2016). Mites are able to rapidly infest honey bees by foraging at a feeder or at flowers (Peck *et al.*, 2016). Testing bee hives in our research were stationary placed in the zones which were little loaded by presence of other bee hives. However, due to intensive migration in search of pasture and non-registration of apiaries, as well as possible feral colonies the effect of drifting foragers cannot be completely excluded.

Interaction between genotype and location did not significantly affect varroa mite infestation of bee colonies (Table 1).

The infestation value of bee colonies during different periods throughout the year is shown in Figure 1.

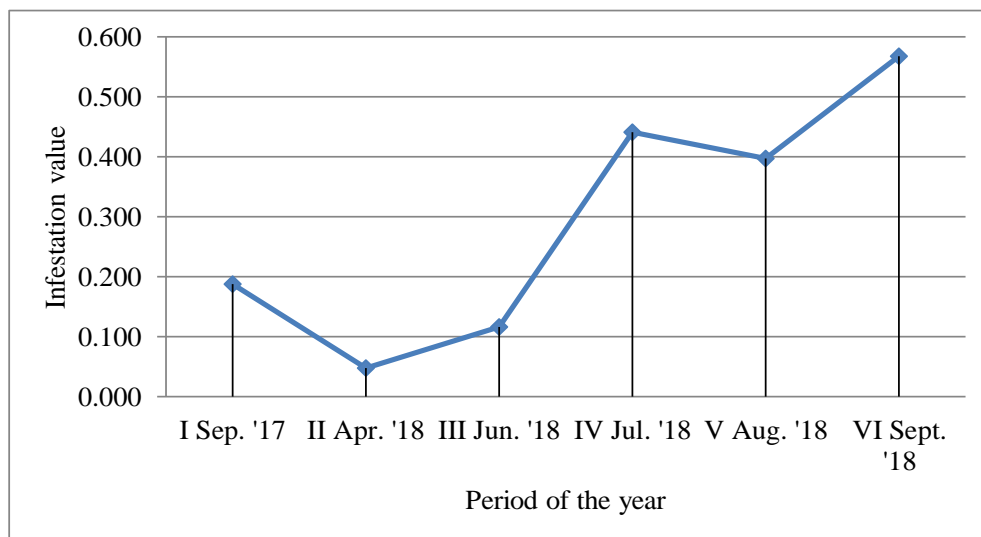


Figure 1. An average infestation of bee colonies depending on a year period

The average level of varroa mite infestation of bee colonies was lowest at control examination in April 2018 while highest average infestation was established at control examination in September 2018.

CONCLUSIONS

In this research a level of varroa mite infestation was monitored in three groups of sister queen bees of different genetic origin and on three different and spaciouly remote apiaries in Serbia. In relation to genotype it was established that differences do exist and that level of infestation in colonies in G1 and G3 groups was by 17.74% and 13.46% lower compared to the colonies in group G2. The established differences were not significant. A location of apiaries significantly affected the average number of varroa in bee colonies. This factor should be further investigated in detail because it is a complex one and could be a consequence of area density populated with other apiaries or feral colonies and climate or geographical characteristics of the region. The established values indicate the existence of variability in regard to level of varroa mite infestation in bees of different origin. The research implicates the existence of bee colonies candidates with higher resistance to varroa mite. They could be a subject of further research in apiculture breeding programmes for the purpose of improving this trait in domestic honey bee population.

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EFFECTIVENESS OF INDIGENOUS KNOWLEDGE ON CONTROL PRACTICES OF SHEEP AND GOAT DISEASES AND PEST AMONG FARMERS IN IKOLE EKITI, EKITI STATE, NIGERIA

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ABSTRACT

The study attempts to investigate the level of access, use and effectiveness of indigenous knowledge practices in controlling diseases and pests in sheep and goats among goat and sheep farmers in Ikole-Ekiti, Ekiti State, Nigeria. Data were gathered through interviews scheduled on 90 goat and sheep farmers. The data were analyzed using descriptive statistics tools of frequencies, percentages and means to describe parameters such as age, sex, household size, educational qualification, and farm size. Pearson correlation coefficient was used to determine the relationship between the dependent variable and independent variables. The results revealed that the mean age of the respondents was 58 years and 63.3% of the goat and sheep farmers were females. The farmers in the study area had low contact with extension workers. The main sources of information were family members, friends and neighbours, and radio. Using sandpaper leaf for mange infection and palm oil for bloat was ranked highly effective. The constraint with the highest percentage was inadequate information of the technique used. Based on the result of the Pearson correlation, accessibility had a positive and significant relationship with effective usage of indigenous knowledge practices. Sequel to the findings of the study, it was recommended that agricultural extension services in Ekiti State should make extension agents available in rural areas to educate the farmers on various indigenous knowledge practices.

Key words: Bloat, diseases, indigenous knowledge, mange, sand paper leaf

INTRODUCTION

Indigenous knowledge is the local knowledge that is unique to a culture of society. Other names for it include: 'local knowledge', 'folk knowledge', 'people's knowledge', 'traditional wisdom' or 'traditional science'. This knowledge is passed from generation to generation, usually by word of mouth and cultural rituals, and has been the basis for agriculture, food preparation, health care, education,

conservation and the wide range of other activities that sustain societies in many parts of the world (World health organization, 2001).

Numerous countries have developed national herbal pharmacopoeias to document medicinal plants that have been found to be effective and to further ensure their safety, efficacy and quality. Emphasis should be placed on the need to further exploit the rich and diverse African natural resources, which can contribute to discovery and development of new traditional and orthodox medicines (Luis,2010).

Traditional medicine has demonstrated great potential of therapeutic benefits in its contribution to modern medicine. More than 30% of modern medicines are derived directly or indirectly from medicinal plants. Examples of these medicines are analgesics (aspirin, belladonna); anticancer medicines (vincristine and vinblastine), antihypertensive agents (reserpine); antimalarials (quinine, artemisinin); and decongestants (ephedrine). Traditional medicine is used to control and cure the diseases of animals most especially small ruminants (sheep and goats) which are reared by rural farmers. Sheep and goats are among the major economically important livestock in Nigeria. In Nigeria small ruminants contribute an estimated 35% to the total meat supply. The major breed of sheep is the Yankasa while the West African Dwarf is the major goat breed. Sheep and goats contribute a quarter of the domestic meat consumption; about half of the domestic wool requirements; about 40% of fresh skins and 92% of the value of semi-processed skin and hide export trade. In the southern guinea savanna region of Nigeria like in many parts of the country, small ruminant production and productivity is impeded by various constraints which include health. This constraint can be alleviated or curtailed by modern or western-style technologies such as vaccination, chemoprophylaxis/chemotherapy, feeding animals with formulated rations. Small ruminants in the study area are largely in the hands of rural farmers. Since these farmers are mostly located in the rural areas, they are scarcely aware of veterinary and improved management services. In some cases, many of those who are aware of the services cannot afford to pay for them because they are expensive (Matekaire and Bwakura, 2004). However, the rural small ruminant farmers have developed indigenous methods or technologies for coping with the constraints. Among the various indigenous methods is the use of herbs to manage animal diseases. Which include use of bark of iroko tree (*Milicia excelsa*)/tagiri (*Adenopus breviflorus*)/unripe pawpaw for treating intestinal worms, grind tobacco leaves for tick infestation, igi-erin (*Hunteria umbellata*)/sand paper leaf (*Ficus exasperata*) and palm-oil for mange infestation, shea butter (*Vitellaria paradoxa*) and salt for foot rot, ground alligator pepper (*Aframomum melegueta*) for Oral dehydration therapy, igi emi (*Vitellaria paradoxa*) for wound, palm oil for bloat treatment, oloora bark (*Rauvolfia vomitoria*) combine with palm oil for treating poisonous plants ingestion, fermented ground maize for treating sheep and goat pox, charcoal mill/efinrin (*Ocimum gratissimum* for diarrhea and dysentery, lapalapa (*Jathropa curcas*) squeeze and palm oil for treating retained placenta/dystokia(prolonged labour) and wood ash for treating broken horn.

In the face of rising cost of western-style (modern) medicine and increased concern about development of drug resistant parasites and tissue residues of chemotherapeutic agents, the sustainability of many of these modern technologies in livestock production is seriously called to question. A search for alternative methods of disease control in sheep and goat is therefore, of utmost necessity. Therefore, the study is to assess the effectiveness of indigenous knowledge practices in sheep and goat diseases and pest control. Other objectives include to (i) describe socio-economic characteristics of sheep and goat farmers in the study area;

(ii) Identify the common pest and diseases of sheep and goats and the indigenous practices used by sheep and goat farmers to control it; examine the sources of information on indigenous practices; and assess the constraints associated with to indigenous knowledge practices.

Hypotheses include: (i) There is no significant relationship between socio-economic characteristics of sheep and goat farmers and effective usage of indigenous knowledge practice.

(iii) There is no significant relationship between farmer's accessibility to the indigenous practices used in sheep and goat diseases and pest control and effective usage of indigenous knowledge practice.

(iv) There is no significant relationship between constraints associated with indigenous knowledge practices used in sheep and goat diseases and pest control and effective usage of indigenous knowledge practice

MATERIALS AND METHODS

The study was conducted in Ikole local Government Area of Ekiti State, southwestern Nigeria, which is largely an agriculture-based state in the country in 2018. Multi-stage sampling procedure was used to select the respondents in the study area. At the first stage, 9 communities were randomly selected from the Local Government Area. The next stage involved snow-ball sampling of 10 respondents from each of the communities to give a total sample size of 90 respondents in all. Primary data were collected directly from sheep and goat farmers through personal interviews with the aid of a interview study designed to obtain information on socio-economic characteristics of the farmers, types of indigenous practices, the sources of indigenous practices used, and constraints to the use of indigenous practices. The data collected were analyzed using descriptive statistics tools of frequencies, percentages, and means to describe parameters such as age, sex, household size, educational qualification, and farm size. Pearson correlation coefficient was used to determine the relationship between the dependent variable and independent variables. To know the level of effectiveness, total scores for each respondent was grouped into 5 categories: very effective, effective, partially effective, rarely effective and not effective. The mean score with standard deviation was used to categorize the effectiveness into high, low and moderate. The score of mean plus standard deviation was considered as highly

effective, mean minus standard deviation was considered as low and different between high and low was considered as moderately effective.

RESULTS AND DISCUSSION

Socio-economic characteristics of farmers

The mean age of the sampled sheep and goat farmers was 58 years and the standard deviation was 7.9. Results in the table1 indicate that majority (70.1%) were between the ages of 50 to 70 years. Most of the young able-bodied men had migrated to the urban areas in search of a better life and older generation is left in the rural areas. The implication of this is that the future of livestock production in the study area is uncertain and will decrease drastically. The findings collaborates Ogunjimi and Ajala (2014) findings which indicated that majority of the farmers in Ekiti were above 45 years. Majority (63.3%) of the respondents are females while the remaining (36.7%) are males. This implies that sheep and goat production is female dominated in the study area. The finding collaborate with Olayemi *et al.* (2012) findings that, women are known to be more involved in agricultural activities than men in sub-saharan Africa (SSA) countries. Results also reveals that majority (92.2%) of the respondents are married. Table 1 further show that, 44.5% of the respondents had primary education, (36.6%) of the respondents had secondary education. This attribute is expected to influence the respondent's perception, awareness and usage of indigenous practices.

The mean flock size for sheep was 8 while that of goat was 13. This implies that majority of sheep and goat farmers were small scale farmers. The result in table 1 also shows that (75.6%) of the farmers had no contact with extension agents in the past one year. Inadequate extension contact might be due to the fact that extension agents were not well-equipped to face the challenges ahead due to inadequate training.

Table 1. Percentage distribution of personal characteristics of respondents

Variables	frequency	Percentage	Mean/std
Age (years)			59.07/7.929
Below 51	18	20.0	
51-60	46	51.1	
61-70	18	20.0	
Sex distribution			
Male	33	36.1	
Female	57	63.3	
Years of schooling			6.67/4.272
Never attend school	19	21.1	
1-6	40	44.4	
7-12	31	34.5	

Source of information of indigenous knowledge practices

The results in Table 2 show that the farmers are mostly informed by family members (100%), friends and neighbours (86.7%). This was followed by radio (45.6%), television (38.9%), extension agents (35.6%). This implies that the respondents are mostly informed about indigenous knowledge practices by their family members, friends and neighbours. This asserts that informal relationships and face to face interaction leads to effective communication. This correlates with Omogor (2013) that says interpersonal communication dominates our activities at home, office, market and elsewhere. It helps to break the barrier of formal relationships, generate warmth and create harmony that is necessary for socio-economic development.

Table 2. Mean distribution of the respondents on the source of information of indigenous knowledge practices in the control of diseases and pest in sheep and goat

Source of information	Frequency	Percentage
Family members	90	100
Friends and neighbors	78	86.7
Radio	41	45.6
Television	35	38.9
Extension agents	32	35.6
Salesmen	28	31.1
Leaflet/agric news letter	21	23.3
Newspaper	18	20.0

Accessibility to indigenous knowledge practices

Results on the accessibility to indigenous knowledge practices with a grand mean of 4.76 (Table 3) indicate that sandpaper leaf (*Ficus exasperata*), shea butter (*Vitellaria paradoxa*), Igi-Erin (*Hunteria unbellata*), wood ash, alligator pepper (*Aframomum melegueta*), lapalapa (*Jatropha curcas*) and oloora (*Rauvolfia vomitoria*) have a mean of 5.00 were highly ranked while fermented maize and unripe pawpaw have a mean of 4.46 and rank 8th. The others are tobacco leaves (mean= 4.43, rank= 10th), palm oil (mean= 4.39, rank=11th) and efinrin (*Ocimum gratissimum*) (mean= 4.33, rank= 12th). This indicates that the indigenous knowledge practices are highly accessible in the study area because they are readily available. This goes in line with (Matlebyane *et al.*, 2010), who reported that herbal medicine offer cheaper, more sustainable, available, reliable and familiar alternatives to imported synthetic drugs.

Table 3. Mean distribution of the respondents on their accessibility to indigenous knowledge practices in the control of diseases and pest in sheep and goat

Accessibility

Indigenous methods	Mean	Rank
Sandpaper leaf	5.00	1 st
Shea butter	5.00	1 st
Igiemi	5.00	1 st
Wood ash	5.00	1 st
Alligator pepper	5.00	1 st
Jathrophacurcas	5.00	1 st
Oloora bark	5.00	1 st
Fermented maize	4.46	8 th
Unripe pawpaw	4.46	8 th
Tobacco leaves	4.43	10 th
Palm oil	4.39	11 th
Efinrin	4.33	12 th

Usage of indigenous knowledge practices

Data from the Table 4 revealed that majority of the farmers are using all the indigenous knowledge mentioned to control diseases and pests in sheep and goat but in order of ranking, alligator pepper and palm oil (mean= 4.67, rank= 1st) came first, followed by igi emi, fermented maize and wood ash (mean= 4.62, rank= 3rd). The others include sand paper leaf (mean= 4.60, rank= 6th), oloora bark (mean= 4.58, rank= 7th), unripe pawpaw (mean= 4.57, rank= 8th), tobacco leaves (mean= 4.57, rank= 8th), efinrin (mean= 4.57, rank= 8th), Shea butter (mean= 4.56, rank= 11th) and lapalapa (mean= 4.52, rank= 12th). This finding shows that most of the indigenous knowledge practices are highly used in the study area.

Table 4. Mean distribution of the respondents on their usage of indigenous knowledge practices in the control of diseases and pest in sheep and goat

Indigenous methods	Mean	Rank
Alligator pepper	4.67	1 st
Palm oil	4.67	1 st
Igiemi	4.62	3 rd
Fermented maize	4.62	3 rd
Wood ash	4.62	3 rd
Sandpaper leaf	4.60	6 th
Oloora bark	4.58	7 th
Unripe pawpaw	4.57	8 th
Tobacco leaves	4.57	8 th
Efinrin	4.57	8 th
Shea butter	4.56	11 th
Jathrophacurcas	4.52	12 th

Effectiveness of indigenous knowledge practices

The Table 5 revealed the indigenous practices in descending order of effectiveness: sandpaper leaf (mean= 4.98, rank=1st), palm oil (mean= 4.77, rank= 2nd), shea butter (mean= 4.66, rank= 3rd), igi erin (mean= 4.62, rank= 4th), tobacco leaves (mean= 4.59, rank= 5th), fermented maize (mean= 4.53, rank= 6th), unripe pawpaw (mean= 4.43, rank= 7th), wood ash (mean= 4.42, rank= 8th), alligator pepper (mean= 4.33, rank= 9th), lapalapa (mean= 4.33, rank= 9th), efinrin (mean= 4.28, rank= 11th) and oloora bark (mean= 4.09, rank= 12th). The findings resulted in a grand mean of 4.40 and standard deviation of 0.20. The results shows IKPs were effective except *Rauvolfia vomitoria* that has low level of effectiveness. This might be as a result of availability and commonality of the materials such as palm oil, shea butter, wood ash and pawpaw could be a factor enhancing their usage and hence effectiveness.

Table 5. Mean distribution of the respondents on the effectiveness of indigenous knowledge practices in the control of diseases and pest in sheep and goat

Indigenous methods	Mean	Rank	Decision
Sandpaper leaf	4.98	1 st	Highly effective
Palm oil	4.77	2 nd	Highly effective
Shea butter	4.66	3 rd	Highly effective
Igiemi	4.62	4 th	Highly effective
Tobacco leaves	4.59	5 th	Moderately effective
Fermented maize	4.53	6 th	Moderately effective
Unripe pawpaw	4.43	7 th	Moderately effective
Wood ash	4.42	8 th	Moderately effective
Alligator pepper	4.33	9 th	Moderately effective
Jathrophacurcas	4.33	9 th	Moderately effective
Efinrin	4.28	11 th	Moderately effective
Oloora bark	4.09	12 th	Less effective

Constraints to indigenous knowledge practices

Table 6 shows the factors militating against the utilization of indigenous knowledge practices by the farmers in the study area. The constraint ranking first is inadequate information of usage techniques (mean= 1.99, rank= 1st) followed by lack of proper management skill method (mean= 1.22, rank= 2nd), inadequate credit facilities (mean= 1.16, rank= 3rd), inadequate know how (mean= 1.13, rank= 4th), inadequate infrastructural facilities (mean= 1.13, rank= 4th). It can be interpreted that most of the respondents in the study faced the series of constraints which could influence the effective usage of indigenous knowledge practices.

Table 6. Mean distribution of the respondents on the constraints of indigenous knowledge practices in the control of diseases and pest in sheep and goat

Constraints	Mean	Rank
Inadequate information on usage techniques	1.99	1 st
Lack of proper management skill method	1.22	2 nd
Untimely credit facilities	1.16	3 rd
Inadequate know how	1.13	4 th
Inadequate infrastructural facilities	1.13	4 th
Inadequate storage facilities	1.12	6 th
High cost of materials	1.11	7 th
Inadequate credit facilities	1.10	8 th

Testing of hypothesis

The correlation result between the socio-economic characteristics of the farmers in the study area and effective usage of indigenous knowledge practice in the control of disease and pests in sheep and goats shows that age ($r=0.243$ $p\leq 0.01$), schooling ($r=0.139$ $p\leq 0.01$) and house size ($r=0.182$ $p\leq 0.01$) had a positive and significant relationship with usage of indigenous knowledge practice. This shows that the higher their age, level of education, house size, and extension contact, the higher their usage of indigenous knowledge practices. The correlation result in Table 7 shows that source of information ($r=0.191$ $p\leq 0.01$) had positive and significant relationship with usage of indigenous knowledge practices. Information is a veritable tool when it comes to usage of indigenous knowledge practices. This shows that the more they have access to information, the higher their level of usage. The results in Table 7 shows that accessibility ($r=0.595$ $p\leq 0.01$) had a positive and significant relationship with the usage of indigenous knowledge practices. This indicates that the higher accessibility to indigenous knowledge practice, the higher the usage of indigenous knowledge practices.

Table 7. Correlation analysis between respondent's personal socio-economic characteristics and effective usage

Variables	Correlation coefficient(r)	Coefficient of determinant (r^2)
Age	0.243**	0.021
Schooling	0.139**	0.021
Extension contact	0.095	0.371
House size	0.182**	0.083
Source of information	0.191**	0.072
accessibility	0.595**	0.354

*, Correlation is significant at the 0.05 level (2-tailed).

**, Correlation is significant at the 0.01 level (2-tailed).

CONCLUSION

Based on the findings of this research work, it can be concluded that use of herbs to manage animal diseases were highly effective in controlling diseases and pests of sheep and goats followed by fermented maize and unripe pawpaw. Furthermore, indigenous knowledge practices are being used and effective in the control of diseases and pests in sheep and goats.. However there was low contact between the sheep and goat farmers and extension agents recorded hence efforts should be made by governmental and non- governmental organizations in training the farmers on knowledge of indigenous practices and usage techniques. Furthermore, programmes that are related to knowledge of farming activities should be aired late in the evening on radio and television when the goat and sheep farmers will be able to listen or watch. There is also need for government and non-government organization to provide credit facilities for the preservation of indigenous practices for future use.

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GENOME-WIDE DISTRIBUTION OF AUTOZYGOSITY ISLANDS IN SLOVAK WARMBLOOD HORSE

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ABSTRACT

The objective of this study was to estimate the distribution of autozygosity islands represented by homozygous segments (ROHs) in the genome of the Slovak Warmblood horse. The Slovak Warmblood is a very efficient breed with the excellent characteristics of a sport horse. The study included 37 animals that were genotyped by GGP Equine70k chip (71,947 SNPs). Only animals (36) and autosomal SNPs (62,439) with call rate >90% and minor allele frequency >1% were included in subsequent analyses. The homozygous segments were defined as stretches with minimum 15 consecutive homozygous SNPs of >500 kb with minimum density 1 SNP per 100 kb and maximum gap between markers of 1,000 kb. The heterozygous or missing calls were not accepted. The analysis indicated in total of 8,501 autozygosity islands in the genome of the Slovak Warmblood horse. The majority of identified segments (85.42%) were most likely derived from the remote ancestors in the past. Only 0.15% of detected segments resulted from the recent selection events affecting the genetic structure of studied population. The proportion of segments varied across chromosomes. The major fraction of autosome residing in ROH was found on ECA1 (8.30%), while ECA31 showed the lowest ROH coverage. The scan for overlapping homozygous segments shared by more than 50 % of animals demonstrated that the ECA6 autosome may be under strong selection pressure. Inside those selection signals, several genes were identified including them associated with immunity and reproduction.

Keywords: *footprints of selection, horse, genomic data, runs of homozygosity.*

INTRODUCTION

The Slovak Warmblood horse is one of the national breeds that is a descendant of Austro-Hungarian warmblood breeds and horses which were ennobled from Arabians, English purebreds and halfbloods. Compared to Czech Warmblood, it has more blood of the Hungarian halfbred, Furioso, Przedswit, Gidran and Nonius

and little of the Oldenburg and East Fresian horse. Recently, the breed was improved through the use of Trakenher and Hanoverian blood. Since 1961, the Slovak Warmblood is bred especially for the purpose of being sport and work horses. It belongs to the medium sized horses with well-developed skeleton and rectangular body frame. The Slovak Warmblood is very efficient breed with excellent movement, good character and lively temperament. The main goal of its breeding is to fix the type and breed in purity, with emphasis on the massive type (Hendricks, 2007; National Stud Farm Topoľčianky, 2019).

Modern horse breeds represent heterogeneous populations selected for specific appearance and performance traits. In general, genomic regions under strong selection pressure due to specific breeding for traits of interest display low genetic variability resulting in increase of proportion of continuous homozygous segments that are common in individuals of target population or breed (Metzger *et al.*, 2015). The development and implementation of new genomic tools, including high-density SNP genotyping arrays, make it possible to analyse such genomic regions and overall genetic background of populations at a deeper level. Previous studies revealed that the application of SNP arrays allow for better resolution of the genome-wide determination of diversity parameters, including selection signatures, genetic bottleneck and trend of inbreeding compared to the most commonly used pedigree analysis. To conserve the genetic resources of native horse breed, several studies highlighted the importance of genome-wide analyses focusing on the distribution of long consecutive homozygous genotype segments referred to as runs of homozygosity (ROH) (Metzger *et al.*, 2015; Kamiński *et al.*, 2017; Druml *et al.*, 2018; Grilz-Seger *et al.*, 2018). The ROHs are a result of parents transmitting identical haplotypes, which can be used to estimate autozygosity (Grilz-Seger *et al.*, 2018). It was demonstrated that the distribution of ROH segments in the genome give insight into a complex population history, genetic events in the past, demographic evolution of a population over time and genetic relatedness among individuals (Peripolli *et al.*, 2017). In addition, the ROHs can be used to assess the impact of selection on the genome through identification of autozygosity islands. Provided that the frequency of certain alleles increases due to positive selection the selection signatures can be valuable resource for mapping of causative mutations (Nolte *et al.*, 2019).

The aim of this study was to analyse the distribution of autozygosity islands represented by runs of homozygosity (ROHs) in the genome of the Slovak Warmblood horse and to identify genomic region under strong selection pressure due to breeding for specific traits of interest.

MATERIAL AND METHODS

The genomic information for 37 animals were used to determine the distribution of autozygosity islands in the genome of the Slovak Warmblood horse. Animals were genotyped for 71,947 SNPs by using GGP Equine70k genotyping array. The quality of genotyping data was checked by R package plinkQC (Anderson *et al.*, 2010) and subsequent SNP pruning was performed using PLINK v1.9 (Chang *et*

al., 2015) to filtered out i) SNP markers with unknown chromosomal position as well as SNPs located on sex chromosomes, ii) animals and autosomal SNPs with call rate < 90 % and iii) SNP markers with minor allele frequency < 1 % across animals. The Hardy-Weinberg equilibrium (HWE) limit was set to 0.00001.

The autozygosity islands were defined as ROH segments that contain minimum 15 consecutive homozygous SNPs of > 500 kb with minimum density 1 SNP per 100 kb, maximum gap between markers of 1,000 kb and no missing or heterozygous SNPs in a run, following the study of Nolte *et al.* (2019). The distribution of ROHs in the genome was scanned by R package detectRUNS (Biscarini *et al.*, 2018). To identify signals of selection the runs incidence per each SNP was calculated. The genome-wide occurrence of SNPs in ROH was expressed as the proportion of overlapping ROH shared among animals. The genomic regions significantly affected by positive selection were recognized based on the SNPs in ROHs shared by more than 50 % of the entire sample. For functional analysis, genomic regions covering signals of positive selection were scanned for annotated genes in the equine reference assembly EquCab2.0 by web based tool Biomart from Ensembl database (<https://www.ensembl.org/>).

RESULTS AND DISCUSSION

From totally 71,947 SNP markers, up to 68,214 loci were positioned across equine autosomes (ECA). Due to low level of genotyping call rate one animal and 1,655 SNPs were removed from the database. The MAF limit did not meet 4,964 loci. After SNP pruning overall 36 animals and 62,439 SNP markers covering 2,240,031.34 kb of the autosomal genome were retained for the detection of autozygosity islands. Among adjacent SNP markers the average spacing at level 35.89 ± 34.66 was found. The obtained genotyping rate across samples and SNPs markers (98.26 %) was in agreement with previous studies in horses (Kamiński *et al.*, 2017; Druml *et al.*, 2018; Grilztz-Seger *et al.*, 2019).

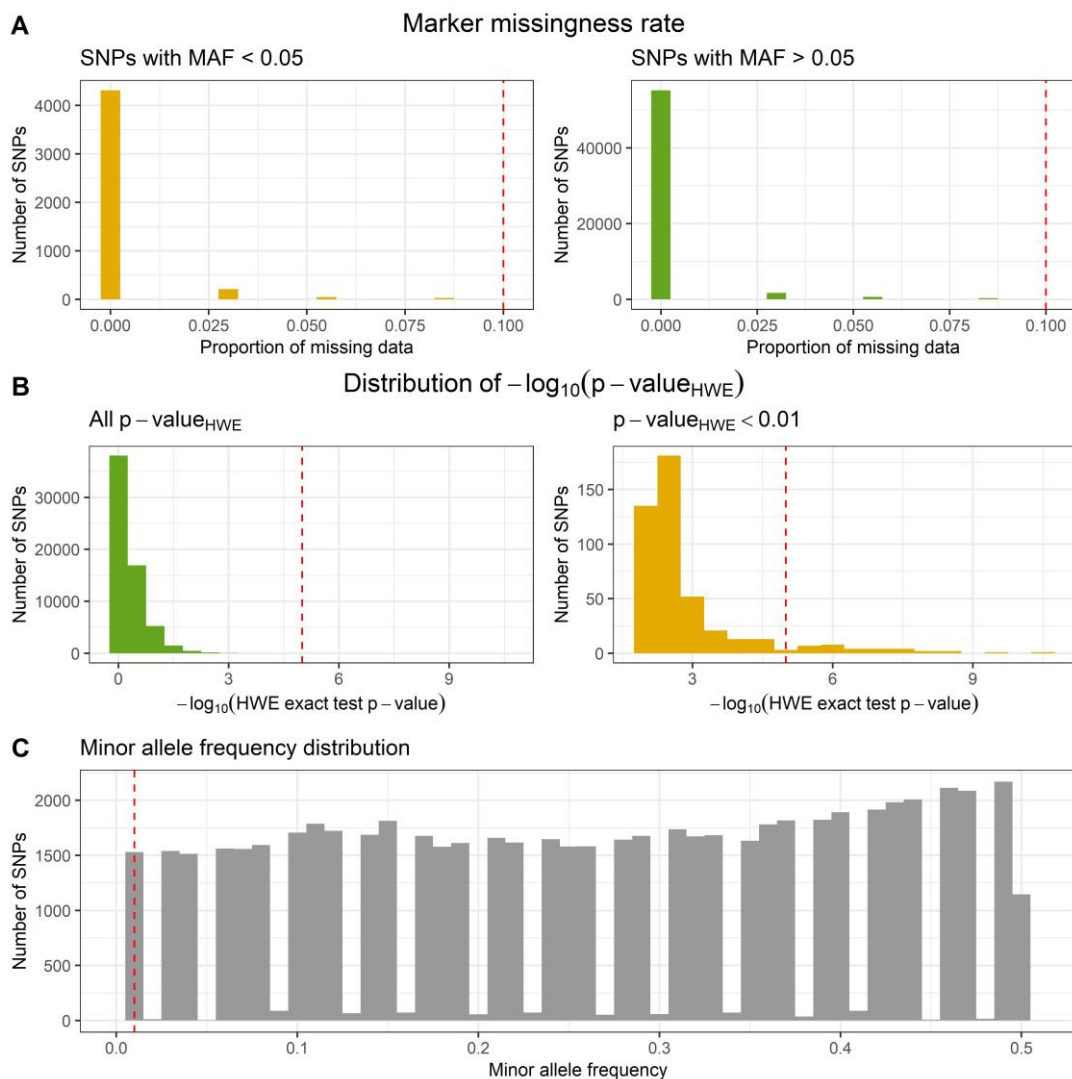


Figure 1. Quality of genotyping data in sample of Slovak Warmblood horse per SNP markers

In the sample of the Slovak Warmblood horses totally 8,501 ROH segments covering in average 8.45 % (189.41 Mb) of the autosomal genome were identified. The similar proportion of ROHs was found e.g. in the genome of Slovak and Hungarian Lipizzan horses (Grilz-Seger *et al.*, 2019) or Posjave horse breed (Grilz-Seger *et al.*, 2018). The number and mean length of the ROH segments was not uniform and varied across autosomes. The highest ROHs proportion was found on ECA1 (8.3 %), while the lowest number of ROHs was detected on ECA31 (0.98 %). The majority of identified segments (85.42%) were most likely derived from

the remote ancestors in the past. Only 0.15 % of detected segments resulted from the recent selection events affecting the genetic structure of studied population. The distribution and proportion of autosomes residing in ROH are in accordance with previous studies in population of Polish Konik horse (Kamiński *et al.*, 2017), Austrian Noriker (Grilz-Seger *et al.*, 2019) or Haflinger horse breed (Druml *et al.*, 2018). Assuming that the ROHs with extreme frequency are most likely results of intensive breeding for traits of interest during the grading-up process of the breed, in the genome of Slovak Warmblood horse totally 8 regions across 7 autosomes (1, 2, 6, 9, 11, 15 and 16) significantly affected by positive selection were identified (Fig. 1). The longest region was found on ECA6, while the shortest was localized on ECA9. The scan for overlapping homozygous segments shared by more than 50 % of animals indicated that mainly the ECA6 autosome showed strong impact of selection. Inside detected selection signals overall 80 protein-coding genes were identified (Table 1).

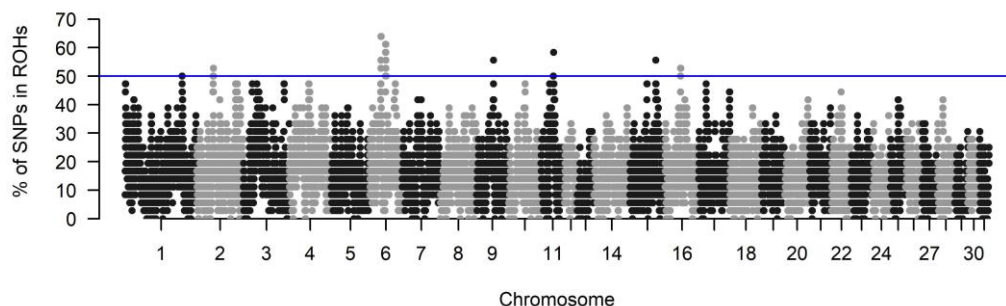


Figure 2. Proportion of overlapping ROH segments shared among analysed Slovak Warmblood horses

Table 1. Signal of selection in genome of Slovak Warmblood horse expressed by ROH segments with extreme frequency

ECA	Start position (Mb)	End position (Mb)	Region size (Mb)	Protein-coding genes
1	147.61	148.06	0.44	STARD9, TTBK2, CDAN1, HAUS2, LRRC57, SNAP23, ZNF106, CAPN3, GANC, VPS39
2	42.74	43.12	0.38	RERE, SLC45A1, ERRF11, PARK7, TNFRSF9
6	29.36	30.02	0.66	CACNA2D4, DCP1B, LRTM2, ADIPOR2
	41.18	42.71	1.54	LRP6, MANSC1, BORCS5, DUSP16, CREBL2, GRP19, CDKN1B, APOLD1, DDX47, GRPC5A, GRPC5D, HEBP1, FAM234B, GSG1, EMP1, GRIN2B
9	44.25	44.53	0.27	UQCRB, MTERF3, PTDSS1, SDC2
11	32.32	33.58	1.26	MSI2, CCDC182, MRPS23, CUEDC1, VEZF1, SRSF1, DYNLL2, EPX, MKS1, LPO, MPO, TSPOAP1, MIR142, RNF43, SUPT4H1, HSF5, MTMR4, TEX14, RAD51C PPM1E, TRIM37, SKA2
15	67.26	67.83	0.57	LBH, YPELP
16	39.90	40.62	0.71	SLC26A6, TMEM89, UQCRC1, MIR711, PFKFB4, SHISA5, TREX1, ATRIP, CCDC51, PLXNB1, FBXW12, SPINK8, NME6, ECATH-3, ECATH-2, CDC25A, MAP4

Inside the genomic region on ECA1 the STARD9, TTBK2 and CAPN3 genes are located. The STARD9 gene was in humans associated with various defects, including epilepsy, acquired microcephaly, and blindness (Okamoto *et al.*, 2017). The TTBK2 gene (Tau tubulin kinase 2) is essential for initiating the assembly of primary cilia in the embryo (Goetz *et al.*, 2012). The CAPN3 gene (Calpain 3) is a member of the calpain family that are intracellular calcium-dependent cysteine proteases found in most eukaryotes. It is well known that calpains are involved in the proteolysis of functionally relevant structural proteins such as the myofibrillar proteins and cytoskeletal anchorage complexes (Bhat *et al.*, 2018). The ADIPOR2, LRP6, GRPC5A, and EMP1 genes were found within the regions showing selection signatures on ECA6. The biological function of these genes was mostly studied in humans. It was suggested that the ADIPOR2 gene could be a determinant for atherosclerosis independent of insulin resistance status, possibly by affecting ADIPOR2 protein levels (Halvatsiotis *et al.*, 2010). The mutations in the LRP6 gene was associated with many complex human diseases, including metabolic syndrome, cancer, Alzheimer's disease and osteoporosis (Wang *et al.*, 2018). The GRPC5A gene plays a role in spontaneous and environmentally induced lung carcinogenesis (Wang *et al.*, 2016). Ahmat Amin *et al.* (2018) revealed that the epithelial membrane protein 1 (EMP1) gene has elevated expression in the cancer cells. Within the region on ECA9 two biologically important genes were identified; the UQCRB gene that is important for mitochondrial complex III stability, electron transport, cellular oxygen sensing and angiogenesis and the MTERF3 gene which is a negative regulator of mtDNA transcription initiation (Park *et al.*, 2007; Kim *et al.*, 2017). The CUEDC1, VEZF1 and SKA2 genes that are located within the identified selection signals on ECA11 are involved in estrogen pathway (CUEDC1), development of blood vascular and lymphatic system (VEZF1) and cell cycle regulation (SKA2) (Gowher *et al.*, 2008; Lopes *et al.*, 2018; Xie and Bu, 2018). Several genes positioned within the detected region on ECA16 were found to be involved in the response to oxidative stress and apoptosis (TREX1, CDC25A), innate immunity (ECATH2, ECATH3) and regulation of cell cycle (CDC25A) (Scocchi *et al.*, 1999; Shen and Huang, 2012; Barizzzone *et al.*, 2013).

CONCLUSION

As expected, due to genetic background of Slovak Warmblood horse the proportion of genome residing in ROH was comparable to other horse populations in Europe. The study showed that the ROH segments covered in average 8.45 % of the autosomal genome expressed by SNPs on the chip. The majority of identified autozygosity islands were most likely derived from the remote ancestors. Only 0.15% of the genome was affected by the recent mating of relatives. Scan for signals of selection revealed seven genomic regions that was significantly affected by positive selection during the grading-up process of Slovak Warmblood horse breed. From biological point of view, genes identified directly in the regions under selection pressure are mostly involved in the genetic control of cell cycle regulation, immunity and reproduction.

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EFFECT OF MICROFINANCE ON SMALLHOLDER FARMERS' LIVELIHOOD IN RWANDA: A CASE STUDY OF NYAMAGABE DISTRICT

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ABSTRACT

Microfinance in Rwanda is considered as one of the most crucial mechanisms in the implementation of the Government program to reduce poverty and to increase economic growth. However, despite the effort made by the Government of Rwanda to put in place microfinance institutions in rural areas, little is known about the effects of microfinance on smallholder farmers' income in Nyamagabe District of Rwanda. This study aimed at examining the contribution of microfinance services to the income of smallholder farmers in Nyamagabe District. Primary data were collected from 240 respondents randomly selected in 3 sectors of Nyamagabe District using structured questionnaires. Data were analyzed using descriptive statistics to describe the socio-economic characteristics of the respondents and Propensity Score Matching was used to assess the effect of microfinance on smallholder farmers' livelihood. The results from descriptive statistics showing that 117 respondents were participants in microfinance services and 123 were non-participants and more men were committed to participate and to access microfinance services than women. Results from Propensity Score Matching Model using both Kernel Based Matching and Nearest Neighbor Matching showed that the households participating in microfinance services increased their total annual income by 256,674 Rwandan francs and 228,246 Rwandan francs more than non-participants, respectively. The study recommended that smallholder farmers should be encouraged to participate in microfinance services to increase their income and agricultural productivity. The use of SACCOs and microfinance services needs to be promoted in order to provide an instrument for mobilizing savings and extending credit.

Keywords: *Microfinance, Smallholder farmers, Livelihoods, Rwanda.*

INTRODUCTION

In developing countries, microfinance and microcredit programmes have changed the well being of smallholder farmers and have a positive effect on agricultural productivity (Abdullah, 2011; Asmamaw, 2014; Asadul Islam *et al.*, 2015). In African countries and especially in Rwanda, microfinance institutions have contributed to standards of living of smallholder farmers and in the country's development. By its Vision 2020, the Government of Rwanda has implemented strategies and policies through microfinance programs for empowering rural community (Minecofin, 2012). MFIs have been seen as an opportunity to offer both financial services as well as education and training services to the farmers in a bid to improve their capacity and livelihood. The institutions have made significant evolution in providing the needed savings and credit facilities for the smallholder farmers thus raising their standard of living and have made substantial development of marketing relationships of farming communities (Duvendack, et al., 2011; North, 2012). The provision of microfinance services facilitated rural household to improve in agricultural inputs and to increase their income generating non-farm activities (Hakim, 2004; Sherin, 2012).

Owuor (2009) stated that smallholder farmers' participant in microfinance credit improves household productive incomes. However, the Government of Rwanda's objectives in rural areas are to extend the leading edge of sustainable microfinance to overcome cost barriers and risks, by encouraging saving mobilization, and improving technology.

Despite the efforts made by the Rwandan Government to support the implementation of microfinance to reduce poverty, the majority of smallholder farmers still having challenges to access microfinance services for their economic development and little is known about the effect of microfinance on smallholder farmers' livelihood in Nyamagabe District. The study sought to analyze the effect of microfinance on smallholder farmers' livelihood in Nyamagabe District of Rwanda

MATERIAL AND METHODS

The study was carried out in Nyamagabe District, Southern Province of Rwanda. The major economic activity of the people is agriculture and the major crops grown are potatoes, beans, wheat, peas, maize, sweet potatoes, and tea. Data were collected using structured questionnaires that were administered to the sample of households' heads via person-interviews. The sample random sampling techniques were applied to select 240 smallholder farmers in three sectors of Nyamagabe District namely Gasaka, Kibirizi and Tare. The present study used both quantitative and qualitative methods. Data were analyzed by using both Statistical Package for Social Sciences (SPSS) Software version 18 and STATA 14.

The data were analyzed by using descriptive statistics and Propensity Score Matching Approach.

Descriptive statistics was used to describe the socio-economic characteristics of smallholder farmers in Nyamagabe District, Rwanda. In this case, frequencies were

presented in the analysis. The study used Propensity Score Matching (PSM) to estimate the effect of microfinance on smallholder farmers' livelihoods in Nyamagabe District. The propensity score is the conditional probability of participation in microfinance of given household characteristics. For using the PSM method, we referred to several studies (e.g., Rosenbaum and Rubin, 1983; Dehejia and Wahba, 2002; Caliendo and Kopeinig, 2005; Smith and Todd, 2005).

The function: $P(X) = Pr\{D = 1 | X\} = E\{D | X\}$ (1)

Where $D = \{0, 1\}$ is the binary variable on whether a household has participated in microfinance services (1) or not (0). X is the multidimensional vector of relatively stable household characteristics in our context that if the exposure to microfinance is random within cells defined by X , it is also random within cells defined by $p(X)$ or the propensity score (Rosenbaum and Rubin (1983). The matching approach purpose is to estimate the counterfactual outcome and to correct for the selection biases created by non-random sampling of the microfinance services participants (Dehejia and Wahba, 2002).

Estimation of the Average Treatment Effects on the Treated (ATT)

The study estimated the Average Effect of Treatment on the Treated (ATT). The expected value of ATT is defined as the difference between expected outcome values with and without treatment for those who actually participated in the treatment (Abadie, 2005).

To compute the ATT, two alternatives matching methods such as *Nearest Neighbor Matching* and *Kernel Matching* were used and compared to analyze the effect of microfinance on smallholder farmer's livelihoods. The estimates of ATT from the two matching algorithms were obtained using the *psmatch 2* command in Stata 14. The outcome variables is "**Total Annual Income**"

Nearest Neighbor Matching

The simplest matching estimator is Nearest Neighbour (NN) Matching. With Nearest Neighbor, each treated group is matched with a control group (Caliendo & Kopeinig, 2008). A simplified formula to compute the estimated treatment effect using the Nearest Neighbor Matching can be written as:

$$ATT = \frac{1}{N^T} \left(\sum_{i \in T} Y_i^T - \frac{1}{N_i^c} \sum_{j \in c} Y_j^c \right) \dots\dots\dots (2)$$

Where, N^T is the number of cases in the treated group and N_i^c is a weighting scheme that equals the number of cases in the control group using specific algorithm. The consequence of this matching method is all treated units find matches and even for fairly poor propensity score of the control group (Becker and Ichino, 2002).

Kernel Based Matching

In kernel Based Matching, all treated subjects are matched with a weighted average of all controls using weights that are inversely proportional to the distance between the propensity scores of treated and control groups. The weighting value is determined by distance of propensity scores, bandwidth parameter h_n , and a kernel function $K(\cdot)$.

The Kernel Based Matching estimator is given by the formulation:

$$ATT^K = \frac{1}{N^T} \sum_{i \in T} \left\{ Y_i^T - \frac{\sum_{j \in c} Y_j^c G\left(\frac{P_j - P_i}{h_n}\right)}{\sum_{k \in c} G\left(\frac{P_k - P_i}{h_n}\right)} \right\} \quad (3)$$

Where $G(\cdot)$ is a kernel function and h_n is a bandwidth parameter, under standard conditions on the bandwidth and kernel and the formulation below is consistent estimator of the counterfactual outcome Y_{0i} .

$$Outcome = Y_{0i} = \frac{\sum_{j \in c} Y_j^c G\left(\frac{P_j - P_i}{h_n}\right)}{\sum_{k \in c} G\left(\frac{P_k - P_i}{h_n}\right)} \quad (4)$$

Variables used in the Model

X_1 = hhgender : Gender of household head (1= Male, 0= Female), X_2 = hhage: Age of household head (in years), X_3 = sizeland: Land size , X_4 = hheduc : Education level of household head, X_5 = HHsize : Size of Household , X_6 = hhmaritalst: Marital status of Household Head, X_7 = hhOccupat : Household main occupation , X_8 = Distance : Distance from homestead to microfinance office, X_9 = Totalassets: Annual Total Assets, X_{10} = Percredel: Perception of credit eligibility, X_{11} : Off_farm_inc: Off- farm income

RESULTS AND DISCUSSIONS

Results from Descriptive Statistics

Participants and non-participants in microfinance services in Nyamagabe District

Table 1. Participants and non-participants by gender

Gender	Participants		Non-participants		Total	
	Frequency	Percent	Frequency	Percent	Frequency	Percent
Male	85	35.4	80	33.3	165	68.7
Female	32	13.4	43	17.9	75	31.3
Total	117	48.8	123	51.2	240	100

Source: Author, Field survey, 2011

Table 1. illustrates that in Nyamagabe District, more men were very committed to participate and access microfinance activities than women. The results show that 35.4 percent of men were participants in microfinance services while 33.3 percent were not participants and only 13.4 percent of women were participants and 17.9 percent were not participants respectively. Despite the improvement of microfinance programs for women empowerment, fewer women were participants in microfinance services.

Table 2. Smallholder Access to credit and access to Savings in three sectors of Nyamagabe District

<i>Sectors</i>	<i>Access to Credit</i>			<i>Access to Savings</i>		
	Yes	No	Total	Yes	No	Total
Kibilizi	23 (9.6%)	58 (24.1%)	81 (33.7%)	47 (19.6%)	34 (14.1%)	81 (33.7%)
Gasaka	17 (7.1 %)	61 (25.4%)	78 (32.5%)	54 (22.5%)	24 (10%)	78 (32.5%)
Tare	20 (8.3%)	61 (25.4%)	81 (33.7%)	50 (20.8%)	31 (12.9%)	81 (33.7%)
Total	60 (25%)	180 (75%)	240 (100%)	151 (62.9%)	89 (37.1%)	240 (100%)

Source: Author's survey, 2011

In order to analyze the participation in microfinance services by respondents in 3 sectors of Nyamagabe District, the respondents were asked to indicate whether they had ever accessed credit and savings services provided by microfinance institutions in Kibilizi, Gasaka and Tare Sectors. However, in Kibilizi Sector more smallholder farmers have participated in credit services than in the other two sectors of Nyamagabe District. In fact, in Kibilizi sector, only 9.6 percent of smallholder farmers accessed credit services while 24.1 percent did not access credit from microfinance institutions. The results show also that 19.6 percent of household have saved their money in formal financial institutions while 14.1 percent were not interested to save in microfinance institutions.

In Gasaka sector, 7.1 percent of household have accessed credit services while 25.4 percent did not access credits from Microfinance institutions. The table shows also that 22.5 percent and 10 percent of households have accessed and do not accessed savings services respectively.

In Tare sector, 8.3 percent of household have accessed credit services while 25.4 percent have not accessed credit. Table 2 shows that 20.8 percent have savings and 12.9 percent did not save their money from microfinance institutions. However, these credit services lead to an increase of smallholder farmers' income and livelihood. Savings services have often been seen as a critical component in improving access to additional investible funds in Nyamagabe District. In this case, smallholder farmers can accumulate money and then draw it for investing in other household assets.

Effects of Microfinance Services on Smallholder Farmers' livelihood in Nyamagabe District

Results of Propensity Score Matching Estimation

The determination of the Average Effect of microfinance services using Kernel-based Matching and Nearest Neighbor Matching involved matching 117 participants in microfinance services and 123 non-participants, and gave an average effect on annual total income of 625,152 Rwandan francs per household (*Equivalent to 735 USD*)

Table 3. Estimates of Propensity Score Matching: Logit Model Dependent Variable: "Participation in Microfinance services" Participatmfs (1/0)

<i>Variables</i>	<i>Estimates</i>	<i>Variables</i>	<i>Estimates</i>
hhgender	-.0753121 (0.823)	hhOccupation	.1907174*** (0.009)
hhAge	.0194483* (0.082)	Distance	-.7411689*** (0.001)
Sizeland	.2790351 (0.386)	Totalassets	7.39e-07 (0.193)
hheducation	.5810336*** (0.005)	Percredel	.0546439 (0.877)
hhsize	-.0121269 (0.877)	Off_farm_inc	-.1322959*** (0.008)
hhMaritalst	.1229581 (0.310)	Contant	-1.465257 (0.146)
Number of Obs = 240		Prob > Chi ² = 0.000	
LR Chi ² (11) = 66.91		Pseudo- R ² = 0.2012	
Log likelihood = -132.82727			

Source: Computed by the Author from the field survey data, 2011

Note: * and *** denote significance level at 10% and 1% respectively

The results from Kernel and Nearest Neighbor Matching show that out of 11 variables 5 were significant. The results showed that *household age* is significant at 10 percent, *Household education* is significant at 1 percent level and *household main occupation* is significant at 1 percent. All these variables are hypothesized to have a positive effect on households' likelihood of participating in microfinance services, while "*distance from homestead and off-farm income*" were both significant at 1 percent but influence negatively the smallholders' participation in microfinance services.

Estimation of Average Treatment Effect on Treated (ATT): Effect of microfinance on Smallholder Farmers' livelihood

Table 4 shows the estimates of ATT from the two matching algorithms obtained, using the psmatch 2 command in Stata 14. The outcome variable is “**Total Annual Income**”

The results stated that small farmers' participants in microfinance services have positively increased their total annual income and their livelihood.

Table 4: Estimation of Average Treatment Effect on Treated (ATT)

	<i>ATT using Kernel Based Matching</i>	<i>ATT using Nearest Neighbor Matching</i>
Treated	873, 484.991	873,484.991
Control	607,810.496	645,239.176
Difference	<u>265,674.495</u>	<u>228,245.816</u>
Standard Error	113,983.58	125,549.482
T-Stat	2.33**	1.82*

Source: Computed by the Author from the field survey data, 2011

*Note: ***, * significant at 1% and 10 % respectively.*

Notes: 1USD = 800.79 Rwf: Exchange Rate on 15th February, 2011

Results from the *Kernel Based Matching* showed that the ATT (Average Treatment Effect on the Treated) is equal to 256,674 Rwandan Francs (412 USD). This means that the households participating in microfinance services have increased their total annual income by 412 USD relatives to that of the non-participants. The results show also that the t-statistics for the ATT is equal to 2.33 It was found to be significant at 5 percent level. Results from the *Nearest Neighbor Matching* showed that the ATT is equal to 228,246 Rwandan Francs (366 USD). This means that the households participating in microfinance services have increased their total annual income by 366 USD) relatives to that of the non-participants.

The results show also that the t-statistics for the ATT is equal to 1.82. It was found to be significant at 10 percent. The results from both Kernel and Nearest Neighbor matching show that the households participating in microfinance services have increased their total annual income relatives to that of the non-participants. This implies that there is a positive significant effect on smallholder farmers' income for those participating in microfinance services.

CONCLUSION AND POLICY IMPLICATIONS

Microfinance institutions in Rwanda will be able to compete favorably in the global market and gainfully increase Rwanda economic development. This study analyzed the effect of microfinance on smallholder farmers' livelihoods in Rwanda. The results show also that the variables “Age, education, main occupation, distance and Off -farm income have influenced the probability to access microfinance services in Nyamagabe District. The study revealed that

microfinance have significantly improved the smallholder s' standard of living such as total annual income. In conclusion, the study found out that the smallholder farmers who had participated in microfinance services in Nyamagabe District had increased considerably their annual total income, and it can thus be deduced that the use of microfinance services is one of the best ways to escape poverty in Nyamagabe District and to increase household livelihoods

This study recommends that:

- The government and other stakeholders who are concerned with microfinance as crucial instrument of poverty reduction should take into consideration for better promotion to improve agricultural productivity and small farmers' livelihoods.
- Smallholder farmers should be encouraged to participate in microfinance and SACCOs in order to increase their income. Microfinance Institutions have to be promoted in order to provide an instrument for mobilizing savings and extending credit. Government and financial institutions must work together to support smallholder farmers in enhancing their agricultural production. To encourage women to participate in microfinance services indeed improves women's decision-making power, particularly over income from their businesses.

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RICE LOSSES CHARACTERISTICS IN VARIOUS HARVESTING METHODS

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ABSTRACT

Grain loss is inevitable during harvesting operations and attempts are made to identify and minimize that. In this study, field performance of five different harvesting methods were assessed which included three indirect harvesting methods of (i) manual cutting + threshing by a tractor driven thresher (T_1), (ii) rice reaper + threshing by a tractor driven thresher (T_2), (iii) rice reaper + threshing by universal combine harvester equipped with pickup type header (T_3), and two direct harvesting methods of (iv) head-feed rice combine (T_4), and (v) whole-crop rice combine (T_5). The results revealed that the maximum and minimum effective field capacity related to whole-crop combine (0.361 ha h^{-1}) and manual cutting (0.009 ha h^{-1}), respectively. Quantitative losses (grain and panicle shattering) in harvesting and threshing obtained to be 2.58% and 2.33% in average on indirect harvesting (T_1 , T_2 and T_3) and direct harvesting (T_4 and T_5), respectively which were not significant statistically. The average qualitative losses (broken, husked and cracked grains) were 2.30% for indirect harvesting and 0.61% for direct harvesting that showed a decline of 63.3% compared to indirect harvesting. Total harvesting losses were 5.07% for T_3 (maximum) and 2.74% for T_4 (minimum). The harvesting method affected the percentage of broken rice after milling significantly. The average broken rice for T_1 , T_2 and T_3 was 23.72, 23.28 and 24.56% respectively which were significantly higher than T_4 (21.05%) and T_5 (20.87%). Also, in the view of loss reduction, applying rice combine harvesters had priority respect to indirect harvesting methods.

Key words: *Rice harvesting, combine harvester, losses, milling.*

INTRODUCTION

Harvesting operations are known as crucial and influential processes on quantity, quality and production cost of rice. Manual harvesting of rice is such a troublesome, time-consuming and costly operation that it needs about 100-150 man-hour per hectare labor. On the other hand, labor shortage and wage rise over work peak period will cause delay in operations and increase of grain and panicle shattering so that farmers encounter severe detriments. In addition, because of seasonal rainfall in northern parts of Iran at harvest time, rice stalks tend to lodge.

Hence, mechanized harvesting operations gets into trouble and the number of labors required for manual harvesting gets up to double. Therefore, it is required to conduct technical and economic investigations for determining appropriate type on the viewpoint of existing conditions across the region.

Investigations by Ali *et al.* (1990), Siebenmorgen *et al.* (1998), Surek and Beser (1998), and Hossain *et al.* (2009) stated that harvest time had significant effect on head rice yield (HRY) so that it was required harvesting on optimum rough rice moisture content to obtain uttermost HRY. If rough rice moisture content becomes lower than critical level, broken rice percentage will raise significantly.

Other researchers examined field performance of different combine harvesters. Kalsirislip and Singh (1999) reported that in a combine equipped with a 3m width head stripper, field capacity and field efficiency were 0.66 ha h⁻¹ and 74% for standing crop and 0.3 ha h⁻¹ and 72% for lodged crop, respectively. Bora and Hansen (2007) examined field performance of a portable reaper for rice harvesting and compared it with manual harvesting. They reported that grain loss was 2.3% and 1% for reaper and manual harvesting, respectively.

Loveimi *et al.* (2008) investigated losses of two rice combine harvesters equipped with spike-tooth and rasp-bar threshing units. In direct harvesting, the average crop loss was 1.73 and 3.68% for spike-tooth and rasp-bar combines, respectively. In indirect harvesting, it was reported 3.45%. Alizadeh (2003) appraised field performance of two types of rice reapers namely self-propelled and power tiller driven against manual harvesting. He pointed out that harvesting loss was the lowest in manual method while it was the highest with power tiller driven reaper. Therefore, this study aimed to investigate technical and field aspects of utilizing rice combine harvesters and comparing them with indirect harvesting on the view of quantitative and qualitative grain losses.

MATERIALS AND METHODS

This study was conducted at experimental station of Rice Research Institute of Iran, Rasht, Iran in the cropping season of 2016-2017 where a high yielding cultivar (Fadjr) had been cultivated. Five harvest methods examined as follows:

- i. Manual harvesting (cutting with sickle) + tractor driven thresher (T₁),
- ii. Rice reaper + tractor driven thresher (T₂),
- iii. Rice reaper + threshing by a universal combine equipped with pick-up header (T₃),
- iv. Head-feed rice combine harvester (T₄),
- v. Whole-crop rice combine harvester (T₅)

Treatments T₁, T₂ and T₃ are considered as indirect harvesting but treatments T₄ and T₅ are known as direct harvesting.

Figure 1 shows machines used in the experiments. In the indirect harvesting (T₁, T₂ and T₃), cut paddy stalks were left across the field around 24 hours to reduce moisture content and then gathered and threshed by a tractor driven thresher. Before operations, crop conditions were measured in terms of plant height, number of hills per unit area, grain moisture content and grain separating force from

panicle (Table 1). Rough rice moisture content was determined by a grain moisture meter (GMK 303 RS, Korea) at harvest time. To determine soil penetration resistance at harvest time, a cone penetrometer (Eijelkamp, UK) was used for measuring soil cone index up to 25 cm deep underneath soil surface whose standard cone had a base area of 5 cm² and diameter of 25.23 mm. Grain separating force from the panicle was measured as an indication of grain shattering level as described by Alizadeh and Allameh (2011).



Figure 1 Machinery used in harvesting tests

Table 1. Agronomic features of used cultivar and field conditions at harvest

Treatment	Plant height (cm)	No. of hills per m ²	No. of plant per hill	Grain yield (kg m ⁻²)	Grain moisture content (wb)	Cutting height (cm)	Grain detaching force (N)	Soil cone index (kPa)
T ₁	112.5 ^a	17.5 ^a	20.3 ^a	0.70 ^a	18.6 ^a	43.1 ^a	0.81 ^a	972 ^b
T ₂	112.8 ^a	18.2 ^a	18.6 ^a	0.65 ^a	18.2 ^a	16.8 ^c	0.84 ^a	1116 ^a
T ₃	117.4 ^a	19.0 ^a	18.8 ^a	0.73 ^a	19.4 ^a	14.2 ^c	0.70 ^a	812 ^b
T ₄	114.2 ^a	18.0 ^a	18.0 ^a	0.61 ^a	20.1 ^a	37.8 ^a	0.85 ^a	900 ^b
T ₅	113.0 ^a	19.7 ^a	19.2 ^a	0.58 ^a	21.6 ^a	34.20 ^b	0.74 ^a	944 ^b

In each treatment, performance parameters of harvesting machines were measured which included travel speed, working width, lost time and total required time. To determine travel speed within operation, time required to traverse 30 m over harvesting was recorded by a digital timer. This was repeated four times in each plot. Theoretical field capacity (C_t), effective field capacity (C_e), work capacity (W_c), and field efficiency (F_e) of harvesting machines obtained from the following formulas (Hunt, 1995; Konaka, 2005):

$$C_t = \frac{W \times S}{10} \quad (1)$$

$$C_e = \frac{S \times W_e}{10} \quad (2)$$

$$W_c = \frac{1}{C_e} \quad (3)$$

$$F_e = \frac{T_e}{T_t} \times 100 \quad (4)$$

Where, C_t : theoretical field capacity, ha h^{-1} , C_e : effective field capacity, ha h^{-1} , W : working width, m, S : travel speed, km h^{-1} , T_t : total time, h, T_e : useful time, h, W_c : work capacity, h ha^{-1} , F_e : field efficiency, %.

To determine quantitative loss before and after harvesting on manual cutting and reaper harvester, a $1\text{m} \times 1\text{m}$ wooden frame was thrown out randomly over four spots in each plot. The grains inside the frame were gathered and weighted. In combine harvesters, losses are observed at two main units i.e. cutting and threshing units (Sangwijit and Chinsuwan, 2010). Therefore, the wooden frame was thrown out back and forth sides of the combine and all grains and panicles inside it gathered and weighted (Roy *et al.*, 2001). Then, the weight percentage of harvesting loss computed by the following formula (Pradham *et al.*, 1998):

$$HL = \frac{W_{gt} - W_{go}}{Y} \times 100 \quad (5)$$

Where, HL: harvest loss, %, W_{gt} : total harvest loss, g m^{-2} , W_{go} : pre-harvest loss, g m^{-2} , Y : grain yield, g m^{-2} .

For determining loss on the threshing stage, a wide plastic sheet was spread over a flat surface and the thresher settled on it. In the experiments, the threshing chamber was fed uniformly and afterward all the grains and the panicles on the plastic sheet gathered and weighted. The weight percentage of the loss derived as a ratio of the weight of the grains thrown out of different parts of the thresher to total grain weight (sum of the grains weight collected from the main outlet and the weight of the grains thrown out).

To determine the percentage of the broken and husked grains, four samples of 100 g rough rice was taken from the outlet of the thresher and the rice combine harvester and then the broken and husked grains separated manually and weighted (Srivastava *et al.*, 1998). To compute cracked grains percentage in each replication, 50 intact kernels of rough rice were randomly selected and their husks were carefully removed by hand. Then, brown rice kernels were placed on the crack tester (Mahsa, 50, Iran). The number of cracked ones counted and weighted.

In order to study the effect of harvest method on milling properties i.e. milling recovery, broken and head rice yield, from each treatment four samples of 150 g rough rice were randomly selected from the outlets of the thresher and combines. All impurities in the samples were removed by hand. Afterwards, samples were placed in an electrical oven with 43°C (Alizadeh *et al.*, 2006) to be dried up to 9% (w.b.). Dried rough rice samples were then husked by a laboratory rubber roll husker (THU35B, Satake Corp., Japan). Next, the outlet of the husker (brown rice) whitened by a laboratory friction-type rice whitener (Baldor, McGill Miller No. 2, USA). A rotary indented grader (TRG058 Model, Satake test Rice Grader, Japan) was used to separate broken kernels from head ones. Milling recovery and head rice yield were calculated as described by Allameh and Alizadeh (2013). Data analysis was done using SAS 9 (2004, SAS Institute, US) as randomized complete

block design (RCBD) laid out in data analysis of variance with five treatments and four replications. Means comparison was conducted by Duncan's multiple range tests.

RESULTS AND DISCUSSION

Field performances of harvesting machines have been shown in Table 2. Among the harvest methods, universal combine harvester equipped with pick-up header has the least travel speed (1.63 km h^{-1}). In this system, combine harvester moves along the field and performs threshing of what has been cut in advance. Also, the results indicated that the highest travel speed belonged to self-propelled reaper in the experiments which it was due to low weight of machine and higher maneuverability.

Table 2. Field performance of machinery used in tests

Treatment	Travel speed (km h^{-1}) ¹⁾	Working width (m)	Total work time (min)	Waste time (min)	Useful time (min)	TFC (ha h^{-1})	EFC (ha h^{-1})	Wc (h ha^{-1})	FE (%)
T1	-	-	665.70	31.00	636.70	-	0.009	111.10	-
T2	2.54	1.2	25.02	5.28	19.74	0.304	0.240	4.17	78.90
T3	1.63	2.40	19.80	4.45	15.35	0.391	0.303	3.30	77.54
T4	2.37	1.40	24.60	5.70	18.90	0.331	0.254	3.93	76.83
T5	2.08	2.38	16.62	4.50	12.14	0.495	0.361	2.77	73.09

Theoretical and effective field capacities of the whole-crop combine were 0.495 and 0.361 ha h^{-1} , respectively which were the highest compared to the other treatments. According to (1), theoretical field capacity depends on working width and machine travel speed. Also, in accordance with (2), effective field capacity is a product of theoretical field capacity by field efficiency. Although, its working width was more than whole-crop combine but because of lower travel speed during harvesting, field capacity of the cereal crop combines equipped with pick-up header was less than whole-crop rice combines.

Working capacity (time required to harvest one hectare) was the highest in manual harvesting with the mean of 111.10 h ha^{-1} while in the whole-crop combine it was the least with the mean of 2.77 h ha^{-1} . The maximum working capacity belonged to a treatment which had the minimum effective field capacity because, based on (3), working capacity was obtained by inverting effective field capacity. Field efficiency varied from 73.09% on the whole crop combine to 78.90% on the self-propelled reaper. This feature depends on wasted time, type and agronomic characteristics of a variety, plot size and operator's skill. Kalsirislip and Singh (1999) reported that for a combine equipped with a 3 m working width head stripper, field capacity and field efficiency were 0.66 ha h^{-1} and 74% for standing crop and 0.3 ha h^{-1} and 72% for lodged crop, respectively. Roy *et al.* (2001) expressed that field capacity and field efficiency of a whole-crop rice combine

harvester were 1.05 ha h^{-1} and 72%, respectively for a common rice variety in Malaysia. Veerangouda *et al.* (2010) reported that field capacity for a tractor operated combine harvester was varied from 2.88 to 3.60 ha h^{-1} .

The average quantitative losses were 2.58 and 2.33% for indirect harvesting (treatments T_1 , T_2 , and T_3) and direct harvesting (treatments T_4 and T_5), respectively (Table 3). In indirect harvesting, loss on cutting and gathering stages was higher than the threshing stage. Among the harvest methods, the maximum and minimum quantitative losses were related to T_3 (2.66%) and T_4 (2.27%), respectively.

Table 3. Means comparison of tested parameters

Treatment	Quantitative losses		Qualitative losses				Total losses	Impurity %
	Reaper and gathering	Threshing	Broken paddy	Husked paddy	Broken and husked	Cracked grains		
T_1	1.60 ^b	0.98	0.53 ^a	0.21 ^a	0.11 ^b	1.20 ^a	4.63 ^a	2.63 ^a
T_2	1.48 ^b	1.04	0.48 ^{ab}	0.23 ^a	0.10 ^b	1.63 ^a	4.96 ^a	2.52 ^a
T_3	1.54 ^b	1.12	0.61 ^a	0.25 ^a	0.27 ^a	1.28 ^a	5.07 ^a	2.78 ^a
T_4	2.27 ^a	-	0.13 ^a	0.07 ^b	0.04 ^b	0.23 ^b	2.74 ^b	2.26 ^a
T_5	2.40 ^a	-	0.24 ^b	0.16 ^{ab}	0.08 ^b	0.27 ^b	3.15 ^b	2.34 ^a

In each column, figures with common letter have no significant difference at 5% level.

In combine harvesting (T_4 and T_5), cutting and threshing losses are considered in the lump.

In the indirect harvesting, qualitative loss obtained 2.30% on average, but it was 0.61% in direct harvesting which showed a decline of 73.5%. Amidst the indirect harvest methods, the highest and lowest qualitative loss found to be 2.44 and 2.05% for treatments T_2 and T_1 , respectively. Qualitative loss was determined 0.47 and 0.75% for treatments T_4 and T_5 , respectively. Total harvest losses (quantitative and qualitative) were the highest for treatment T_3 (5.07%) while the lowest (2.74%) belonged to treatment T_4 . In general, total harvest losses in indirect method averaged out 4.88% but it was 2.94% in direct method which decreased 39.75%.

The proportion of harvest losses in each stage of the experiment is shown in Figure 2. As it shows, quantitative and qualitative losses are 79.5 and 20.5% in direct harvesting by rice combines but they are 53.30 and 46.70% in indirect harvesting, respectively. The results indicated that the harvest loss in the direct method occurred mainly on the cutting stage. Qualitative loss constituted a considerable proportion of total harvest losses in the indirect harvesting. Among the experiment stages for all harvest methods, reaping had the highest proportion in the loss whereas the broken and husked grains had the lowest proportion in it. Also, the cracked grains had the highest proportion amid the qualitative losses. This was explicitly observed in the indirect harvesting, as it was mentioned earlier, where environmental tensions applied on the grains during cutting and threshing operations.

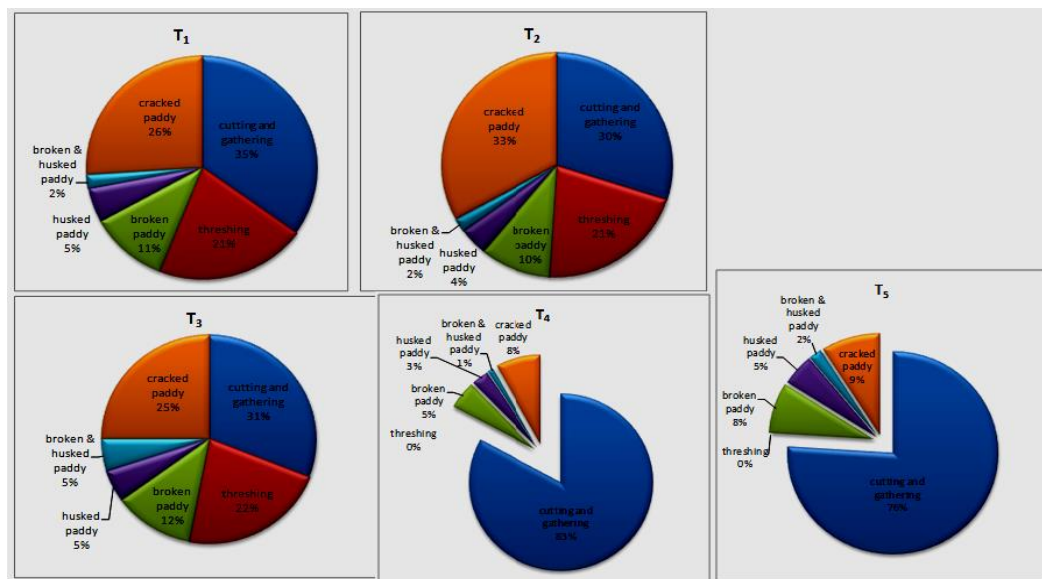


Figure 2. Contribution of different stages in harvest losses

In their research, Loveimi *et al.* (2008) reported that rice harvest losses in the indirect method were 3.77 and 1.67% by a combine equipped with rasp-bar and spike-tooth type threshing drum and they were 3.6 and 1.8% in direct method, respectively. Harvest loss of a rice combine harvester was 1.68% for a common variety in Malaysia (Roy *et al.* 2001). Fouad *et al.* (1990) in their investigations in Egypt reported that harvest losses were 178-380 kg ha⁻¹ for a common variety harvested by rice combines.

In general, loss could be attributed to harvest and threshing method, harvest time, type of variety and its physical properties, crop condition in terms of maturity, lodging and soil condition. In indirect harvesting, cut paddy is laid out on stubbles from 24 to 48 hours depending on the weather conditions. Then, they are collected and threshed. Therefore, crop moisture reduction would lead to not only a rise in grain shattering during gathering and packing but also paddy would be exposed to environmental tensions that bring about crop qualitative loss in consequence.

Table 4 shows the comparison of rough rice milling properties obtained by different harvest methods. The average milling recovery was 67.00% in indirect harvesting treatments and 67.72% in direct ones which indicated a significant difference ($p < 0.05$). Also, the broken and head rice yield was 23.85 and 76.15% in indirect harvesting and 20.96 and 79.04% in direct one, respectively.

Table 4. Milling losses in different harvest methods

Treatment	Milling recovery (%)	Broken rice* (%)	Head rice* (%)
T ₁	66.58 ^b	23.72 ^a	76.30 ^a
T ₂	67.07 ^b	23.28 ^{ab}	76.73 ^a
T ₃	67.32 ^{ab}	24.56 ^a	75.45 ^a
T ₄	67.24 ^{ab}	21.05 ^b	78.95 ^a
T ₅	68.20 ^a	20.87 ^b	79.13 ^a

* Broken and head rice are derived from total milled rice.

In each column, figures having the same letter have no significant difference.

As the results have shown, the broken rice in the indirect harvesting was significantly higher than the direct one. This, on one side, could be attributed to the mechanical stresses applied on the grains during harvesting and threshing and on the other side environmental tensions due to reabsorption of dried grains across the field and their crack formation which results in rise of the broken rice and fall of head rice yield within milling process. This has been approved by Siebenmorgen *et al.* (1998); Nguyen and Kunze (1984); Banaszek and Siebenmorgen (1990).

CONCLUSION

The maximum and minimum effective field capacity averaged to 0.361 and 0.009 ha h⁻¹ for treatments T₅ and T₁, respectively. Time requirement was 111.10 h ha⁻¹ for manual harvesting (T₁) but it was 3.54 h ha⁻¹ for mechanized treatments (T₂, T₃, T₄ and T₅) on average which saved 96.80% compared to manual method. Quantitative and qualitative losses constituted 53.30 and 46.70% of total harvest loss in indirect harvesting on average, while they were 79.50 and 20.50% in the direct harvesting on average, respectively. Total harvest loss was 4.88% in the indirect harvesting whereas it was 2.95% in the direct method which declined 39.75%.

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CHARACTERIZATION OF THE CALVING INTERVAL IN THE MERTOLENGA BREED: THE INFLUENCE OF THE COMMON AGRICULTURAL POLICY BETWEEN 1986 AND 2012

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ABSTRACT

Natural conditions in most of the Portuguese territory (marginal soils and severe water deficit in the summer) do not favor intensive meat production, which in turn determines a low stocking rate unless the pastures are well managed and the animals adequately supplemented when necessary. These improvements are costly and pointless in most cases explaining why breeders do not adopt this strategy. As grassland and forage production, in most cases, are not suitable for efficient fattening, the conversion of land use has led to an increase in the number of suckler cows in the studied period (1986 to 2012), since these animals are less dependent on forage quality and have lower feed costs. It is under this complexity of factors that the Mertolenga breed stand out for its sturdy build, ease of delivery and low food requirements. Establishing periods of calving/mating, and the shortening of these periods, allows co-ordination of the greater nutritional requirements of the animals with the time of the year of greater pasture growth. This would enable the reduction of supplementary feed. The definition of breeding season allows the use of reproductive technologies, which increases neonatal survival until weaning. When the political conditions are added to the natural conditions, the question arises as to the extent to which the efficiency of production has been altered through the stages of the CAP. Also how can the economic viability be supported in the future regardless of the Community support.

Keywords: *Mertolenga, Calving interval, Productive efficiency, CAP.*

INTRODUCTION

The Common Agricultural Policy (CAP) of the European Union (at the time European Economic Community) was established in 1962 in order to respond the needing of increase agricultural productivity, to ensure the regular supply of agricultural products and to stabilize prices, together with the guarantee of fairer and more stable incomes for farmers. The negative side-effects were, in particular, environmental imbalances, creation of surpluses, excessive protectionism of

Community products and high expenditure of the agricultural sector in the EU budget (in 1970 the CAP consumed about 70% of the budget).

The situation led to a revision of the CAP in 1992, which adopted measures such as the establishment of prices closer to the world market and therefore more competitive, establishing quotas for some products in order to avoid the accumulation of surpluses and the promotion of a more environmentally friendly agriculture (Alves, 2011). During the CAP reform period under study (from 1986 to 2012), the beef sector in Portugal has continuously increased its dependence on subsidies, losing competitiveness and leading to an inverse result. However, the differentiation in the production of food products, with a certificate of origin and a quality label, allowed the domestic bovine breeds sector to gain their own dynamics through their Breeders' Associations, in particular that of the Mertolenga Breed, leading to the emergence of new specific products and regions other than those traditionally housing herds. The aim of this study was to assess the dynamics of the farms' adaptation to the successive stages of the CAP and how they reflected on the reproductive management of holdings, particularly on the interval between calving.

MATERIALS AND METHODS

The Association of Mertolenga Cattle Breeders (Associação de Criadores de Bovinos Mertolengos - ACBM), since its establishment in 1987 made the collection of information provided by its members continuously, and therefore has a very complete database that allows to characterize the dynamics of the national Mertolenga breed and influence of different CAPs. The period under study covered the years 1986 to 2012 comprising 4 stages of the CAP, namely: - Stage 1 - from 1986 to 1991; - Stage 2 - from 1992 to 1999; - Stage 3 - from 2000 to 2007; - Stage 4 - from 2008 to 2012. Bettencourt and Romão, (2009) and Vinatea and Madrigal, (2010) emphasize the importance of reproductive performance, since obtaining a calf weaned per cow and per year directly affects profitability, so adjust the genetic characteristics of bovine populations to conditions is key to improving productive efficiency (Nielsen et al., 2013). In this context, defining clear reproduction objectives allows the development of economically more effective reproductive strategies and allows the identification of parameters that contribute to the accurate prediction of characteristics that affect commercial profitability (Costa, 2015).

The establishment of periods of calving / mate and the shortening of these periods allow to coincide the moment of greater nutritional requirement of the animals with the time of the year of greater availability of pasture, enabling the reduction of food supplementation or even its elimination (Valle *et al.*, 2000). On the other hand, it also has the advantage of allowing health management to fit with reproductive management through a prophylactic plan (Valle *et al.* 2000; Reis, 2010). The definition of breeding season allows the use of reproductive technologies such as synchronization of heat, or group management, which increases neonatal survival and until weaning, due to reduced cohabitation of offspring of different ages (Reis,

2010). According to Robalo Silva (2003), the parameters most used in the measurement of this efficiency are the distribution of deliveries throughout the time of delivery, (or the interval between deliveries in continuous breeding systems), fertility rates, gestation and weaning, and finally, the age at first calving. Regarding the interval between deliveries, it should not theoretically exceed 365 days, since gestation time varies between 285 and 290 days and postpartum anestrus is 75 to 80 days (Bettencourt & Romão, 2009). According to Fernandes (2011), the interval between delivery and conception should not exceed 83 days for this objective to be achieved. In order to study this parameter in the referred period, the statistical values of the Mertolenga breed and its three phenotypes - red, piebald and rosillo - were subjected to descriptive statistical analysis and analysis of variance. The analyzes was chronologically framed in the four stages of the CAP between 1986 and 2012 using the NCSS (Number Cruncher Statistical System) and Excel.

RESULTS AND DISCUSSION

The calving interval, usually an indicator of the reproductive management efficiency, did not undergo major changes during the 4 Stages of the CAP under study. In general, it can be said that the distributions followed the same trend with the asymmetry coefficients always positive and as such with tails displaced to the right, which means that the median is greater than the mode and the mean greater than the median. In relation to the measures of central tendency, Stages 2, 3 and 4 had coincident values for mode (365 days) which indicates that this is the reference value for the cattle producers regardless of the policies determined for the sector; the mode in Stage 1 (1986-1991) had a value of 369 days, 35% of calving being equal to or less than this value; this fact, combined with a median that was the lowest of all the Stages - 386 days - led to graphically the first 3 classes of frequency to stand out from the rest, as shown in Figure 1.

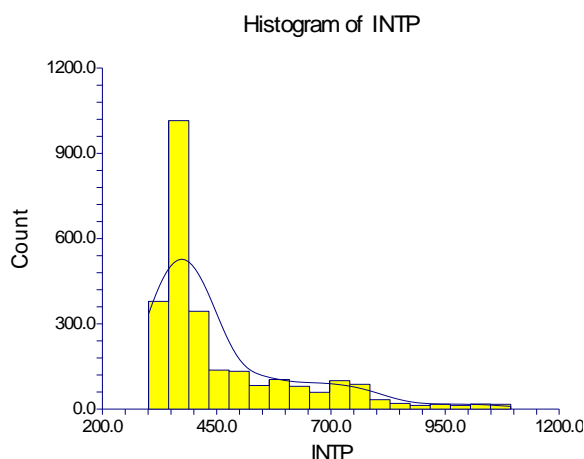


Figure 1 – Calving interval during Stage 1 of CAP (1986-1991)

During this Stage, there was a number of changes to the CAP. From 1 January to 5 April 1987, transitional arrangements were adopted to ensure the continuity of the calf premium and adjustments to the variable premium. From 6 April 1987 to 31 December 1988, the Commission authorized the intervention, maintaining the existing premiums (variable slaughter premium, calf premium, suckler cow premium). In addition, the suckler cow premium was increased from 15 to 25 ECU. During Stage 2 (1992-1999) statistically the mode of the calving interval decreased slightly from 369 to 365 days, but only 30% of deliveries occurred around or below this value, indicating that there was a widening of the interval. To confirm it the median increased from 386 to 404 days.

Graphically and by comparison with what happened in Stage 1, it can now be seen that the modal class and the median class still stand out from the rest, (Figure 2), but these now have greater expression in the graph set, since also the average rose from 460 to 468 days.

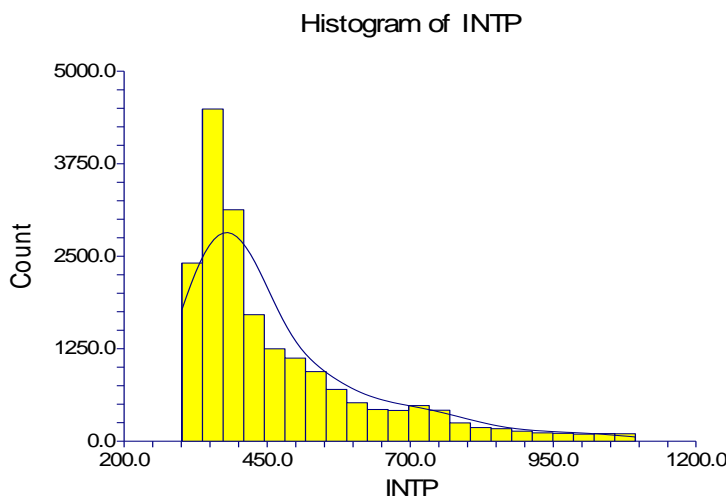


Figure 2 – Calving interval during Stage 2 of CAP (1992-1999)

Since the policies adopted led to a growth of agricultural production of 2% per year, while domestic consumption stood at 0.5%, this gap between supply and demand quickly accumulated stocks of various products, including beef. In order to solve the problem of agricultural surpluses, the volume of production was reduced through *set-aside*, extensification, conversion of production and aid linked to non-use of land.

In the beef sector, income support was largely proportional to the volume of production and therefore the bulk of support was given to larger and more intensive holdings; there was therefore a widening of the calving interval as the fall in prices did not justify a greater efficiency of production and the income was ensured by the mere holding of the animals.

In Stage 3 (2000-2007), although statistically the mode remained at 365 days and 30% of deliveries occurred below this value, there was a slight contraction of the median (from 404 to 401 days) and the mean (from 468 to 450 days). From Figure 3, it can be seen by comparison with Graph 2 that the upper classes including the middle class have a higher frequency and with fewer lags between them, giving the tail of the graph a more regular aspect.

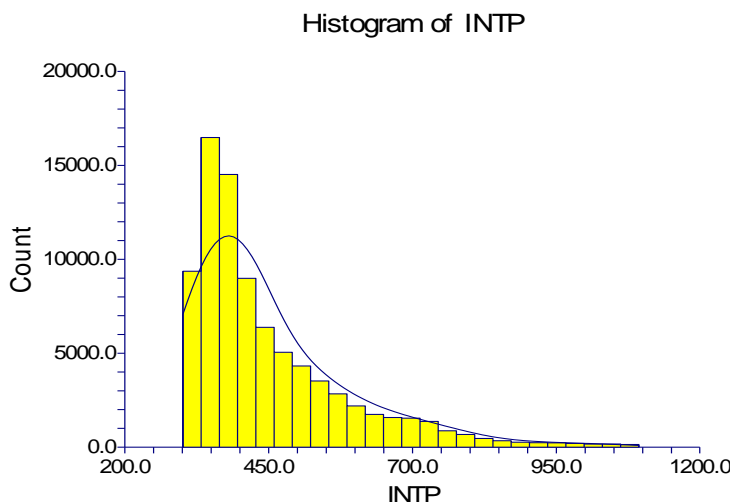


Figure 3 – Calving interval during Stage 3 of CAP (2000-2007)

As the dispersion coefficient decreased between Stages 2 and 3, from 27.7% to 23.8%, this means that deliveries recorded in frequency classes above the median were more concentrated contributing to this aspect of the graph. The reasons for this were that direct aid was introduced, in which the new regulation introduced a series of changes by increasing the value of premiums over a period of three years (special premium for males and cows) and introduced a slaughter premium on the condition that it would be paid directly to the producer.

In Stage 4 of the CAP (2008-2012) mode maintained as in Stage 3 but there was an increase in both the median (from 401 to 430 days) and mean (from 450 to 477 days). In Figure 4 it can be seen by comparison with Figure 3 that, similarly to what happened from Stage 2 to Stage 3, the upper classes present a higher frequency to the middle class and with fewer lags between them, further accentuating this trend.

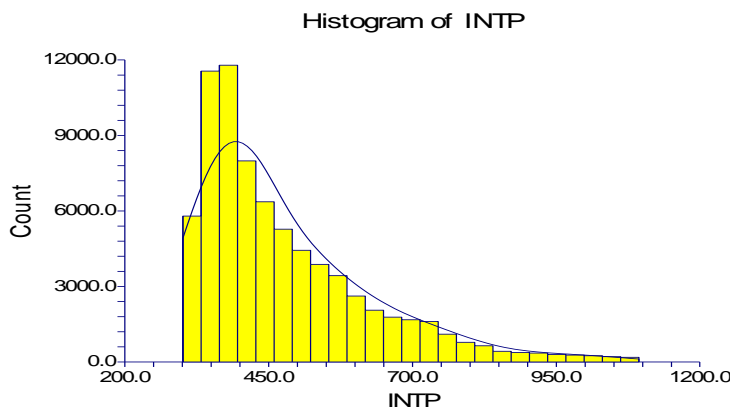


Figure 4 – Calving interval during Stage 4 of CAP (2008-2013)

More specifically, a breeder could qualify for the special premium for male bovines which would be increased in three stages to €210 per head / year for bulls and €150 per head per year for steers in the year 2002 and would continue to do so in the following years; the premium would be granted in the form of an annual premium per calendar year and per farm within the regional limits. The annual premium for suckler cows would be increased to €200 in 2002 plus a national supplement of €50 per head that could be added to that premium.

The variance analysis (Tukey-Kramer multiple comparison test) of the calving interval found in the ACBM regions over the 4 PAC Stages resulted in the values in Table 1.

Table 1 - Multiple comparison analysis of calving interval

<u>Stages of PAC</u>	<u>Calving interval (days)</u>
1 (1986 – 1991)	475,2 <u>ab</u>
2 (1992 – 1999)	473,0 <u>b</u>
3 (2000 – 2007)	459,3 <u>c</u>
4 (2008 – 2012)	483,9 <u>a</u>

The results show that during Stage 3 premiums for the slaughter of calves and steers encouraged breeders to increase the reproductive efficiency of their holdings in order to obtain more animals to benefit from Community aid than suckler cows. During Stage 4, there was a significant widening of the calving interval, although the CAP measures for cattle did not change. The economic recession that has been felt during this period with a direct impact on the reduction in domestic demand for beef within the European Union may partly explain this lower reproductive efficiency (widening the interval between deliveries) to which some adverse climatic effects, in particular the years of precipitation below the average (2008, 2009 and 2012).

CONCLUSIONS

The calving interval of the Mertolenga breed varied throughout the four Stages of the CAP between 1986 and 2012 and was directly affected by the policy measures put in place, namely slaughter premiums, premiums for suckler cows and production premiums; when premiums for production were attractive, breeders worked to reduce the calving interval.

Indirectly, the economic recession that began in 2008 and had repercussions in the following years has altered the EU's internal consumption patterns affecting prices. This situation led to less efficiency on the part of breeders who, during the fourth Stage, supported the income of their holdings in the premiums obtained for the holding of suckler cows, thereby neglecting the production of calves; also the climatic irregularity and the low rainy years of 2008, 2009 and 2012, contributed to a deficient and irregular pasture production, which had a negative impact on the reproductive indices of the animals.

The calving interval of the Mertolenga breed was thus a reflection of measures of reproductive management inherent to the enterprises, political measures that could affect this management, and external economic and climatic factors that also exerted their effects.

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ASSESSMENT ON PERFORMANCE OF PARTNERSHIP EXTENSION MODELS IMPLEMENTED IN TEA SMALLHOLDING SECTOR IN SRI LANKA

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ABSTRACT

Tea smallholding sector provides the highest contribution to Sri Lankan tea industry. In recent years the productivity of tea smallholdings has shown a declining trend. This could mainly be attributed to limitations of providing an optimum extension service. The Public-Private Partnership (PPP) extension models have been introduced during the last decade as an alternative to a part of the tea smallholdings sector. This study was carried out to assess the performance of three such well-established partnership extension models and to identify the factors affecting their success. Three partnership extension models representing a factory-based model (FBM), an input supplier-based model (ISBM) and, a development agency-based model (DABM) were selected for the study. Six key components of a successful partnership i.e. trust and cohesiveness, motivation to participate, resource sharing, support to achieve long-term expectations, sharing technical information and, satisfaction about the model were used to assess the success of PPP. The primary data was collected using pretested questionnaire schedule followed by key informant interviews with randomly selected 90 smallholders (30 from each model) and with extension partners from each model. The findings revealed that productivity of tea smallholder lands in FBM is the highest when compared to that of other two models. This could be attributed to the more frequent contacts with smallholders and better provision of other services. Some success factors of the models viz. trust and cohesiveness, resource sharing, technical information sharing and motivation to work showed a significant relationship with age, experience, tea land extent and productivity ($p < 0.05$). Development agency model was highly rated by poorer tea smallholders, while those having higher land extent highly rated the other PPP models. Partnership models should serve equally to all tea smallholders and therefore, it could be recommended that partners of PPP

extension model should further promote trust and cohesiveness, sharing of technical information and resources to establish successful partnerships.

Keywords: *Public-Private Partnership extension, Partnership components, Tea smallholders.*

INTRODUCTION

Tea is one of the most important agricultural commodities in Sri Lanka, which provides employment to nearly two million people. Total tea production of the country in 2017 was 307.08 Million kg, of which 288.98 Million kg (94% of Production) was exported, earning Rs. billion 233.3 (Central Bank, 2017). The total tea production by the tea smallholders in 2017 was 231.96 Million kg, which was 76% of the total production (Sri Lanka Tea Board, 2017). Even though the smallholding sector is the dominant and most important sector, the average productivity is around 1991 kg/ha/year (TSHDA Annual Report, 2017), which is far below its potential of over 3000 kg/ ha/year (TRI, 2002). The technology dissemination in the tea smallholdings sector is in the hands of public and private parties operating through various channels. However, the public extension system in the tea sector is not expanding at the required rate to meet the increasing demand mainly due to financial constraints and inadequate manpower availability. The field extension officer to farmer ratio is nearly 1:2700 when it is believed that it should be 1:1000. This shows the need for expansion of the TSHDA staff strength as well as the need for more collaborative and partnership approaches to better serve the tea smallholders. The extension arms of private organizations such as agro-input and service agencies often operating through bought leaf factories provide information that promotes increased use of their products (Amarathunga, Wanigasundera and Wijerathne, 2017). These private sector channels recover their costs through the margin on the product they are either selling or buying. They do not make any direct charge for the extension services provided. Most grassroot level field staff of the private channels are not technically competent to serve as extension workers (Amarathunga, 2015). However, involving other organizations in the tea sector to disseminate information help to increase the coverage and effectiveness of extension public sector (Obesekara, 2009). The emerging partnership extension services between public and private sectors could be the effective and efficient solution to provide good extension service. Evaluation of the such PPP models will help to identify the present situation of their collaboration, strengths, and limitations (Krell et al, 2016). Hence, this study was carried out to assess the performance of three such partnership extension models and to identify factors affecting the success.

General objective

To assess the strengths and the weaknesses of different partnership extension models implemented in Low country tea small holding sector.

Specific objectives

- To identify the partnership extension models implemented in tea smallholding sector.

- To assess the influence of the factors affecting the success or failure of the partnership extension models implemented.
- To recommend improvements to partnership extension services operating in the low country tea smallholding sector.

MATERIALS AND METHODS

Public-Private Partnerships Model

Public-private partnerships are defined as any collaborative effort between the public and private sectors in which each sector contributes to the planning, resources, and activities needed to accomplish a mutual objective (Spielman & Grebmer, 2004). Partnership provides opportunities for all partners to learn new competencies. The process of building a public-private partnership consists of five phases (Hartwich et al., 2008). They are identifying common interest, negotiating the partnership, implement the partnership, evaluation of partnership and deciding to continue or close the partnership. The main design of the organization should include representation, decision making, work organization, information exchange and communication among partners, monitoring and evaluation and administration for financial resources. Based on Hartwich's model, PPP concept to technology dissemination process of tea smallholdings sector was proposed by Amarathunga (2015). This study was conducted with the conceptual framework given in Figure 1.

Factors affecting the success of Partnership Extension models implemented in Tea Smallholding sector

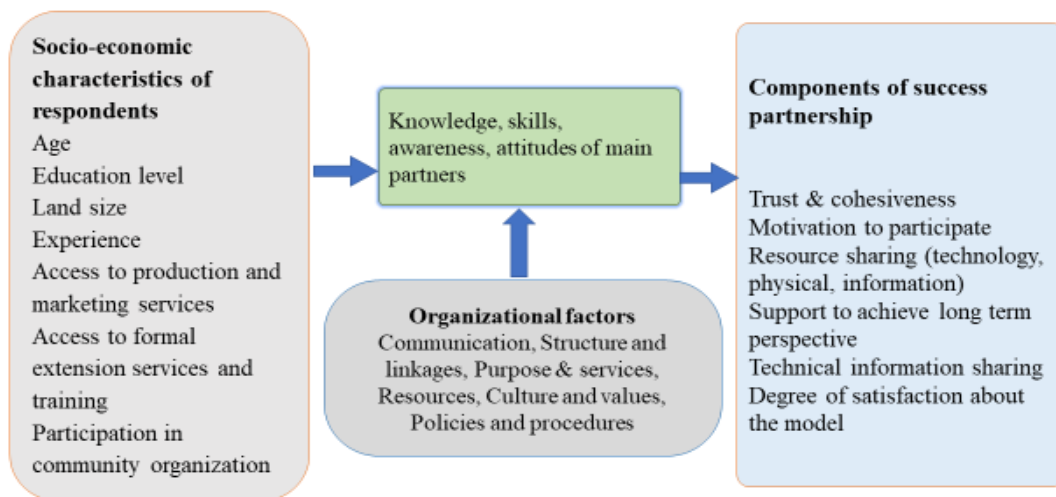


Figure 1. The conceptual framework for the study

Three different leading partnership extension models such as **Tea factory-based partnership extension model** (Public Private partnerships -3Ps originated from the Tea Smallholder Factories PLC., has field extension service for improving

productivity and thereby tea smallholder's livelihood development), **Input supplier-based partnership extension model** (Public Private partnerships -3Ps oriented from the CIC Agribusiness which is a diversified subsidiary that is involved in promoting the use of high-quality agricultural inputs and services) and **Development agency-based partnership extension model** (Public, Private and Producer Partnership -4Ps model oriented from the International Fund for Agricultural Development-IFAD conducting smallholder agri-business project in order to provide better services of financial and input to tea smallholders) were selected for the study. The primary data on social status of smallholders and other partners (Age, Gender, Education, Experience, No of households, involvement in tea cultivation on full or parttime basis, position of society/CBO) extent, yield and other field information, and extension activities done by tea related organizations, frequency of participation, was collected using pretested questionnaire schedule followed by key informant interviews with randomly selected 90 smallholders (30 from each model) and extension partners from each model. The questionnaires were subjected to the Cronbach alpha reliability test and the reliability coefficient was above 0.7. The questionnaires were also tested for validity by an expert panel. Six key components of a successful partnership i.e. trust and cohesiveness, motivation to participate, resource sharing, support to achieve long-term expectations, sharing technical information and, satisfaction about the model were used to assess the success of PPP. Secondary data was obtained from various sources such as the TRI, TSHDA, SLTB, Central Bank Reports, Reports of Census and Statistics and tea smallholders record books and records of tea factories and smallholding societies. Data collected from the tea small holders and other partners were coded. Constructs in some variables were made with weightages according Saravanan and Veerabhadraiah, (2003) and Amarathunga (2015). Mean values of the dependent variables were used to compare the partnership models as explained by Amarathunga, Wanigasundara and Wijerathna (2017). One-way ANOVA and Post hoc Bonferroni tests were used to compare the dependent variables of tea smallholders and Kruskal-Wallis test was used to compare the dependent variables of other partners. Correlation analysis was also used to test the relationship between socio-economic factors (age, education level, experience, tea land extent and productivity) and dependent variables of respondents. Data analysis was done using the SPSS Software.

RESULTS AND DISCUSSION

The main objective of the research was to assess the strengths and weaknesses of different partnership extension models implemented in the Low country tea smallholding sector. Tea smallholders interviewed, 87 are male respondents and 03 are female.

Comparison of components of success partnership models

Constructs used for measurement of those components were weighted by an expert panel according to importance to measure the components. As a result of conducting more frequent collaborative extension activities, TSHDA officials have

more opportunities to meet their tea smallholders in FBM and ISBM models (Table 1). Therefore, level of trust and cohesiveness between TSHDA and tea smallholders is significantly higher in the factory-based model (FBM) and input supplier-based model (ISBM) than development agency-based model (DABM) ($p=0.001$). DABM has conducted Smallholder Agri-business Project (SAP) by coordinating between regional staff of TSHDA and other partners of the model. Therefore, it was observed that there is a high level of trust and cohesiveness between TSHDA officials and smallholders and also between other partners and smallholders. However, these interactions are not significant compared with same components studied in relevant groups of other two partnerships models. Level of motivation among TSHDA and leading partner to participate in the model is significantly higher in ISBM than other two partnership models ($p=0.001$).

Table 1 Mean level of components of success according to tea smallholders

Components of success	Partnership ¹	FBM	ISBM	DABM
Trust and cohesiveness among the partners	A	27.39**	27.34**	18.34
	B	21.0**	26.79**	10.41
	C	27.39**	27.34**	18.34
Level of the motivation of partners to participate in the model	A	21.24**	25.04**	14.64
	B	16.88*	22.08**	8.96
	C	28.64**	21.96	20.24
Level of resource sharing among the partners	A	17.1*	20.65**	12.1
	B	13.85*	18.7**	7.25
	C	23.85**	17.45	16.35
Level of model support to achieve long term perspective		12.79*	11.37	10.04
Level of technical information sharing in the model		24.36**	20.42**	16.38
Level of satisfaction about the partnership model		27.68**	23.53*	19.29

**Significant at 0.01 *Significant at 0.05,¹ A - Partnership b/w TSHDA & Tea smallholders, B - Partnership b/w TSHDA & Leading partner, C - Partnership b/w Leading partner & Tea smallholders

Leading partner in ISBM provide sponsors for extension programs and they are conducting more frequent collaborative extension activities. As result of frequent contacts of smallholders by the other factory base extension coordinators for the purpose of continuation of green leaf supply chain in sustainable manner, the level of motivation among leading partner and tea smallholders to participate in the model is significantly higher in the FBM than other two partnership models ($p=0.001$). Level of resource sharing among TSHDA and tea smallholder is significantly higher in the FBM than the DABM ($p=0.04$). FBM coordinates to get land development subsidies for tea smallholders from TSHDA. The factory extension team facilitates financial support to smallholders in order to improve land productivity in short term as well as long term, also conduct Extension programs frequently and provide inputs such as fertilizer, agro equipment, nursery plants, etc. Additionally, they have conducted community and social relationship program, such as health camp, welfare society, annual bonuses scheme, for their

smallholders and family members attached to each factory supply base. As a result of leading partner provide sponsorships for TSHDA extension programs, Level of resource sharing among TSHDA and leading partners is significantly higher in the ISBM than other two partnership model ($p=0.001$). Level of resource sharing among leading partner and tea smallholder is also significantly higher in the FBM than ISBM and DABM ($p=0.001$). Tea smallholders were benefited by loans, bonuses, machines to success by leading partners and tea smallholders provide good tea leaves to leading partners in FBM. Extension team of FBM, facilitates for improving smallholder land productivity by implementing replanting project providing financial and technical assistance. Hence, smallholders attached to FBM have more confidence on long term benefits granted by the extension model. Therefore, level of support to achieve long term perspective is significantly higher in the FBM than DABM ($p=0.001$). Tea smallholders in FBM model are more benefited than other PPP models. They get more support to develop their tea lands. With the regular meeting of partners for providing services to smallholders, level of technical information sharing in the model is significantly higher in the FBM than other two partnership models ($p=0.001$). Therefore, the level of satisfaction of tea smallholders about partnership model is significantly higher in the FBM than other two partnership models ($p=0.001$). Tea smallholders in FBM have a more benefits and support from other partners.

Relationship between socio-economic characteristics and the success of extension partnerships

Influence of socio-economic characters (Age, education level, experience, tea land extent, and productivity) of tea smallholders on the success of extension partnership was shown in this section. Correlation analysis was applied separately on each model for the analysis of above relationships.

The results showed a positive association between tea land extent of smallholders with the level of trust and cohesiveness in the FBM (Table 2). Tea Factories expect more green leaves from the tea smallholders. They are motivating maintain a close relationship with tea smallholders who have the higher extent of tea land. The studied all success factors on effective partnership are positively associated with age and experience of smallholders and which means that extension staff of factory based more focus to maintain close rapport with elderly and experience smallholders in order to build up trust and confidence, and to maintain their green leaf supply base. This positive association should be taken into consideration to strengthen the effectiveness of partnership model. It was also observed that studied all success factors on effective partnership are positively associated with the productivity of smallholder lands. Therefore, strengthening success factors of partnership will enhance the productivity of tea smallholding and thereby their livelihood.

Table 2. Correlation between socio-economic characteristics of tea smallholders and success factors on partnership in the factory-based model

Factors of success		Age		Education level		Experience		Tea extent		Productivity	
		r value	Sig. (p)	r value	Sig. (p)	r value	Sig. (p)	r value	Sig. (p)	r value	Sig. (p)
Trust and cohesiveness		0.09	0.96	-0.12	0.53	0.04	0.85	0.36	0.04*	0.14	0.45
Motivation to participate		0.18	0.36	-0.02	0.93	0.20	0.29	0.43	0.02*	0.31	0.10
Resource sharing		0.17	0.36	-0.11	0.57	0.17	0.36	0.34	0.07	0.26	0.17
Support to long term expectation		0.02	0.99	0.12	0.52	0.08	0.69	-0.02	0.92	0.21	0.26
Sharing of information		0.36	0.04*	-0.19	0.32	0.41	0.03*	-0.10	0.61	0.74	0.70
Level of satisfaction		0.23	0.22	-0.10	0.59	0.32	0.09	0.16	0.41	0.13	0.50

*Correlation is significant at 0.05 level

Table 3 shows that positive association between tea land extent of smallholders with the level of trust and cohesiveness in the partnership model ISBM. Input suppliers may focus to motivate with smallholders who having higher extent of tea lands to promote their product. The studied all success factors on effective partnership are positively associated with the productivity of smallholder lands. Additionally, extension staff of this model also positively interact and motivate with experienced smallholders for the strengthening of their input supply base.

Table 3 Correlation between socio-economic characteristics of tea smallholders and success factors on partnership in input supplier-based model

Factors of success		Age		Education level		Experience		Tea extent		Productivity	
		r value	Sig. (p)	r value	Sig. (p)	r value	Sig. (p)	r value	Sig. (p)	r value	Sig. (p)
Trust and cohesiveness		-0.10	0.6	0.19	0.31	0.37	0.04*	0.40	0.03*	-0.42	0.02*
Motivation to participate		-0.05	0.80	0.31	0.10	0.37	0.04*	0.47	0.01**	-0.47	0.01**
Resource sharing		0.05	0.80	0.29	0.12	0.47	0.01**	0.53	0.01**	-0.49	0.01**
Support to long term expectation		0.04	0.84	0.05	0.08	0.17	0.38	0.37	0.04*	-0.20	0.30
Sharing of information		0.10	0.58	-0.07	0.70	0.25	0.18	0.39	0.03*	-0.31	0.10
Level of satisfaction		-0.01	0.96	0.14	0.47	0.23	0.23	0.47	0.01**	-0.02	0.29

**Correlation is significant at 0.01 level, *Correlation is significant at 0.05 level

Leading extension partner of the DABM model more concern on development of smaller scale tea smallholders land than the higher for the development of them (Table 4). Partnerships in DABM positive associate with experience regarding the level of resource sharing in the model. Extension partners in DABABM will provide more benefits for their old customers to develop the partnership.

Table 4. Correlation between socio-economic characteristics of tea smallholders and success factors on partnership in development agency model

Factors of success		Age		Education level		Experience		Tea extent		Productivity	
		r value	Sig. (p)	r value	Sig. (p)	r value	Sig. (p)	r value	Sig. (p)	r value	Sig. (p)
Trust and cohesiveness		0.26	0.16	0.27	0.14	0.26	0.16	-0.41	0.02*	0.32	0.09
Motivation to participate		0.31	0.10	0.21	0.28	0.20	0.29	-0.38	0.04*	0.27	0.15
Resource sharing		0.29	0.12	0.22	0.25	0.23	0.23	-0.38	0.04*	0.31	0.10
Support to long term expectation		0.50	0.01**	0.15	0.44	0.13	0.50	-0.46	0.01**	0.37	0.04**
Sharing of information		0.39	0.04*	0.29	0.12	0.32	0.07	-0.31	0.10	0.36	0.04*
Level of satisfaction		0.36	0.06	0.06	0.76	0.04	0.82	-0.47	0.01**	0.24	0.20

**Correlation is significant at 0.01 level *Correlation is significant at 0.05 level

It was also observed that studied all success factors on effective partnership are positively associated with the productivity of smallholder lands whilst level of technical information sharing and support to achieve long term expectation have significantly positive association with productivity of smallholding. Therefore, strengthening success factors of partnership will enhance the productivity of tea smallholding. The result illustrates in Table 4 shows that the extent of the tea smallholding land is negatively associated with the level of motivation to participate in the DABM.

CONCLUSION

This study confirms that leading partners in factory-based partnership model are providing better extension services with input by more frequent contacting their smallholders and conducting extension program. In the ISBM, the productivity showed a significant negative relationship with trust and cohesiveness, resource sharing and motivation. DABM was highly focus on poorer tea smallholders, whilst extension partners of other model more concern to strengthen the relationship with smallholders who having higher land extent. This study proves that the trust and cohesiveness, resource sharing, technical information sharing and motivation to work are the success factors for straightening of the partnership and land productivity of tea smallholding.

By illustration the results of above empirical study, authors provide sufficient evidence to prove that the success of the public private partnership models are strongly depend on the key characters of Trust and cohesiveness, resource sharing, technical information sharing and motivation to work among the partners.

RECOMMENDATIONS

Increase the frequency of meeting with partners and the number of extension programs which will help to straighten partnership among the partners. Enhance the trust and cohesiveness, resource sharing, technical information sharing and motivation to work for straightening of the partnership and land productivity of tea smallholding. Therefore, it is strongly recommended that all extension agencies develop a higher level of partnership and closer interaction among them and smallholders.

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TOWARDS SUSTAINABLE RURAL ENTERPRISES: ADOPTION STUDY OF INTEGRATED AQUACULTURAL TECHNOLOGIES AMONG FISH FARMERS IN OSUN STATE, NIGERIA

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ABSTRACT

The study was designed to assess Adoption of Integrated Aquacultural Technologies (AIAT) among Fish Farmers in Osun State, Nigeria. Specifically, the personal attributes of respondents were described, level of awareness of integrated aquacultural technologies was determined, the sources of information on integrated aquacultural technologies available to fish farmers in the study area and constraints inhibiting adoption were also identified. A purposeful sampling procedure was used to select 150 farmers that registered with Osun State Agricultural Development Programme (ADP). Validated and structured interview schedule was used to elicit requisite information from the respondents. Simple descriptive statistical techniques were used to summarize the data, while Pearson Moment Correlation was used to make inferential deductions. The results showed that respondents had a mean age of 42.5 ± 8.12 years and majority of them (84.30%) were males. It was also revealed that higher percentage of the respondents were aware (60.0%) of the technologies. Also, majority (56%) of the respondents adopted 7-9 integrated aquacultural technologies out of 15 integrated aquacultural technologies introduced to them. Extension agents were the information providers for the respondents. In addition, there were positive and significant relationships between AIAT and educational level ($r=0.316$) and numbers of ponds owned ($r=0.325$) at $P \leq 0.05$ significance level. It was therefore concluded that regular training and capacity building of the fish farmers would enhance sustainable fish farming in the study area and Nigeria in particular.

Keywords: *Fish farmers, integrated aquacultural technologies, adoption, sustainable fish farming.*

INTRODUCTION

The contribution of fish to the existence of man cannot be overemphasized, being a good source of animal protein, it plays vital roles in the nutritional diet of man, and serving as sources of employment and income (CTA, 2001). For many centuries, open water fisheries have been important as major fish food sources and for trade

in most countries of sub-Sahara Africa. In contrast aquaculture (farming of aquatic organisms) has been introduced in the last fifty years (Olakunle, 2000). Fish farming, a branch of aquaculture is defined as the raising of fish for personal use or profit (FAO, 1988). In Africa, fish production increased at an annual rate of 12.1 percent between 1984 and 1995 (FAO, 2012). The increment might have been connected to favourable attitude of farmers in many African countries who enthusiastically adopted fish farming as major economic enterprise. Also, government initiatives over time, including the Federal government's collaboration with host states and private sector to rehabilitate selected fish farms and hatcheries for the production of fish seeds in the National Special Programme for Food Security (NSPFS).

In any part of the country, the type and level of integration depends on the prevalent environmental conditions, social norms, cultural values and religious factors. For example in northern part of the country, fish cum pig integration is not advisable because of religious factor or belief. The agricultural enterprise to be combined and their level of intensity determined the type of integration. Fish culture can be extensive, semi-intensive or intensive. The semi-intensive earthen pond fish culture is the most suitable integrated aquaculture system because of the natural eco-system that can conveniently accommodate both crop and livestock production (Ayinde, 2003). Common species of fish cultures in the state government farms include Clarias, Tilapia, Heterotis and *cynprinus carpo* (common carp). In Osun State like in other states of the federation, aquaculture is practiced on extensive and semi-intensive level, characterized with low-density culture with minimum input and low production per unit area (Fagade and Ugwumba, 1992). Fish farming in Osun state ranges from homestead fish pond to fish production hatcheries, ponds and tanks. Of these, pond fish culture is the most prevalent (Ita *et al.*, 1995).

Adoption of innovation by farmers is an important process through which systematic social change takes place in rural areas. Adoption usually passes through many stages. Ekong (2013) identified five stages of adoption. This is in line with the stages identified by North Central Rural Sociology Committee. Alao 1980 These are: awareness, interest, evaluation, trial and adoption, passing from one stage to another in a chronological order. Alao (1980) also identified these stages but he claimed that these could be fused into three, which are easily noticeable. These are: awareness, trial and adoption. However, no matter the number of stages involved, innovations like improved management practices that is seen to be of great benefit to the farmers would be followed to the last stage, which is complete adoption. Innovativeness often occurs among the adopters. This is the degree to which the individual farmers are relatively earlier in adopting new idea than others.

In 1972, some capture fisheries were practiced in some rivers and streams like Osun and Opa rivers in Obafemi Awolowo University which has served as experimental reservoir for the Department of Zoology. With the breakthrough in this research, the result leads to interest and adoption of fish farming technologies

in few towns in the State. However, about 54% of the fish consumed in the country is still being imported from other countries. Based on output from fish farming as against artisanal farming, fish farming needs to be encouraged more among Nigerians to boost the output of fishes. Raji (2003) reported that farmers are not aware of some management practices or technologies; improved feeding, fertilization, stocking using polyculture, liming and water quality management are alien to fish farmers in Osun State due to inadequate dissemination of technological information. Hence, most fish farmers in Osun State depend on trial and error method, which often resulted into low output. One is therefore enthused to investigate the extent of adoption of aquacultural technologies among the fish farmers in Osun State, Nigeria.

The main objective of the study was to investigate the extent of adoption of integrated aquacultural technologies among Fish Farmers in Osun State. The specific objectives are to:

- i. describe the personal characteristics of fish farmers in the study area;
- ii. identify the integrated aquacultural technologies disseminated to fish farmers in the study area and determine the extent to which integrated technologies disseminated by extension agents are adopted.
- iii. identify the sources of information on integrated aquacultural technologies available to fish farmers in the study area.
- v. identify the constraints associated with the adoption of integrated aquacultural technologies.

METHODOLOGY

The study was carried out in Osun State. A multistage sampling technique was used to select the respondents for the study for the sampling 10 which was Nigeria's coastal capital city for over a century (Olupona, 2011). A purposeful sampling procedure was used to select 150 farmers that registered with Osun State ADP. Interview schedule was administered to collect relevant quantitative data from the respondents. Questions were asked basically on personal characteristics of the respondents, sources of information and constraints associated with adoption of integrated aquacultural technologies among the fish farmers in the study area.

The data were analysed using SPSS software while simple descriptive statistical techniques such as frequency counts, percentages, means and standard deviation were used to summarize the data collected. Chi-square and Pearson product moment correlation PPMC were used to make inferential deductions.

RESULTS AND DISCUSSION

Personal Characteristics of the Respondents

Results in table 1 show that high percentages (47.06%) of the respondents were within age group of 41-50 years with the mean age of 42.5 ± 8.12 years. Age is usually regarded as one of the parameters generally used for measuring level of biological and intellectual maturity and experience. It also depicts that the farmers are still in their active age and have strength for aquacultural practices. Majority

(84.3%) of the respondents were male. The result indicates that majority of the fish farmers have more physical strength to meet the rigorous tasks of fish farming activities. This also contributes to the fact that male are known to fish in the area and female are processing it. Deji (2011) further opined that women are usually the vulnerables in many issues regarding them in Africa. Majority (74.5%) were married implying that they were people with responsibilities and marriage is often considered as a respected institution and married people are regarded as mature and responsible. Also, the family member could serve as additional farm labour.

Results in table 1 also show that majority (39%) of the fish farmers had no contact with extension agents. This clearly revealed that majority had no regular contact with extension agents and this can slow the rate of adoption. Very low (35.3%) of the fish farmers income is between N200,000.00 and 400,000.00. This shows that fish farming is a lucrative business. Majority (66.6%) had between 1 to 5 years' experience. This clearly reveals that integrated aquaculture technologies is still new in the study area and this could affect the adoption. Majority (62.7%) of the respondents did not obtain loans. This implies that they started the business with their personal money. Also, majority (72.5%) of the fish farmers crop/harvest twice a year.

Table 1. Distribution of respondents by their selected personal and socio-economic characteristics (n=150)

Personal Characteristics	Frequency	Percentage	Mean	Std. Deviation
Age				
<21-30	5	9.9	42.5	8.12
31-40	13	25.53		
41-50	24	47.06		
50>	9	17.65		
Sex				
Male	43	84.3		
Female	8	15.7		
Marital Status				
Single	9	17.6		
Married	38	74.5		
Divorced	2	3.9		
Widowed	2	3.9		
Household size				
<4	19	32.7		
4-8	32	62.8		
Contact with Extension Agents				
0	20	39		
1	8	15.69		

2	7	13.73
3	6	11.76
>3	10	19.61
Income (Naira)		
<200,000	9	17.6
200,000-400,000	18	35.3
400,000-600,000	10	19.5
600,000-800,000	12	23.5
800,000 and above	2	3.9
Fish farming experience		
1-2 years	34	66.7
3 yrs or above	17	33.3
Source of loan		
Friends and relatives	2	3.9
Agricultural credit scheme	4	7.8
Cooperative society	10	19.6
Commercial bank	3	5.9
Personal savings	32	62.7
No of cropping per year		
1	3	5.9
2	37	72.5
3	5	9.8
4	6	11.8

Source: Field Survey, 2018

Extent of Adoption of Integrated Aquacultural Technologies

The results in table 2 show that 56.9% of the respondents adopted 6-8 IAT, (19.6%) adopted between 9-11 IAT while (15.7%) adopted 3-5 IAT and very low (7.8%) adopted 0-2 IAT. The analysis revealed that IAT are new technologies and high percentage of fish farmers adopted the innovation. This result supports the work of Jibowo (2001) that adoption is significant to the level of education and extent of orientation of the farmers.

Table 2. Distribution of respondents by the extent of adoption of Integrated Aquacultural Technologies (n=150)

Adoption score	Frequency	Percentage
0-2	4	7.8
3-5	8	15.7
6-8	29	56.9
9-11	10	19.6
Total	150	100

Source: Field Survey, 2018

Source of information available to fish farmers

Results in table 3 show that majority (86.3%) of the respondents' source information on IAT from radio. About 62.7% source information from commercial fish dealers' while 33.3% source information from television. Only 21.6% source their information from newspaper whereas 19.8% and 9.8% claimed that they source information from feed mill and internet. These are in tandem with Ladele and Edgal (2005) that radio is the cheapest source of information and quickest and the most used source of information in developing countries.

Table 3. Distribution of respondents by available information sources (n=150)

Source of information	Frequency	Percentage
Television	17	33.3
Newspaper	11	21.6
Radio	44	86.3
Internet	5	9.8
Feed mill	10	19.6
Commercial input dealers	32	62.7

Source: Field Survey, 2018

Awareness of Integrated aquacultural technologies by the respondents

The results in table 4 show that majority (80.30%) of the respondents were aware of IAT like construction of fish ponds while 51.00%, 63.00% and 78.00% were aware of liming, stocking of improved fish seed and use of imported feed, respectively. Also, 25.00%, 22.00% and 16.00% were inclusion of maggot to feed fish, use of animal waste to feed fish and practicing of integrated fish farming such as fish cum/rice or fish/cum poultry respectively. In addition, 20.00% were aware of fish breeding, 59.00% of water quality management while 96.00% of harvesting and 14.00% of processing and packaging. This implies that farmers are aware of the technologies introduced to them.

Table 4. Distribution of fish farmers according to awareness of aquacultural technologies

Aquacultural technologies	Frequency	Percentage
Modern method of fish pond construction	41.0	80.3
Liming	26.0	51.0
Stocking of improved fish seed	32.0	63.0
Use of imported feed (floating feed)	40.0	78.00
Inclusion of maggot to feed fish	13.0	25.00
Use of animal waste to feed fish	11.0	22.00
Practicing of integrated fish farming such as fish cum rice/fish cum poultry	8.0	16.00
Fish breeding programme	10.0	20.00
Water quality management	30.0	59.00
Harvesting using modern methods	49.0	96.00
Processing and packaging	7.0	14.00

Source: Field Survey, 2018

Hypothesis of the study

Result shown in table 5 depicts that four sources of information were significant to the adoption of integrated aquacultural technologies by fish farmers in the study area. The variables are television, newspaper, extension agent, radio and internet. The result further indicate that the more the magnitude of variation in these variables, the higher the number of information sources that will be adopted by fish farmers.

Table 5. Correlation and Chi-square analysis showing relationship and association between adoption of integrated aquacultural technologies and sources of information.

Variables	Chi-square	p-value	DF	Decision
Television	30.35	0.10	8	S
News paper	23.13	0.03	8	S
Extension agent	19.04	0.15	8	S
Radio	30.49	0.10	8	S
Internet	29.80	0.10	8	S
Feedmill	5.90	6.58	8	NS
Commercial input dealers	4.20	8.38	8	NS

Source: Correlation Analysis

S: Significant; NS: Non-Significant

CONCLUSION AND RECOMMENDATIONS

This study concluded that majority of the fish farmers did not have extension contact for training in aquacultural technologies and source information from radio and commercial input dealers. They crop their fish farm twice a year. Also, personal savings and cooperative society remained major source of loan/credit to fish farmers. It is therefore recommended that Government should employ more extension agents to level the wide range of gap between extension agents and farmers. In addition, government and financial institutions should stick their loan interest into a single digit.

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DIGITAL TRANSFORMATION IN AUSTRIAN SECONDARY COLLEGES FOR AGRICULTURE AND FORESTRY

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ABSTRACT

The process of digital transformation has been gaining momentum in secondary colleges for agriculture and forestry. Based on data from an online survey about the digital transformation of Austrian secondary colleges of agriculture and forestry this paper gives insights into the status quo. It focuses on three central questions. (I) What is the standard of digital equipment at the colleges in relation to its integration into the learning environment and the education offered? (II) What is the level of confidence of pupils in their own digital competence? (III) Who are the learners and teachers and what are the levels of acceptance of digital transformation among the latter? This paper looks at the above in the greater context of employability within today's global, political and administrative settings. The paper proposes the notion of a 'digital-generalist' who has a level of expertise and is able to act in an ethically responsible and sustainable way. Moreover, the results reveal that these colleges are undeniably in the process of digital transformation. Nevertheless, it is an ongoing process that should be based on a sustainable and smart integration of modern digital technologies and media into the teaching and learning environment. Suitable equipment, learning settings and teachers trained are crucial for digital transformation in secondary colleges, as is the support from appropriate governing and institutional structures. Furthermore, there are enormous potentials in digital transformation that demand research activities and networking as well as continuous information and awareness-raising.

Keywords: *agriculture and forestry, digital equipment, education in secondary colleges, pupils' digital competence, teachers' digital attitude, Austria.*

INTRODUCTION

Digital transformation is increasingly recognised as a crucial issue in the education for today's pupils and tomorrow's graduates of the secondary colleges for agriculture and forestry. These colleges, as well as primary schools and universities, have begun to implement digital technologies and media into their learning environment. However, it has been shown that colleges and pupils are not necessarily keeping up with the evolving needs derived from this rapid progress, i.e. maintaining the same educational standard or level of expertise. This

notwithstanding, it is not unreasonable, in our so called digitally-permeated society (cf. Martin, Grudziecki, 2006), to think of this ongoing process in education as doing the following. Digital transformation imparts the competences needed for 90% of the jobs in the near future (World Economic Forum, 2018), it contributes to the functioning of society (Gilster, 1997), it constitutes an essential requirement for life (Bawden, 2008), or functions as a tool to make life easier or improve life changes in a more sustainable way (Eshet-Alkalai, 2004).

At the same time, the concept of digital transformation is a multi-faceted moving target. It has been researched, interpreted and implemented in various ways in policy documents (Federal Ministry for Digital and Economic Affairs, n.d.; Federal Ministry of Education, Science and Research, 2018), academic literature (Bertelsmann Stiftung, 2016; BITKOM, 2015; EC, 2019; EC, 2014; Ferrari, 2013) as well as in teaching/learning and certification guides and practices (accenture 2015; EuropeanSchoolnet, n.d.; FAO, 2011; SchoolEducationGateway, o.J.).

Given its nature, any change to learning environments that digital transformation brings about entails new challenges and potential. Pupils of these secondary colleges must acquire the competence to apply, learn and work with digital technology and media; be it in class, free time activities or for professional purposes. This digital education begins before college and continues afterwards. It is essential in a world that has become increasingly challenged by interconnected economic, environmental, cultural and political problems (cf. Brundtland Report; United Nations, n.d.). The challenge for these colleges and their educators is to prepare their pupils to deal effectively with the digital transformation in order to raise a productive and flexible workforce. In this regard, digital competence becomes vitally important for both learners and teachers.

This paper, therefore, presents a framework for assessing the digital transformation of secondary colleges. This approach allows information to be obtained on: (I) the standard of the equipment (digital technology and media) and its integration into teaching, i.e. whether it should be a mixture of analogue and digital, (II) the level of pupils' confidence in their digital competence and (III) comparative mapping of the learners' confidence and the teachers' attitudes. The data for the analysis is taken from an online survey about 'Digital transformation in Austrian secondary colleges for agriculture and forestry'. The analysis of select survey data is based on the work by Bos et al. (2014), Calvani et al. (2016) and EC (2019, 2014). Moreover, the results of this mapping will clarify the existing needs of pupils and identify where measures for continuous information and awareness-raising, networking and research activities as well as political and social governance have to be taken.

Digital transformation framework of secondary colleges

Educational interactions are increasingly mediated by digital transformation. Digital transformation is both a requirement and a right. And that, not only for learners! As the pace and extent of digital transformation have increased, so have the literature about and discussion within educational institutions (cf. Bertelsmann

Stiftung, 2016; BITKOM, 2015). Different concepts and frameworks for the development of digital transformation are available (e.g. Ala-Mutka, 2011; Calvani et al., 2016; EC, 2014; Ferrari, 2013). In this respect, the digital transformation framework broadly describes the level of digital performance, integration and excellence within a secondary college. This digital transformation framework includes the following aspects. (I) Multidimensionality covers the intersection between environment, people and confidence in competence that contributes to educating a 'digital-generalist' fit for the modern world (cf. Brundtland Report). (II) Complexity refers to the holistic nature of the framework which cannot currently be simplified into quantifiable indicators. The speed of the change adds to the challenge. (cf. Luhmann, 2006). (III) Interconnectedness means that the framework is not independent from the key infrastructure, social milieu and general key competences with which it overlaps (cf. Ala-Mutka, 2011; Luhmann, 2006). In this context, the design of the classroom and architecture of the college, the social relationships, the common general competences (for instance, reading, problem solving, numeracy, logical, inferential and metacognitive) are also part of the learning system. (IV) Sensitivity to the socio-cultural context: it would be unreasonable to think of a unique model as adequate at all times and in all contexts (cf. Street, 1984). The significance of this digital transformation framework will also change partly depending on the various educational settings (e.g. basic training, professional training, specialised training, virtual learning).

Among the various dimensions addressed within the digital transformation of these colleges, the emphasise in this framework is on the co-existence of three dimensions. These are the technology and media environment, the people and their levels of confidence, and also the intersection:

- Environment, as the general basic equipment is given, focuses on modern digital technology and media and their technical implementation in an integrated, flexible and sustainable way.
- People refers to the digital expertise of pupils and the teachers' acceptance of digital technology and media where it makes sense.
- The idea of confidence concerns the belief in one's own capability and competence in the digital world, which is both needed and essential for learners within the learning environment and for their future employability.
- The intersection between the three dimensions represents the ability to use digital technology and media to perform tasks, manage information, communicate and collaborate, create and share content, solve problems in an ethically, responsible and sustainable way (Ferrari, 2013), i.e. a 'digital-generalist'.

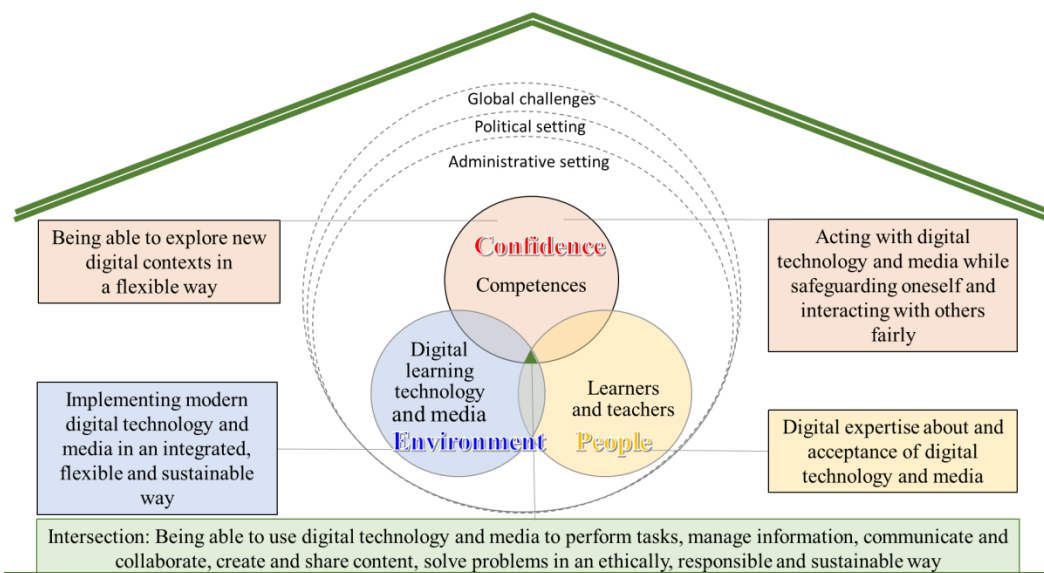


Figure 1. Digital transformation framework of secondary colleges (own visualisation in compliance with Bos et al., 2014 and according to Tribble Bottom Line and Calvani et al., 2016).

It should not be forgotten that the dimensions also belong to different disciplines, for example computer science (ICT), media studies, psychology, pedagogy, etc. The implementation and assessment of this framework require an understanding of all these underlying conceptualisations. In literature, very often the majority of dimension issues are already foreseen, although the focus remains on equipment and technical operations. In this framework the approach is a balanced one, where each of these dimensions and its issues are equally developed. Figure 1 summarises the framework adopted.

MATERIAL AND METHODS

This framework proposed and the discussion above forms the basis for the forthcoming analysis. In a very simplified way the framework proposed provides the fundamental dimensions and indicators (Figure 1 and table 1) for any evaluation that assesses the digital transformation of colleges. The author does not suggest that the framework includes all elements of an evaluation plan needed for assessment.

Table 1. Description of the dimensions and indicators of the digital assessment framework.

Dimensions	Description of categories
Environment	Equipment including digital technology and media Mix of analogue and digital teaching
People	Pupils' level of confidence in their competence Attitude (digital acceptance) of the teacher towards digital technology and media
Confidence (competence areas)	Technical operation: Using digital means to perform tasks Information management: Being able to search, access, process, store and organise information Communication and sharing: Being able to communicate and cooperate using online tools Problem solving: Being able to analyse, reflect and discuss through digital means and identify digital needs Ethics and responsibility: Behaving in a digital milieu in an ethical and responsible way

*Source: adopted from BITKOM (2015), Bos et al. (2014) and EC (2014, 2019).

The data presented (cf. Table 1) in this research is drawn from a comprehensive survey 'Digital transformation in Austrian secondary colleges for agriculture and forestry' (Quendler et al., 2019). The survey was conducted as an online-questionnaire in March 2018. The survey link was randomly distributed to the pupils by the heads of the colleges. A total of 1,963 questionnaires were evaluated. This corresponds to 53% of the pupils attending these colleges.

For the data used in this analysis, the scale of answers was based on a 5-Likert scale and ranged from 5 = very good, 4= good, 3= average, 2= poor and 1= very poor (equipment), for competences from 1 = very good, 2= good, 3= average, 4= poor and 5= not at all. Those based on a 4-Likert scale ranged from 4= strongly agree, 3= agree, 2= disagree and 1= strongly disagree, 0= do not know (mix of analogue and digital teaching) and for teachers' attitude from 4 = a lot, 3= good, 2= moderate and 1= low. Since competence was not directly measured in this survey, the confidence level of pupils is used as an approximate measure of digital competence. Digital confidence, an index, is calculated as an equally weighted average of the six competence categories (Table 1): technical operation, information management, communication and sharing, knowledge creation, ethics and responsibility, problem solving and application.

The select data was compiled for analysis using RStudio Version 1.2.1335. The analysis includes statistical tools such as mean, standard deviation, frequency, chi-square test, mosaic plot, correlation (method Kendall) and the hierarchical agglomerative clustering technique (using squared Euclidean distance as the proximity measure and Ward's method as the clustering algorithm).

RESULTS AND DISCUSSION

Digital transformation has been around for the last decades, first with computers and notebooks and most recently, the Internet (Web-Based learning). As equipment has been improving (cf. Moore's Laws) the evolution and the adoption of digital technology and media in classrooms, have increasingly shaped the pupils' learning environments – both the physical and the virtual. OECD (2015) suggested, however, that the simple provision of digital equipment and infrastructure is not sufficient, there should also be the influence of personal expertise and interest, i.e. attitude, in the process of digital transformation. Similarly, being born in a digital era does not necessarily imply having the confidence to use digital technology and media in a critical, creative and informative way (EC, 2014).

Digital technology and media and mixture of digital and analogue teaching

The digital transformation in learning has long been measured in terms of the actual digital technology and media equipment and their integration into learning. Not surprisingly, with reference to the equipment the majority (80%) still favour a mixture of analogue and digital forms of teaching. As illustrated by figure 2 there is a significant difference in terms of digital equipment and the mix of analogue and digital teaching [χ^2 is 35.23, $P = 0.004$]. It turns out that the lower the standard of digital equipment at the college is, the more a mixture of analogue and digital teaching [τ is -0.07, $P = 0.001$, $z = -9.05$] is seen as needed. It can be assumed that the better the school is equipped; the more digital teaching practise has already been implemented in the classroom. This notwithstanding, in many classrooms, the textbooks are still the linchpin of the lesson. Nevertheless, half of the pupils still hope that learning will take place more and more in virtual spaces in the future (Quendler et al., 2019). This development is also confirmed by EC (2019) and (Bennett, Maton, 2010). It is generally accepted, for instance, that current and recent students demand instant access to information and expect digital learning technology and media to be an integral part of their educational experience (e.g. Oblinger, Oblinger 2005; Barnes et al., 2007; Philip, 2007).

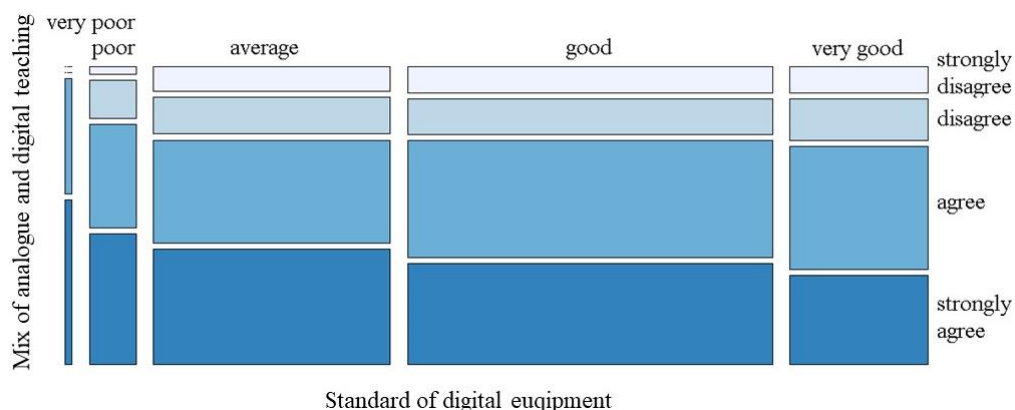


Figure 2. Digital equipment of the secondary colleges versus the mix of analogue and digital teaching, 2018.

*Source: own visualisation of survey data 'Digital transformation in Austrian secondary colleges for agriculture and forestry' (n=1,963).

Pupils' digital confidence in competences

As argued above, digital competence is fundamental for every path of life, therefore, there is a need to validate and recognise digital competences. Competence categories and the digital confidence level are given in table 2. The general average of digital confidence is 1.99. As shown in table 2, the highest level of confidence that the pupils have is in the competence category 'information management' with the general average of 1.85. The lowest one is 'problem solving' with a score of 2.41. This competence, one out of six, has the weakest result and shows the most room for improvement. In the case of secondary colleges for agriculture and forestry, the pupils' confidence in their digital competence scored better in every category than for Austria as a whole as well as Europe (EC, 2019).

Table 2. Descriptive statistics about the competence categories 2018.

Competence categories	Level of confidence (%)					Mean	SD
	not at all	poor	average	good	very good		
Technical operation	0.27	2.23	13.83	50.46	33.21	1.86	0.75
Information	0.44	1.91	13.06	50.95	33.64	1.85	0.76
Communication and	0.54	2.34	16.98	46.71	33.64	1.90	0.80
Knowledge creation	0.33	2.78	17.31	49.43	30.16	1.94	0.78
Problem solving	2.72	9.53	30.92	39.25	17.58	2.41	0.97
Ethics and responsibility	1.20	2.29	14.21	46.05	36.25	1.86	0.83
Colleges	0.16	0.65	5.81	48.94	44.44	1.99	0.62

*Source: Source: own visualisation of survey data 'Digital transformation in Austrian secondary colleges for agriculture and forestry' (n=1,963).

A further analysis, as to whether there is a connection between the level confidence of pupils in their digital competence and the standard of equipment, the mixture of analogue and digital teaching and the digital acceptance of teachers, is shown in table 3.

Table 3. Digital confidence levels of pupils and descriptive statistics according to standard of equipment, mixture of analogue and digital teaching as well as digital acceptance of teachers, 2018.

	Level of confidence							Sum
	Mean	SD	not at all	poor	average	good	very good	
			Count (%)					
Digital equipment [τ is 0.01, $P = 0.502$, $z = 0.58$]								
very poor	1.84	0.78	0.00	0.05	0.16	0.27	0.43	0.92
poor	1.98	0.72	0.05	0.16	1.09	3.04	1.63	5.97
average	2.02	0.63	0.11	0.16	6.19	16.60	6.73	29.79
good	1.97	0.59	0.05	0.16	3.15	10.04	3.96	17.36
very good	1.99	0.61	0.05	0.54	7.27	27.84	10.26	45.96
Mix of digital and analogue teaching [τ is 0.18, $P < 0.000$, $z = 8.88$]								
strongly disagree	2.25	0.78	0.11	0.29	1.17	2.71	0.83	5.12
disagree	2.14	0.63	0.06	0.17	3.32	7.91	2.20	13.67
agree	2.05	0.58	0.06	0.46	8.01	21.23	7.57	37.33
strongly agree	1.84	0.59	0.00	0.17	5.35	25.92	12.42	43.88
Digital acceptance of teachers [τ is 0.68, $P < 0.000$, $z = 31.74$]								
low	2.18	0.80	0.16	0.16	1.52	2.93	1.47	6.24
moderate	2.04	0.63	0.27	0.05	4.99	13.78	5.32	24.42
good	2.01	0.60	0.16	0.05	2.82	15.08	6.78	24.91
a lot	1.86	0.56	0.49	0.00	8.52	25.99	9.44	44.44

*Source: own visualisation of survey data 'Digital transformation in Austrian secondary colleges for agriculture and forestry' (n=1,963).

According to table 3, there is no significant relationship between the level of digital confidence of pupils and the equipment of the colleges. Anyway, more than half (53%) of the pupils with a digital confidence level from 'good' to 'very good' attend a college equipped to a standard of 'good' to 'very good'. Not surprisingly, 67% of the pupils having a confidence level from 'good' to 'very good' agree with a mixture of teaching. The connection is significant and it turns out that the higher the level of digital confidence, the more the pupils are in favour of a mixture of analogue and digital teaching. For the indicator teachers' digital acceptance, 57% of the pupils with a confidence level from good to very good see the former as 'good' to 'a lot'. Also there is a significant positive connection between the digital confidence

level of pupils and the acceptance of teachers: The more teachers are open towards digital media, the better the digital confidence level of the pupils is.

Comparative mapping the learners and teachers

Pupils' confidence level and teachers' attitudes to digital transformation are naturally linked with each other. Their relationships may, however, not be so obvious. Based on the cluster analysis, six categories of relationship covering three basic possibilities are proposed. Either the pupils have the upper hand (superior) compared to the teachers in their values, both groups are on equal footing or the teachers have the upper hand. These relationships are depicted in figure 3, as follows: (1) 'Pupils superior' (high) representing 15% of the sample (cluster 1). These pupils claimed a high level of digital confidence although the level of digital acceptance of their teachers is seen as very low. (2) 'Pupils superior' (average) representing 20% of the sample (cluster 2). In this cluster the relationship between the digital confidence level of pupils and the digital acceptance of teachers is 'on a par'. (3) 'Equal footing' (high) representing 18% of the sample (cluster 3). These pupils and teachers are those with a high level of confidence and digital acceptance. (4) 'Equal footing' (average) representing 29% of the sample (cluster 4). This cluster is similar to the 'equal footing' (high) but both the interest of pupils and teachers are on an average level. (5) 'Equal footing' (low) representing 11% of the sample (cluster 5). This cluster is categorised by pupils and teachers with a low interest in digital issues. (6) 'Teacher superior' (high) representing 7% of the sample (cluster 6). In this cluster the teachers have an excellent acceptance of digital media but this has not positively affected the pupils' confidence. Clear differences in their patterns of confidence level and teachers' attitude towards digital media can be established, permitting the formation of different clusters. Given these clusters, secondary college pupils and teachers are far from homogeneous. Taken together, these findings provide further impetus to move beyond debates about 'digital transformation' by seeking more sophisticated understanding of how pupils' digital confidence and teachers' digital acceptance can be harmonised and benefit learning and teaching.

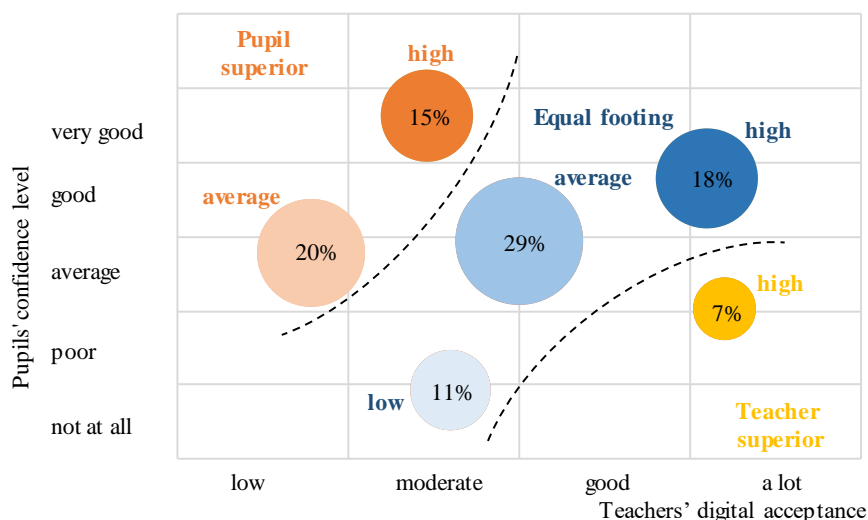


Figure 3. Categories of relationship between pupils' level of confidence and teachers' digital acceptance in secondary colleges, 2018.

*Source: own visualisation of survey data 'Digital transformation in Austrian secondary colleges for agriculture and forestry' (n=1,963).

Discussion of the intersection

The intersection, see figure 1, between the three dimensions is based firstly on the available digital technology and media (including infrastructure). This digital technology and media (including infrastructure) should be comprehensively expanded and continuously upgraded in order to promote digital innovation and solutions for learning. The appropriate equipment (including infrastructure), a reliable technical functionality and the availability of high-quality software are indispensable when digital technology and media are increasingly being used for learning in colleges. With this in mind it must also be possible to use an up-to-date digital technology and media (including infrastructure) without being exposed to a latent fear of failure. WLAN, wireless beaming, procurement of hardware, etc. have to meet professional demands and allow pedagogy to re-prioritise technology (Fullan, Langworthy, 2014, 5; Quendler et al., 2019). Furthermore, digital technology and media available should be used to transform instructional pedagogy and transcend traditional learning environments to make teaching, more pupil-friendly, diverse and modern (Quendler et al., 2019). At the same time, the expansion of knowledge associated with the digital technology and media requires an intensified focus on competence-oriented learning (cf. Albrecht, Revermann, 2016, Sauter, 2018). The integration of digital technology and media into the pupils' learning environment should serve to impart professional, general, holistic and expansive competences, i.e. with a view to becoming a 'digital-generalist' who sees the big picture. In this context, the influence of teachers' acceptance of digital media is crucial. Teachers can exploit the didactic potential of digital technology and media in a learning environment to enrich the education offered. This

comprises the meta-learning output of the learning process and is associated with (a) agency and communicative initiative, (b) digital dialogue and collaborative knowledge construction, (c) open educational resources (OERs) and (d) interdisciplinary as well as social learning projects in the form of action or process learning (Sorensen, 2008). Furthermore, teachers' training is fundamental to the success of digital transformation in these colleges. It needs prepared teachers who feel empowered by the use of digital tools and want to use them in the most efficient and fullest way. In this respect, the results of the pupils' survey, as well as the final report of Steele et al. (2014) on the Mastery Learning project, like many others before him, suggest that teachers should be given the opportunity to acquire digital competence through continuing education and shared teaching development.

CONCLUSION

Digital transformation seeks to embrace a broad, complex, interacting set of core dimensions. This paper provides a comparative analysis and gives the following insights into the digital status quo of the 11 secondary colleges for agriculture and forestry:

- The results show the diversity in the standard of the digital equipment in relation to the mixture of analogue and digital teaching. The contemporary model desired is a very well equipped college with a mixture of both analogue and digital forms of teaching. Although pupils are in favour of a mix, a further area of research should identify the benefits and shortcomings of either form and mix with the view to establishing the best balance.
- The focus on digital competence and the pupils' levels of digital confidence in secondary colleges is recent and necessary. Generally, the current levels are far from uniform.
- Ideally the aim should be a 'digital-generalist' with an appropriate level of digital confidence who sees the bigger picture and how a mix of all the (digital) specialties can contribute to sustainable careers and (digital) social change. The importance of learning about digital competence is becoming a central aspect of any education with an employability perspective. As a further area of research it is nowadays necessary to adopt a transversal model which takes stock of the diversity of digital competence. It is time to develop the digital component of '(new) competences, skills, aptitudes and attitudes for new jobs' on the labour market.
- Clear similarities and differences in the relationship between digital confidence levels of pupils and the digital acceptance of teachers can be established. These allow clusters of levels of affinity within the digital transformation process. The diversity of the cluster results shows that (i) there is a digital gap, (ii) a systematic transfer in and between the clusters is desirable and (iii) that it is important to maintain a digital transformation culture that is built on the pupils' expertise and teachers' interests as well as on their needs. This implies a further field of research regarding the motivation for digital transformation and the training in digital confidence and competence. This should focus on learning

from each other in a way that combines digital knowledge transfer, competence acquisition, and practical application. Furthermore, in order to drive the digital transformation of teaching and learning within these Austrian colleges, it is paramount to understand the digital needs both teachers and pupils have with respect to future employability.

- The intersection (see figure 1) shows the link between the three dimensions from the perspective of the 'digital-generalist'. It also infers that, a sustainable and smart digital transformation can only succeed if is grounded within the current context of the Austrian education system. In that context, it can be supported and guided by administration and policy. General areas are standards in learning settings, teacher training and equipment of digital technology (including infrastructure) and media.

The focus in this paper is the survey of pupils. However, we know little of the perspective on digital transformation of teachers, the administration, curriculum designers and political decision makers. Secondly, there are a number of demographic variables that may predict the preference for digital technology and media in learning, pupils' digital confidence and teachers' attitude to the 'digital'; these include age, gender, college location, and cultural background. This may also be an area for future research, together with looking at the benefits, drawbacks, professional requirements and challenges. Finally, it should be noted that these colleges have already faced major transformations, but it is an ongoing process caused by the continued integration of modern digital technology and media into teaching and learning.

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PERFORMANCE OF SAFFRON GROWTH ON DIFFERENT SOILS UNDER HOMOGENEOUS ENVIRONMENTAL CONDITION

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ABSTRACT

Soil is the major factor determining saffron yield. Although saffron tolerates different soil types, some soils with specific characteristics perform better than others. This work was conducted to evaluate the performance of saffron crop on different soil types under homogeneous environmental conditions. Four soil types sampled from different regions were tested: Rendzic Leptosols, Anthropic Regosols, Hypercalcaric Fluvisol and Eutric Cambisols. Soil samples were put in large plastic pots (radius=0.27 m, height=0.44 m) and organized in complete block design with four replicates. Combined analysis for four years revealed significant differences between soil types regarding most yield parameters. Saffron corms performed better on calcareous clayey Rendzic Leptosols soil with respect to plant height(PL), flowers per plot, flowers per corm cluster, total stigmas fresh and dry weights, fresh and dry weight of single stigmas and total number of corms. Corms grown on Hypercalcaric Fluvisol soil produced the largest content of Crocin, Picrocrocin and Safranal. A regression analysis was used to evaluate the performance of soil types on the number of flowers per mother corm through four years of the study. In this regard, a positive significant higher slope was obtained for Rendzic Leptosols ($y = 4.23x - 8514.3$, $R^2 = 0.69$, $p < .0001$). Quantitative yield attributes such number of flowers per corm cluster was significantly correlated with organic matter t ($r = .60$, $p = .016$) and calcium ($r = .52$, $p = .041$) contents. Correlation analysis showed that the soil parameters most attributed to the saffron yield were organic matter, phosphorus, potassium and calcium. For soils with limiting factors (Eutric cambisols and anthropic regosols) further studies should focus on improving their performance under saffron crop.

Keywords: *Rendzic Leptosols, Anthropic Regosols, Crocin, Corm cluster.*

INTRODUCTION

As a new and promising crop, Saffron cultivation in Lebanon was initiated approximately two decades ago to replace *Cannabis sativus*. Besides its cultivation in traditional farming, saffron can be accepted as a family business. Other attractive features of Saffron cultivation is that saffron yield could be stored for a long period without losing its essential values. Furthermore, the high price of dried stigmas and the low cultivation requirements (fertilization, irrigation and pest management) make Saffron very promising and an alternative to many crops especially in marginalized areas (Dar *et al.*, 2007, Gresta *et al.*, 2007, Birouk *et al.*, 2011, Chaouqi *et al.*, 2016). The biological cycle of saffron in main producing areas displays relatively similar stages starting from sprouting and flowering in autumn till corm dormancy in summer. Six stages were reported by (Lopez-Corcoles *et al.*, 2015). Yasmin and. Nehvi (2018), Gresta *et al.*, (2007) reported that timing of the phenological stage is observed to be closely related to weather parameters in particular air temperatures. Saffron grows within a wide range of geographical zones from Irano-Touranian , east Asia to the Mediterranean regions. Saffron is cultivated in a wide range of climate zones (from temperate to dry climates) (Gresta *et al.*, 2007). These climatic conditions ensure high saffron yield (Fernández, 2004). Annual rainfall in the cultivated areas in Spain ranges from 250 to 500mm, in Sardinia from 300 to 600 mm while in Greece is about 560mm (Tammara ,2017). Average annual precipitation in Lebanon ranges from very low (< 300 mm/year) in Hermel region to very high (>1200 mm/year) in Mount Lebanon (Darwish, 2012). Despite its small territory (10452 m²), Lebanon as a mountainous country is featured by a diverse and complex geography. Land forms, climate, soils, and vegetation differ markedly within short distances (Wikipedia). The fertile Bekaa valley separates the two mountain chains: Mount Lebanon (stretching from north to south facing Mediterranean sea) and anti-Lebanon (bordering Lebanon with Syria) (Geography of Lebanon). In addition to climatic factors, Soil plays an important role in determining quantitative and qualitative parameters of saffron yield. The role of some soil properties is essential in enhancing and increasing yield (Emami ,2015). Amoon *et al.*, (2013), reported that Saffron yield parameters respond significantly on the degree of soil fertility. Although Saffron tolerates various soil types, deep and well drained clay-calcareous soils with a loose texture are the appropriate for better growth and root penetration (Dar *et al.*, 2017). Light and moderate soils rich in nutrient enhance the performance of Saffron (Tammara, 2017). Clayey soils with poor drainage causes corm decay. These soils are low in organic matter (> 1%) (Skinner *et al.*, 2017). The Lebanese land is characterized by a wide range of soils (from good to poor soils) which have a typical Mediterranean nature (LIDO, (2014) (Vogiatzakis in Mediterranean mountains environments)]. Terra-Rossa (Red Mediterranean soils) and the Rendzinas represent 70 percent of Lebanese soils (LIDO ,2014). Several small-scale trials were established by the Lebanese agricultural research institute in 5 stations located in different regions for evaluating saffron production. The yield varied among these trials. Because of the scarce researches on Saffron in Lebanon,

this study was conducted to evaluate the relationship between Saffron yield and some soil types and properties under homogeneous environment.

MATERIALS AND METHODS

Site description

The study was conducted for four years from 2013 to 2017 at The Lebanese Agricultural Research Institute in Lebbaa station ,Jizzin province at altitude 350 m asl. Soils were collected from four regions. The main characteristics of sites are shown in table 1. Soil samples were put in large plastic pots (radius=0.27 m, height=0.44 m) and organized in complete block design with four replicates. 6 homogeneous corms allocated to each experimental unit.

Site sampling

Flowers were collected early in the morning. The yield parameters recorded in the study included plant height(PL), number of flowers per pot(FP) ,number of flowers per corm cluster (FCC), fresh (FWS) and dry (DWS) weight of stigmas, length of stigma(LS),total number of corms per pot(CP), dry leaf biomass(DLB), crocin, picrocrocin and safranal content. The separated stigmas (red part of stigmas) were dried under ambient lab temperature. Fresh and dry weight of single stigma were weighted on a precise digital balance up to 0.000g accuracy. The components of air-dried stigmas (Crocin , Picrocrocin and Safranal) were determined according to ISO 3632-2 :2010 test method by using UV-vis spectrophotometer. The results for these three compounds were obtained by direct reading of the specific absorbance at three wavelengths (257nm-picrocrocin,330nm –Safranal,440nm crocin). Soil analysis was done at Lebbaa laboratory using ISO 10390:2005, 11265: 1994, 11263:1994 for pH,electrical conductivity , and phosphor parameters respectively. For organic matter Walkley-black method was used. Combined analysis was performed in SAS 9.2 for Windows (SAS Institute Inc., Cary, NC, USA) to evaluate the effect of treatments (soils), time (year) and their interaction on saffron yield parameters . Tukey's multiple comparisons test of significance at $p= 0.05$ was used to evaluate differences between these groupings

Table 4 .Geographic and weather characteristics of the sites and their soil types.

Site	Altitude (m)	Latitude	Longitude	Rainfall ¹ (mm)	Temperature ¹ (C ⁰)	Soil type
Lebaa	354	33°32.68N	35°27.08E	852	Min:9.7 Max:30.2	Rendzic Leptosols ²
Nabatieh	508	33°21'50N	35° 29'33E	800	Min:9.6 Max:31.5	Anthropic Regosols
Sour	7	33°15'54N	35°13'03E	697	Min:13.7 Max:26.4	Hypercalcaric Fluvisol
Tel-Amara	915	33 °28'N	36°30'E	503	Min: -3.6 Max:43	Eutric Cambisols

¹ Weather data were obtained from weather stations of the Lebanese agricultural research institute

² Soils were named based on soil map of Lebanon (Darwish et al., 2006)

RESULTS AND DISCUSSION

Summary results for the physic-chemical analysis of soils samples are shown in table 2.

Table 5. Physico-chemical analysis of the selected four soil samples

Soil type/ <i>I</i>	pH	EC	Ca ⁺⁺	Mg ⁺⁺	P2O5	Total CaCO3	Active CaCO3	O.M	Na	K	Texture
		ms/m	ppm	ppm	ppm	%	%	%	ppm	ppm	
Rendzic Leptosols	8.2	98.3	9044a	261.1	70.5	54.5	15.8	2.4	79	450.2	Clay
Hypercalcaric Fluvisol	8.8	94.4	3500	401.7	42.4	71	7.2	1.7	33.5	287.9	Sandy loam
Anthropic Regosols	7.5	63	6972	341.5	37.3	2.75	0.9	0.5	360.5	350.1	Clay
Eutric Cambisols	8.4	99.8	6300	361.5	21.8	17.5	18.4	1.6	213.1	488	Clay
<i>P</i>	.001	.18	<.0001	.73	.0002	<.0001	<.0001	<.0001	<.0001	<.0001	
<i>η</i> ²	.71	.33	.96	.10	.80	.99	.99	.89	.92	.9	

The soils were named based on the soil map of Lebanon 1:50000 (Darwish et al., 2006). Sampled soils of Sour region were sandy loam whereas the other three soils have a clay texture. The highest organic matter content was measured in soils of Lebbaa region (Rendzic leptosols)(Darwish et al., 2006). Significant differences between tested soils were observed in regard to main soil parameters except for electrical conductivity and magnesium content. Further analysis was explored to examine the effect of soil attributes on saffron yield.

The combined analysis over four years of the study revealed that the soil samples affected all studied saffron yield component. The Length of stigma, number of flowers per pot(F/P), number of flower per corm cluster(F/CC), stigmas fresh(SFW) and dry(SDW) weights were significantly affected by soil type and year respectively (Table 3). The greatest values of these parameters were recorded from Rendzic leptosols soil samples. Soil type and year interaction with a marginal significance was observed only for number on flowers per pot. Fresh weight of single stigma was affected by soil type and did not differ significantly from year to year.

Table 6. Means and (SD) of the main yield parameters as affected by soil type over four years (2014-2015-2016-2017) of the study.

Soil type/Location	Stigma length,cm	#Flower	# of flower/mother corm	Stigma fresh weight,g	Stigma dry weight,g	Fresh weight of stigma	Dry weight of stigma,g
Rendzic Leptosols(Lebaa)	3.4 ^a (0.3)	64.5 ^a (34.2)	11.2 ^a (5.9)	1.507 ^a (0.84)	0.277 ^a (0.155)	0.024 ^a (0.005)	0.0041 ^a (0.0006)
Hypercalcaric Fluvisol (Sour)	3.1a ^b (0.5)	43 ^{ab} (36.6)	8.0 ^{ab} (5.9)	0.911 ^b (0.93)	0.167 ^b (0.178)	0.022 ^{ab} (0.005)	0.0040 ^a (0.0011)
Eutric Cambisols (Tel-Amara)	3.1 ^b (0.3)	30.4 ^b (14.9)	5.4 ^b (2.6)	0.585 ^b (0.27)	0.112 ^b (0.055)	0.020 ^{bc} (0.003)	0.0036 ^{ab} (0.0011)
Anthropic Regosols(Nabatieh)	2.9 ^b (0.5)	31.2 ^b (23.8)	6.7 ^b (6.0)	0.565 ^b (0.42)	0.107 ^b (0.090)	0.018 ^c (0.004)	0.0032 ^b (0.0008)
Year	.0004	<.0001	<.0001	.003	<.0001	.479	.011
Soil type	.04	<.0001	.0004	<.0001	<.0001	.002	.014
Year*soil type	.60	.062	.123	.223	.223	.369	.516
η^2	.656	.78	.78	.72	.74	.52	.53
CV	11.0	45.9	44.8	59.9	58.3	20.8	24.3

On the fourth year, the stigmas dry weight obtained from rendzic leptosol soils was twice greater than that obtained from hypercalcaric fluvisol and three times from Anthropic regosols and Eutric combisols. These changes in the main yield components may be attributed to some soil properties in particular organic matter. This was supported by the relatively high significant positive correlation between organic matter and number of flowers per corm cluster($r=0.60$, $p=.0016$). Moreover, the number of flowers/CC was also positively correlated with phosphor and calcium content respectively($r=.46$, $p=.075$; $r=.52$, $p=.042$). A regression analysis was used to evaluate the performance of soil types on the number of flowers per corm cluster(CC) through four years of the study. In this regard, a positive significant higher slope was obtained for Rendzic Leptosols(4.23 , $SE=0.79$, $t=5.55$, $R^2=.69$ $p<.0001$)($4.23 \pm 2.145 * .79 = 1.69$) (Figure 1).

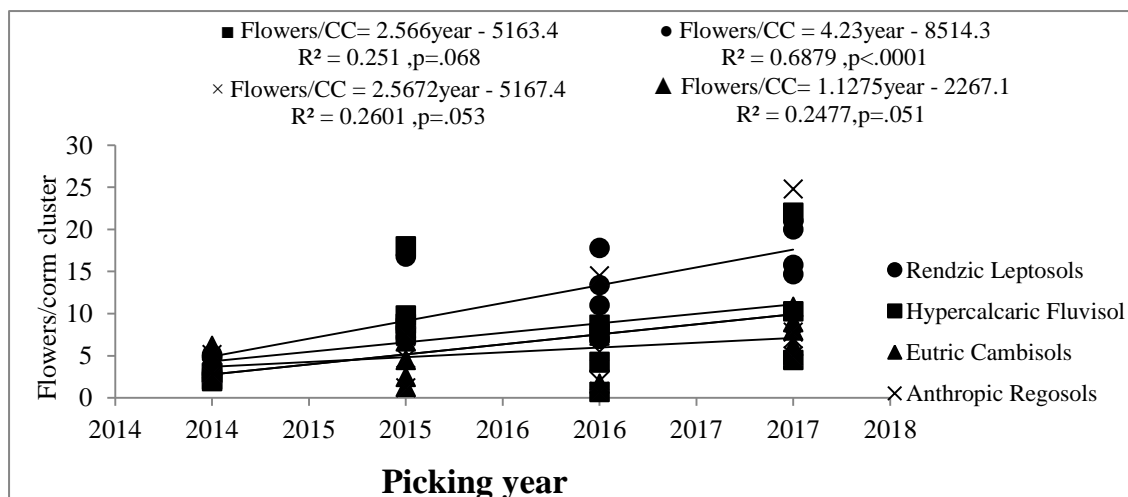


Figure 5. Scatter plot of the flowers/corm cluster as affected by soil type through four years of the study.

Hypercalcaric fluvisol with a sandy loam texture presented an intermediate performance showing no significance with other three tested soils for most yield parameters. This was agreed with the results obtained by Turhan H., et al., (2007) which stated that sandy soils had a positive effect on saffron yield. But their findings were contrary to our results which indicated that Rendzic soils with a clayey texture showed a better results.

The quality of dried stigmas related to the color (Crocine), bitterness (Picrocrocine) and aroma (Safranal) was also affected by soil type. The better results were obtained from hypercalcaric fluvisol soil samples. These sandy loam soils with moderate organic matter content (1.7%) have a high content of total calcium bicarbonate (71%) and the lower calcium concentration (3500 ppm) compared to the other tested soil samples. Crocine and picrocrocine were positively correlated with total calcium bicarbonate respectively ($r = .55$, $p = .035$; $r = .6$, $p = .018$). Negative correlation between soil sodium and calcium content and saffron quality (crocine and picrocrocine) was distinct respectively (picrocrocine: $r = .52$, $p = .045$; crocine: $r = .51$, $p = .05$), (picrocrocine: $r = .45$, $p = .077$; crocine: $r = .68$, $p = .034$). Yarani, (2016) reported a negative correlation between saffron quality and leaf calcium and sodium content.

Table 7. Analysis of variance for the effect of soil type on saffron quality attributes

Soil type	Picrocrocin	Saftanal	Crocin
Rendzic Leptosols	73.6(4.3ab)	24.7(1.2)b	128.5(8.9)b
Hypercalcaric Fluvisol	84.6(15.9)a	37.1(3.1)a	187.3(26.5)a
Eutric Cambisols	70.8(12.4)b	27.7(3.5)b	145.1(12.7)ab
Anthropic Regosols	66.9(4.4)b	25.9(8.1)b	127.1(20.7)b
<i>P</i>	.0189	.001	.007
η^2	.65	.82	.72
<i>cv</i>	10.9	8.7	8.7

Corms were pulled and categorized into three classes. First class contained corms less than 2g, the second class ranged from 3 to 4g and the third class was more than 4 g. No significance differences between soil types were observed among the first and third classes. A significant total number of corms was recorded from Rendzic soil samples. These soils were rich in organic matter (2.4%) as compared with other tested soil samples. A significant positive correlation between corm yield and organic matter content was recorded ($r=.68, p=.005$). This was agreed with the results obtained by Turhan *et al.*, (2007).

Table 8. Analysis of variance of the effect of soil type on the total corm number and corm classes.

Soil type	Total corms	Corm classes		
		≤ 2	3-3.9	≥ 4
Lebaa	320a	.72	.13a	.15
Sour	181b	.79	.05b	.16
Nabatieh	193b	.72	.15a	.14
Tel amara	189b	.80	.10ab	.10
<i>p</i>	.025	.469	.0425	.679
η^2	.52	.18	.48	.11

At the last year of the study plant height ranged from 31.2 to 48.8 cm and was highly correlated with leaf biomass ($r=.87, p<.0001$). The highest values were observed in Rendzic soils for both plant length (Mean =48.8±4.3 *df* (3,12), $F=15.1, p=.0002, \eta^2=.79$) and biomass (Mean =14.3±3.6 *df* (3,12), $F=5.42, p=.0156, \eta^2=.6$) respectively. Since the study was carried out in homogeneous condition (climate condition) but different soil samples, the observed differences in saffron yield parameters are most likely associated with soil characteristics. Outside the scope of this study, other conditions such as geographical location, temperature and rain may have an impact on the quality of saffron.

CONCLUSION

Results of the study showed that the most of saffron yield attributes were affected by some soil parameters. Soil samples of Lebaa region (Rendzic leptosols) demonstrated the best results regarding quantitative yield characteristics. This

superiority was consistent from year to year. This differentiation in soil performance was supported by the positive significant correlation between main quantitative yield parameters and some of the soil components such organic matter and calcium content. The quality of saffron yield in regard to the coloring, taste and aroma was affected positively by calcium bicarbonate. Soils with relatively high sodium content resulted in low saffron quality. The soils with limiting factors can be managed to improve their performance under saffron crop.

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