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Preface

We would like to present, with great pleasure, the inaugural volume-8, Issue-5, May 2022, of a scholarly journal, *International Journal of Environmental & Agriculture Research*. This journal is part of the AD Publications series *in the field of Environmental & Agriculture Research Development*, and is devoted to the gamut of Environmental & Agriculture issues, from theoretical aspects to application-dependent studies and the validation of emerging technologies.

This journal was envisioned and founded to represent the growing needs of Environmental & Agriculture as an emerging and increasingly vital field, now widely recognized as an integral part of scientific and technical investigations. Its mission is to become a voice of the Environmental & Agriculture community, addressing researchers and practitioners in below areas.

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Environmental science and regulation, Ecotoxicology, Environmental health issues, Atmosphere and climate, Terrestric ecosystems, Aquatic ecosystems, Energy and environment, Marine research, Biodiversity, Pharmaceuticals in the environment, Genetically modified organisms, Biotechnology, Risk assessment, Environment society, Agricultural engineering, Animal science, Agronomy, including plant science, theoretical production ecology, horticulture, plant, breeding, plant fertilization, soil science and all field related to Environmental Research.

Agriculture Research:

Agriculture, Biological engineering, including genetic engineering, microbiology, Environmental impacts of agriculture, forestry, Food science, Husbandry, Irrigation and water management, Land use, Waste management and all fields related to Agriculture.

Each article in this issue provides an example of a concrete industrial application or a case study of the presented methodology to amplify the impact of the contribution. We are very thankful to everybody within that community who supported the idea of creating a new Research with *IJOEAR*. We are certain that this issue will be followed by many others, reporting new developments in the Environment and Agriculture Research Science field. This issue would not have been possible without the great support of the Reviewer, Editorial Board members and also with our Advisory Board Members, and we would like to express our sincere thanks to all of them. We would also like to express our gratitude to the editorial staff of AD Publications, who supported us at every stage of the project. It is our hope that this fine collection of articles will be a valuable resource for *IJOEAR* readers and will stimulate further research into the vibrant area of Environmental & Agriculture Research.

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Cereals or Basic Grains: Oats, Wheat, Barley, Rye, Triticale, Corn, Sorghum, Millet, Quinoa and Amaranth	Oilseeds: Canola, Rapeseed, Flax, Sunflowers, Corn and Hempseed
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A Study on Beta-Carotene Contents of Egg Yolk In Relation To Storage Duration, Temperature and Its Correlation with Some Egg Quality Traits

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Abstract— *The experiment was conducted to investigate the effect of storage duration and temperature on β-carotene contents of egg yolk. Also, correlation between β-carotene contents of the eggs and some egg quality traits were examined. Both the storage duration and temperature were tested at three levels using a total of two hundred and seventy eggs laid by Isa Brown at fifty one week. The storage duration studied were 1 day, 7 days and 14 days, while the temperature regimes studied were 4 ^{0}C, 10 ^{0}C and 23 ^{0}C. Standard methods were used to determine the width, weight, length and shape index prior to storage. Spectrophotometer was used to determine the β-carotene contents of the eggs. Progressive decline in β-carotene content^s of eggs was observed as the storage duration prolonged. Decline in β-carotene as temperature increased was negligible, which implies that storing eggs between 4 ^{0}C and 23 ^{0}C for a period of 14 days will not adversely affect the β-carotene content of the eggs. Slight negative correlation exists between β-carotene and egg weight, while strong negative correlations were observed between β-carotene and egg length, and β-carotene and egg width. Consequently, selecting for egg weight, egg length and egg weight entails regressive selection against β-carotene value of the egg.*

Keywords— β-carotene, egg quality traits, egg yolk, storage duration and temperature.

I. INTRODUCTION

1.1 Background

Egg yolk contains appreciable quantity of carotenoids which are highly bioavailable. The density of these carotenoids in egg yolks can be manipulated through the diet of laying hens. Beta-carotene is the most important group of carotene which serves as the primary source of vitamin A in the diet of man and farm animals (Olson, 1996). Vitamin A plays some key roles in both animal and human nutrition in that it is indispensable for good night vision, normal development of bone and teeth, development of healthy skin as well as mucous membrane (Maynard *et al*., 1979; Coutate, 1996; Geofrey, 1998; Ross, 1999; Thomas, 2006; Mahendra, 2017). The deficiency of this vitamin causes poor growth, weakness and decrease in egg production (Mahendra, 2017).

There are diverse sources of beta-carotene, and these sources include; sweet potatoes, carrots, kale, spinach, lettuce, fresh thyme, water squash, turnip greens, cantaloupe romaine etc. (Groff *et al.,* 1995). Egg yolk, milk, and liver are the major animal sources of beta-carotene. In spite of these sources, deficiency in dietary beta-carotene is prevalence in both animal and human nutrition. The reason being partly due to the low level of concentrations of the beta-carotene in these nutrients and partly due to the unstable nature of beta-carotene.

Egg Yolk appears to be the most excellent source of beta-carotene. However, the concentration of beta carotene in egg yolk vary considerably. Okonkwo (2009) and Nnaji *et al.* (2013) reported discrepancies in beta content of egg yolk from local and exotic breeds of chicken. Plausibly, a number of factors may affect the beta carotene contents of egg yolk, though there is dearth of information to this effect. Consequently, this study is aimed at studying the effect of storage duration and temperature on beta-carotene contents of egg yolk.

1.2 Aim and Objectives

The study is aimed at determining the effect of chicken's strain, storage duration and temperature on beta-carotene contents of egg yolk.

The specific objectives were to determine the:

A. Effect of temperature on the beta-carotene content of egg yolk

B. Effect of storage duration of B-carotene content of egg yolk.

C. Effect of storage and temperature interaction on B-carotene of egg yolk.

D. Correlation beta-carotene and other egg quality traits.

II. MATERIALS AND METHOD

2.1 Study Area

A total of two hundred and seventy eggs were collected once from the Department of Animal Science and Technology Teaching and Research Farm, Nnamdi Azikiwe University, Awka, Anambra State, and analyzed at the departmental Laboratory.

2.2 Design of the Experiment:

The experiment was conducted under a 3 x 3 factorial in CRD to test the effect of storage duration and temperature and their interactions on the beta carotene contents of egg yolk. The statistical model used was:

$$Y_{ijkl} = \mu + D_i + T_j + D_iT_j + \sum_{ijkl}$$

Where:

Y_{ijkl}= the observed Beta carotene index

μ = the population mean;

D_i = the effect of $_i$th storage duration, $_i$= 1, ---- 3

T_j= the effect of $_j$th temperature, $_j$ = 1, --- 3

D_iT_j = the interaction between the storage duration and temperature

$\sum_{ijkl}$= is the error term associated with the observations.

2.3 Determination of Egg Weight, Egg Width and Egg Length

The egg weight was determined at the day of collection using electronic weighing balance (Mettler's), while Egg length and Egg width were obtained with the help of a vernier caliper. The shape index of the eggs was calculated by dividing the length of each egg with its width and multiplying with 100.

2.4 Determination of B-carotene

The egg was gently broken to recover the egg yolk and electric weighing balance was used to get the actual weight of the yolk. The egg yolk was homogenized in 50 ml of cold acetone. Thereafter, the mixture was filtered and the filtrate collected in 20 ml of petroleum ether. It was rinsed in distilled water to wash off acetone. Carotene layer was collected in 25 ml standard flask through a funnel with cotton wool saturated with sodium sulphate. Petroleum ether was added to make up the volume to 25 ml mark. Then, using a spectrophotometer, the absorbance was read at 450 nm and beta-carotene concentration in mg/g of the egg yolk was calculated as:

$$Conc.\left(\frac{\text{mg}}{\text{g}}\right) \text{of } \beta - \text{carotene in the egg yolk} = \frac{A \times Vol.(ml) \times 10^4}{A^{10\%^\circ}1_{cm} \times Sample\ \ weig\,ht}$$

Where A = Absorbance

$A^{10\%°}$= 2592 to beta – carotene

Vol. = 25ml

Sample weight = weight of egg yolk (Maynard *et al.,* 1979; Coutate, 1996)

2.5 Statistical Analysis

Data obtained were subjected to two-way analysis of variance (ANOVA) to determine the effects storage duration, temperature and their interaction on the beta carotene contents as well as the correlation between some egg quality traits of chicken eggs. GenStat 14th edition was used and differences between treatment means were separated using the least significant difference (LSD) at 5% level of significance.

III. RESULTS AND DISCUSSION

3.1 Effect of Storage Duration on beta carotene content of chicken egg

The effect of storage duration on beta carotene of chicken egg is presented in Table 1.

TABLE 1
EFFECT OF STORAGE DURATION ON BETA CAROTENE CONTENT OF CHICKEN EGG

Trait	D1(day 1)	D2(day 7)	D3(day14)	SEM	Level of significance
Beta Carotene	4.61^{c}	4.16^{b}	3.69^{a}	0.17	S

Progressive decrease (P<0.05) in beta carotene contents of eggs was observed as eggs were stored from day 1 (D1) to 14th day (D3). As storage duration increases, the β-carotene values decrease. Rock *et al*. (1996) reported that β-carotene in corn depreciated by 60% in seven months of storage, Okonkwo (2009) and Nnaji *et al.* (2013) reported a similar trend in poultry eggs. Thus, β-carotene values of agricultural produces deteriorate with time irrespective of source (animal or plant) as storage progressed (Rock *et al*., 1996; Thomas, 2006). The decline in β-carotene contents may be due to photochemical effects and enzymatic actions. According to Geoffrey (1998) and Nowaczewski *et al*. (2008) freezing and prevention of the product from direct sun rays will minimize the loss of β-carotene as storage duration prolonged.

Generally, the values of Beta-carotene obtained from egg yolk at from day 1 to day 14 falls within the referral value (17.33% and 37.90%) (Kotrbacek *et al.*, 2013). This implies that even at day 14, the level of beta carotene is still significant.

3.2 Effect of Temperature on beta carotene content of chicken egg

Table 2 represents the effect of Temperature on beta carotene content of chicken egg.

TABLE 2
EFFECT OF TEMPERATURE ON BETA CAROTENE CONTENT OF CHICKEN EGG

Trait	T1(4^{0}C)	T2(10^{0}C)	T3(23^{0}C)	SEM	Level of significance
Beta Carotene(mg/g)	4.53	4.52	4.50	0.17	NS

No significant differences (P>0.05) were observed in beta carotene content of eggs stored at 4 ^{0}C (T_1), 10 ^{0}C (T_2) and 23 ^{0}C (T_3) which implies that whether stored at 4 ^{0}C, 10 ^{0}C or 23 ^{0}C, the level of decline in β-carotene content is negligible. This is contrary to the report of Kotrbacek *et al*. (2013). However, the discrepancies in this result might be as a result of temperature range and storage duration. At higher temperature range and or as storage duration exceeds 14 days, it is imperative that the beta carotene level will decline.

3.3 Temperature x Storage Duration Interaction Effect on Beta Carotene

Table 3 represents Temperature x Storage Duration Interaction Effect on Beta Carotene contents of chicken eggs. No significant differences were observed (P>0.05) as a result of interaction between temperature and storage effects on beta carotene contents of chicken eggs.

TABLE 3
TEMPERATURE X STORAGE DURATION INTERACTION EFFECT ON BETA CAROTENE

Temperature	Duration	Beta carotene
Temp1	D1	4.38
	D2	4.58
	D3	4.79
Temp 2	D1	4.70
	D2	4.76
	D3	4.83
Temp 3	D1	4.76
	D2	4.75
	D3	4.74
SEM of Trait		0.29
Level of significance		NS

3.4 Correlation between beta carotene and egg quality traits

Table 4 shows the inherent correlation between beta carotene content of egg and some egg quality traits. While slight negative correlation (r = -0.176) exists between beta-carotene and egg weight, strong negative correlations were observed between beta carotene, and egg length and width (r=-0.327 and -0.437, respectively). The highest correlation was observed between beta-carotene and yolk weight (r=-0.864). Roughly zero correlation was observed between beta-carotene and shape index (r=0.054).

TABLE 4
CORRELATION BETWEEN BETA CAROTENE AND OTHER EGG QUALITY TRAITS

	Beta-carotene	Egg weight	Length	Shape Index	Width	Yolk weight
Beta-carotene	1.000					
Egg weight	1.000	1.000				
Length	-0.176	0.190	1.000			
Shape index	-0.32	0.343	-0.617	1.000		
Width	-0.437	0.493	0.179	0.540	1.000	
Yolk weight	-0.864	0.365	0.371	-0.087	0.320	1.000

There is limited information on relationship between β-carotene and other egg quality traits. Y. Nys (2000) working on dietary carotenoids and egg yolk coloration maintained that there is a high positive correlation between dietary carotenoids and egg yolk coloration.

In this study, β-carotene contained in egg yolk had a slight negative correlation with its egg weight. This implies that heavy sized eggs within range of 61-62g classified as jumbo size according to USDA classification may contain less amount of β-carotene than those of Medium size, ranging from 55 to 57g. Eggs of longer length had a strong negative correlation, r = -0.327, implying that longer eggs ranging from 4.34cm and above has lower content of BC than those ranging 4.28cm and below. Negative correlation was stronger between β-carotene and Egg width. r = -0.437. As narrower eggs are higher in β-carotene content than broader ones. Shape index which is termed to be obtained by dividing egg length with the egg width is roughly zero in correlation with β-carotene. r = 0.054, implying that there is no correlation between β-carotene egg yolk of ISA Brown and the shape index of the egg. The highest correlation was observed between β-carotene and yolk weight r = -0.864. Eggs containing small size of yolk with bright color contain higher proportion of β-carotene than those of larger weight. This may be due to accumulation of much watery substance. Studies reveal that ISA Brown hens show better capability to transfer pigments from the diets to egg yolk compared to other breeds having lower yolk: egg ratio (Leo and Lieber, 1999; Sirri *et al*., 2007).

IV. CONCLUSION

The results of this study shows that eggs of varied sizes, width, length that vary in composition of Beta-carotene are significantly affected at storing periods, thereby influencing the ultimate consumption of the eggs. Beta carotene content found in egg yolk is significantly reduced in quality at longer periods of storage.

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Studies on effect of Integrated Nutrient Management on Growth and Yield of Potato (*Solanum tuberosum L.*)

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Abstract— *The present investigation entitled ""Effect of intrgrated nutrient management on growth and yield of potato (Solanum tuberosum L.)" was conducted during 2016-17 at the experimental farm Department of Agriculture, Mata Gujri College, Sri Fatehgarh Sahib, Punjab, India. The experiment was laid out in a randomized block design with three replications and ten treatments. The treatments consisted of T_0: Control, T_1: RDF, T_2: 100% RDF + FYM @10 t ha^{-1}, T_3: 100% RDF + FYM @20 t ha^{-1}, T_4: 100% RDF + Vermicompost @10 t ha^{-1}, T_5: 100% RDF + Azotobacter @ 6 kg ha^{-1} T_6: 100% RDF + FYM @10 t ha^{-1} + Azotobacter @ 6 kg ha^{-1}, T_7: 100% RDF + FYM @10 t ha^{-1} + Vermicompost @10 t ha^{-1} T_8:100% RDF + FYM @20 t ha^{-1} + Vermicompost @10 t ha^{-1} T_9: 100% RDF + FYM @20 t ha^{-1} + Azotobacter @ 6 kg ha^{-1}Application of different levels of fertilizers in combination with organic manures and biofertilizers significantly increased the growth, yield and quality of potato. The maximum plant height (62.04 cm), number of compound leaves (56.97), fresh weight of haulm (161.27 g), dry weight of haulm (20.36 g), moisture content(13.00%), number of tubers/plant(10.20), tuber length (85.01 mm), average weight of tubers (61.13g) tuber yield/plant (609.70g), tuber yield/plot (13.92 g), tuber yield/ha (348.10 q), stubble yield/ha (98.7 q) and biological yield/ha (446.80 q) were recorded with the combined application of 100% RDF + FYM @20 t ha^{-1} + Vermicompost @10 t ha^{-1}. Whereas, benefit: cost ratio (1.28:1) were recorded with the conjoint application of 100 per cent RDF + FYM @20 t ha^{-1} + Vermicompost @10 t ha^{-1}. Therefore, application of 100 per cent RDF + FYM @20 t ha^{-1} + Vermicompost @10 t ha^{-1} may be suggested after on-farm testing in trail for commercial cultivation of potato for getting higher tuber yield with maximum net returns per unit area in potato.*

Keywords— FYM, Growth, NPK and Yield.

I. INTRODUCTION

Potato (*Solanum tuberosum* L.) is herbaceous annual plant belonging to the family Solanaceae with its edible part a modified underground stem known as tuber. Potato is one of the important crops of the world and is consumed by over million people across the global mainly as a leading vegetable. It ranks fourth in terms of volume production after maize, rice and wheat. According to Aykroid (1941) potato tuber contains 74.7% water, 22.9% carbohydrates, 1.6% protein, 0.1% fat and 0.6% minerals and every 100 g of boiled edible portion provides 69 calories energy (Singh *et al.*2007). In India the potato production during the year 2015-16 was estimated to be around 48.0 lakh MT from the area of 20.85 lakh ha in the country as per the 1st estimate of Govt. of India. Potato demands high level of soil nutrients due to relative poorly developed and shallow root system. Compared with cereal crops, potato produces much more dry matter in a shorter cycle. This high rate of dry matter production results in higher amount of nutrients removed per unit time from per unit area, which generally most of the soils are not able to supply. Hence, nutrient application from external sources as fertilizers becomes essential. High yields can only be sustained through the application of optimal NPK dose in balanced proportion. Potato being a heavy feeder of nutrients requires high amount of nitrogen, phosphorous and potassium fertilizers. Chemical fertilizers are the source of nutrients in potato crop. However, continuous dependence on chemical fertilizer causes imbalance and harmful effects on physio-chemical and biological properties of soil as well as on human health. Considering the higher cost of fertilizers and their harmful effects on soil, environment as well as on the quality of potato it is necessary to find out an alternative which besides improving the productivity and quality of potato should also be eco-friendly to the environment. The beneficial impact of organic manures like Farm yard manure (FYM), vermicompost and other composts on improving soil properties, its fertility and productivity is well known. Farm yard management (FYM) is an approach of supplying nutrition or food to the crop by including organic and inorganic source of nutrients. Bio-fertilizer are also important members of organic sources in INM system and plays a major role in supplementing the crop nutrients through biological nitrogen fixation and solubilization of bound forms of phosphorous in soil. Potato requires specific climatic condition for its better growth and quality. The high rate of dry matter production results in larger amounts of nutrients removed per unit time, when generally soils are not able to supply. Hence nutrient application from external sources fertilizers becomes crucial for achieving high yields. The potato is a major staple fulfilling human nutritional requirements. Worldwide, the potato comes forth in terms of production after wheat, maize and rice. In many countries potato serves as their staple food because of its excellent nutritional content. This judicious use of chemical fertilizer with other sources of organic matter enhances crop growth, yield and soil health as well as declined environment pollution.

II. MATERIAL AND METHODS

An experiment was carried out in Randomized Block Design with three replications comprising of ten treatments combination of inorganic fertilizers, organic manures and bio-fertilizers.

Treatment Details

T_0	Control
T_1	100% RDF
T_2	100% RDF + FYM @10 t ha^{-1}
T_3	100% RDF + FYM @20 t ha^{-1}
T_4	100% RDF + Vermicompost @10 t ha^{-1}
T_5	100% RDF + Azotobacter @ 6 kg ha^{-1}
T_6	100% RDF + FYM @10 t ha^{-1} + Azotobacter @ 6 kg ha^{-1}
T_7	100% RDF + FYM @10 t ha^{-1} + Vermicompost @10 t ha^{-1}
T_8	100% RDF+ FYM @20 t ha^{-1}+ Vermicompost @10 t ha^{-1}
T_9	100% RDF + FYM @20 t ha^{-1} + Azotobacter @ 6 kg ha^{-1}

RDF = Recommended dose of fertilizer (N: 187.5, P_2O_5: 62.5, K_2O: 62.5 kg/ha)

Variety	:	Kufri Pukhraj
Number of Replications	:	3
Number of Treatments	:	10
Plot Size	:	2m × 2m
Total number of experimental plots	:	30
Design of Experiment	:	Randomized Block Design (RBD)
Spacing	:	65 cm × 25 cm
Date of sowing	:	October, 2016

The observations were recorded on plant height (cm), fresh and dry weight of haulm, moisture content tuber length (mm), tuber width (mm), number of compound leaves, fresh and dry weight of plants (g), number of tubers per plant, average weight of tubers, yield per plant (g), yield per plot (kg), yield per hectare (q). All recommended cultural practices were adopted during the course of planting.

III. RESULTS AND DISCUSSION

3.1 Growth attributes

Data revealed that the highest plant height at different stages of crop growth (30, 60 and 90 DAS) was observed under the treatment T8 (32.52, 48.32 and 62.04 cm). The increase in plant height by the use of NPK with integration of FYM and vermicompost might be due to the influence of nitrification inhibition properties of vermicompost in the soil. Besides, it may also be due to rapid elongation and multiplication of cell in the presence of adequate quantity of nitrogen, Sahota and Grewal

(1969). Maximum number of compound leaves were recorded at 30, 60 and 90 days after planting (DAP) in the treatment T_8, which were 42.18, 48.49 and 56.97. This might be due to higher uptake of nutrients resulted in increased synthesis of carbohydrates utilized in building up of new cells (Taya *et al.* 1994). The elevated fresh and dry weight of haulm was recorded in T_8 which were around 161.27 g and 20.36 g. This might be due to the application of higher dose of nitrogen resulted in elevated in the plant height and foliage thereby increasing the fresh and dry weight of shoot per plant with increase in nitrogen levels. The nitrogen fertilizer also increases the leaf area which increases the amount of solar radiation intercepted and consequently, increases dry matter production of different plant parts (Banjare *et al.* 2014). The highest moisture of haulm 13.00% was noticed in $T_{8.}$ The maximum dry matter might be due to high biomass production efficiency of the crop. Mulching increases soil temperature and soil moisture content, stimulate root growth which leads to greater vegetative growth of plant (Sarolia and Bhardwaj, 2012). However, the minimum growth traits were found in control treatment.

3.2 Yield attributes

The maximum number of tubers per plant (10.20) produced with treatment T_8. The probable reason for favorable increase in yield attributes owing to the application of vermicompost, FYM and NPK could be attributed to well-developed root system which ultimately resulted into a healthy plant system, Barman *et al.* 2018. The maximum tuber length (85.01 mm) was observed in T_8 (100% RDF + FYM @20 t ha^{-1} + Vermicompost @10 t ha^{-1}) treatment, whereas, minimum average tuber length 50.21 mm was obtained in the T_0 (Control). The interaction effects of organic and inorganic fertilizer were significantly different on average tuber number. Application of different rate of inorganic fertilizers along with different rate of organic manures significantly increased average tuber numbers compared with plants that received no treatments or control. Muhammed *et al.* (2015). The highest yield of tuber per plant was (609.70 g) produced with T_8 (100% RDF + FYM @20 t ha^{-1} + Vermicompost @10 t ha^{-1}) treatment. However, stubble and biological yield was also highest in treatment T_8. Similar finding were observed in harvest index.

TABLE 1
EFFECT OF INTEGRATED NUTRIENT MANAGEMENT ON GROWTH CHARACTERS OF POTATO

Sr. No.	Plant height (cm)			No of compound leaves/plant			Fresh weight of haulm (g)	Dry weight of haulm (g)	Moisture Content (%)
	30 DAS	60 DAS	90 DAS	30 DAS	60 DAS	90 DAS			
T_0	18.27	34.81	42.07	26.15	29.50	32.31	128.36	11.27	8.54
T_1	20.76	36.76	47.27	28.05	31.60	33.31	143.26	13.72	9.56
T_2	21.89	37.21	48.31	29.96	32.63	34.77	145.97	15.56	10.66
T_3	23.07	39.35	50.77	31.96	36.48	41.10	155.76	17.55	10.87
T_4	28.09	43.01	54.67	39.08	44.39	51.75	157.56	17.63	11.28
T_5	22.42	38.81	50.27	30.56	33.79	37.49	147.82	16.50	10.83
T_6	25.43	42.18	52.30	35.52	39.21	44.75	156.60	17.62	10.59
T_7	30.93	43.33	55.93	40.30	46.71	53.70	157.76	17.78	11.19
T_8	32.52	48.32	62.04	42.18	48.49	56.97	161.27	20.36	13.00
T_9	24.25	41.36	50.87	33.00	35.72	39.69	154.43	16.71	10.82
SE(m)±	1.52	1.99	2.71	1.23	1.30	1.49	1.21	8.92	9.81
$CD_{0.05}$	4.55	5.97	8.04	3.68	3.92	4.42	3.60	2.56	1.82

TABLE 2
EFFECT OF INTEGRATED NUTRIENT MANAGEMENT ON YIELD CHARACTERS POTATO

Treatment	No of tubers /plant	Average weight of tuber (g)	Tuber yield /plant (g)	Tuber yield /plot (kg)	Tuber yield/ hectare (q)	Stubble yield (q/ha)	Biological yield (q/ha)	Harvest Index (%)	B:C Ratio
T_0	7.27	51.28	371.92	8.19	204.72	79.4	284.12	72.05	1.26
T_1	8.20	55.92	458.18	11.21	280.15	88.3	368.45	76.03	1.74
T_2	8.40	60.59	507.88	12.21	305.33	90.0	395.33	77.23	1.76
T_3	9.20	58.12	534.55	13.03	325.66	96.3	421.96	77.17	1.74
T_4	9.40	58.74	574.55	12.69	342.16	97.09	439.25	77.89	1.60
T_5	8.33	56.52	470.30	12.81	320.29	91.3	411.59	77.81	1.48
T_6	9.33	57.43	535.76	13.03	325.70	96.7	422.40	77.10	1.85
T_7	10.10	59.78	593.30	13.80	345.02	97.3	442.32	78.00	1.39
T_8	10.20	61.13	609.70	13.92	348.10	98.7	446.8	77.90	1.42
T_9	9.78	55.41	541.82	13.22	330.50	95.3	425.8	77.61	1.73
SE(m)±	0.15	0.85	7.95	0.19	4.66	0.08	0.36	NS	
$CD_{0.05}$	0.44	1.35	23.62	0.55	13.84	1.23	4.50	NS	

IV. CONCLUSION

Integrated approach of 100% RDF + FYM @20 t ha^{-1} + Vermicompost @10 t ha^{-1} performed better with respect to growth characters (plant height, number of compound leaves, fresh weight of potato plants, dry weight of potato plants) and yield contributing characters like number of tuber per plant, yield per plant , yield per plot, yield $ha^{-1}$and moisture. Therefore, application of 100% RDF + FYM @20 t ha^{-1} + Vermicompost @10 t ha^{-1} may be suggested after on-farm testing in trail for commercial cultivation of potato for getting higher yield.

Application of research: Beneficial to farmers and improve soil health

Research category: Studied of effect of INM on growth and yield of Potato

Abbreviations:

NPK: Nitrogen, Phosphorus, Potassium

RDF: Recommended dose of fertilizer

Kg: Kilogram

G: Gram

FYM: Farm yard manure

DAS: Days after sowing

B:C: Benefit cost ratio

q/ha: quintal per hectare

SEm: Standard error mean

CD: Critical Difference

Cm: Centimetre

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Cost-Prediction Models for Managing Transmission Units of locally-Fabricated Palm Nut Digesters

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Abstract— *The cost components of the transmission unit of locally-fabricated oil palm fruit digester were studied for the economic management of our local small-scale oil mills. 5 major oil mills in Orumba South Local Government Area of Anambra State Nigeria were studied and a representative company whose operational activities and available records were most amenable to the analytical models selected. Descriptive survey was adopted for this research. The records were painstakingly collated and processed, and the costs modeled using regression methods. The purchase price, maintenance cost and scrap value were each predicted with time as exponential models with R^2 values of 0.9833, 0.9572 and 0.9641 respectively. The scrap value and maintenance cost were each predicted as a 2nd order polynomial function of the new unit's purchase price; with R^2 values of 0.9719 and 0.9351 respectively. The accumulated annual maintenance cost was predicted as a 2nd order polynomial function of the annual digested nut output with R^2 values of 0.8963. The annual depreciation increased with successive units change, reflecting the dependence of depreciation on purchase price. It also decreased for each successive year of use for any particular unit. The results of the study did not corroborate the general approach of estimating machinery salvage value as 10% of the purchase price, or the practice in some quarters of budgeting 10% of the machine price for its maintenance cost. Understanding these costs dynamics will facilitate our locally-fabricated oil palm fruit digester's competitiveness via economic management of the transmission units.*

Keywords— Oil-palm-nut digesters, Machinery costs, Cost prediction, Cost dynamics, Management.

I. INTRODUCTION

Nigeria today has enormous economic problems that require the diversification of her economy (Okafor *et al.*, 2010). Resuscitating her agricultural sector; the oil palm production sub-sector inclusive, is a welcome idea. Nigeria was the world's largest producer of palm oil in the 1950s and 1960s (Okafor, 2007). The production lines deployed during the era of palm oil production boom in Nigeria were mostly of the traditional technique, which incurred minimal breakdown and equipment cost. Advanced technologies are needed for palm oil production today due to its increased demand; occasioned by the growing world population and recent emphasis on renewable energy.

Modern oil milling today employs, among others, palm nut digesting and mashed nut oil- expressing machines which have high wear and breakdown in their material-processing screws and power transmission units. While the digesting and oil-pressing units of these machines are fabricated locally, their power transmission units which have gear transmission systems are imported. As a result, foreign exchange is incurred in the procurement of these gear transmission units. Sound management of production machines are needed to realize the intended benefits of machinery deployment. All investments, agricultural machinery investments inclusive are engaged for profit and other attractive economic benefits (Amaefule *et al.*, 2018a and Takeshima *et al.*, 2020). Adequate information is required by a machinery manager to make cost-effective machinery management decisions.

Few studies on agricultural processing equipment costs and economics have been carried out in the country. Repair and maintenance costs of rice mills under different ownership systems in Southeast Nigeria were studied by Oluka and Nwani (2013). Nwajinka (2010) developed computer-assisted methods for predicting the optimal-cost size and replacement time for farm tractor in Nigeria. Amaefule *et al.* (2018a) developed a minimum-cost model for selecting heavy tillage machinery for combined use of farmers, and tested it with data from tillage operations in Anambra State Nigeria. A presentation of the maintenance and replacement scenario and costing encountered in the Nigerian manufacturing industry milieu was given by Bagshaw (2017).Deploying relevant cost and economic data for the management of oil palm fruit digester gear transmission units is needed for profitable oil palm milling. This study is therefore aimed at predicting the purchase, operation and maintenance costs, and the scrap values of the gear transmission units of the locally-fabricated small-scale oil palm nut digester.

II. MATERIALS AND METHODS

2.1 Theoretical Considerations

Machinery costing must be properly addressed for cost or profit control and optimization. Fixed costs and variable costs are the broad categories of machinery cost. While fixed costs are independent of machine use, variable machinery costs vary directly as the machinery use and can be expressed on hourly basis or cost per unit output or other appropriate measures (Field and Solie, 2007 and Amaefule *et al*, 2018b). Machinery depreciation, shelter cost, interest on investment, insurance costs and taxes and duties make up the fixed costs, while variable costs are made up of fuel, oil and lubricants, labour and repair and maintenance costs. Costs approximation is acceptable for future costs estimation since the future cannot be perfectly predicted (Hunt and Wilson, 2015). For ease of mathematical manipulation in cost modelling, machinery costs can be expressed as function of machine purchase price, (Field and Solie, 2007 and Amaefule *et al.*, 2018a). This makes the machinery purchase price an important predictor of machinery costs.

2.2 Machinery Cost Evaluation

Machinery cost analysis provides a framework for combining net cash flows for several machine operations, or machinery services, into a single annual value. Some of the studied cost items are discussed below.

2.2.1 Depreciation of machinery

Depreciation accounts for the reduction in machine value with the passage of time because every substance experiences a continual decay (Bagshaw, 2017 and Amaefule, 2018). The accumulated depreciation along with the salvage value should be able to replace the machine at the end of the useful life. Hunt and Wilson (2015) gave the following reasons for machine depreciation.

i) The need to change the existing capacity owing to changed operational scale,
ii) Failure of irreplaceable or economically irreparable parts,
iii) Increase in the expense of operation and
iv) Obsolescence arising from availability of better machines.

Methods used in evaluating equipment depreciation include: Estimated value method, Straight line method, Declining balance method, Sum-of-the-year' digits (SYD) method and the sinking fund method. The straight line method is the simplest but does not reflect the actual trend of the equipment value over the years. SYD method is among the more realistic methods as it attributes higher depreciation values to the earlier years of the machine life. In this method, the ratio of the remaining years of the machine life to the sum of the machine years digits is obtained. The depreciation (D) charged each year is evaluated as a product of the difference of purchase price and the salvage value and this ratio (Hunt and Wilson, 2015) as seen in Equation 1.

$$D = \frac{L-n}{YD}(P - S) \tag{1}$$

where:

D = depreciation charged for the the year in question, monetary value

L = machine life, yr

n = age of the machine, yr

YD = sum – of – the years' digits, yr

P = price of the machine, monetary value

S = salvage value of the machine, monetary value.

For unknown salvage value of the machine, 10 percent of the machine price is used.

2.2.2 Energy and lubricant costs

Energy is generated in prime movers to power the unit operations for transforming raw materials. Industrial outfits in the urban areas can run on the cheaper electric power from the public electricity supply grid. Inadequate public power supply leads to the need for the costlier standby generator power alternative. Outfits located in the rural areas where most oil palm mills are found in Nigeria, use mostly stationary engine power. Fuel and oil consumption is measured or estimated and multiplied by their respective prices to determine their cost (Field and Solie, 2007). Older machines tend to consume more fuel and oil.

2.2.3 Labour costs

Manpower involvement in utilizing agricultural machinery includes the machine work scheduling, maintenance, attendance and operation. Kepner *et al.* (2003) stated that labour charge should be based upon prevailing wage rate. Oluka and Nwani (2013) agreed with this opinion, stating that prevailing circumstances and local variations make it difficult to predict operator's wages in especially private and co-operative enterprises. Labour cost for the owner-operator should be determined from the alternative use of the owner time, while for the hired operator, a constant hourly rate is appropriate. Increased labour cost ensues with machine deterioration, as more human attention and longer batch production time are required.

2.2.4 Repair and maintenance costs

Maintenance enables an equipment to perform its proper function (Bagshaw and George, 2015), while inadequate maintenance shortens equipment service life (Oluka and Nwani, 2013). Hunt (1999) stated that deterioration of equipment results mostly from use, and that maintenance corrects or retards deterioration in equipment. He further added that the labour and parts costs for changing replacement parts and reconditioning renewable parts constitute repair cost. The relatively minor maintenance cost is usually lumped with the much larger repair cost under repair and maintenance costs. The various components of a machine incur more repair and maintenance cost as the machine ages. Because repair and maintenance cost tends to increase with machine age (Oluka, 2000), it should be an important factor in determining the optimal age for machinery replacement.

Hunt and Wilson (2015) stated that maintenance cost per hour of use tends to remain constant as a machine becomes older, and depends on machine type. Deterioration through normal wear is directly related to use, whereas component failures are more random with respect to time and become more predictable only as accumulated value over the service life of the machine. The accumulated repair and maintenance cost (RM) for use hours was given by Hunt and Wilson (2015) as a 3rd order polynomial function. Kastens (1997) reported it as a logarithmic function. Calcante *et al.* (2013) used the power model for predicting maintenance cost in the study of self-propelled combines in Italy and Nigeria respectively. Oluka and Nwani (2013) developed power models for estimating the maintenance cost of rice mills under different ownership systems in Nigeria based on their accumulated use hours. Kastens (1997) argued that machinery management styles affect the annual repair and maintenance cost and suggested that the simulated cost should be multiplied by a factor between 0.75 and 1.25 to reflect this.

2.3 The Case Study

5 major palm oil mills in Orumba South Local Government Area; lying within latitudes 5.96778N – 6.0163N and longitudes 7.14758E – 7.3166E, were visited in Anambra state, Nigeria. Their mode of operations with regards to the material processing, and equipment maintenance and replacement activities was observed to be same. The oil mill complexes have locally-fabricated palm fruit digesters and other equipment that performed various functions. The oil palm digesters studied are of the vertical type. They operated on rotary mechanism and are each powered by an 8 HP stationary diesel engine. A batch of the digester, (referred to as 1 drum in this study), held 540 kg of oil palm nut.

Because of capital paucity, local oil palm digesters fabricators deploy used rear axle of trucks for the power transmission unit, since the cost is more affordable than standard gearboxes. Particularly foreign-used Toyota Dyna model truck axles were procured and reconstructed for this purpose. Breakdown maintenance of the transmission unit was practiced in the company, and was only done when the unit failed. A representative company whose operational activities and available records were most amenable to the analytical model was chosen as a case study.

2.4 Methodology

Descriptive survey was adopted for this research. Questionnaire was used to conduct reliable interview with the operators and maintenance technicians. Primary data was obtained from the field, while data from machine manufacturers' manuals, relevant handbooks on machine maintenance and scientific journals formed the secondary data. The transmission unit's initial cost, salvage value, service life and average maintenance cost were obtained from the collected data. The annual quantity of the oil palm nut digested was also obtained. The fuel consumed for the digester operation was also obtained from the company's record, while its cost was evaluated by multiplying it with the unit price obtained from national statistical data. The obtained data was regressed so that the corresponding ones for the other unavailable years covered in the study could be estimated. The salvage value and maintenance cost of the unit was also presented as a function of the machine price. Whereas it was difficult to obtain the machine use hours and its accumulated value, the quantity of palm nuts processed were extracted from the company's records.

III. RESULT AND DISCUSSION

3.1 Transmission Unit Purchase Price, Scrap value and Maintenance Costs

Table 1 shows the transmission units' cost components at each change period. The unit's purchase price, scrap value price and maintenance cost are comparatively presented. The transmission unit was procured for ₦3,000.00 in 1999, ₦5,000.00 in 2002, ₦8,000.00 in 2006, ₦12,000.00 in 2011, ₦14,000.00 in 2014, ₦20,000.00 in 2018 and ₦30,000.00 in 2020. The price (P) was increasing with increasing replacement year (x). The price was modelled as an exponential function (Equation 2), with an R^2 value of 0.9833.

$$P = 2379e^{0.3657x} \quad (2)$$

The increasing price could be due to market forces, tax changes, and inflation. Adverse prices are expected for increased foreign exchange regime. Nigeria has an import-dependent economy. Riggs (1977) and Kasten (1999) reported that inflation affects cost of material and production. Custom duties are paid on imported items and Value-Added Tax (VAT) is practiced in Nigeria as in many parts of the globe. However certain incentives; including a 5-years tax-free operation are part of government's effort to encourage establishment of agricultural enterprises, (Fonteh, 2013 and Amaefule, 2018). The price of the unit may also be related to how close-to-new status ("grade") of the unit. Ongkunaruk and Janssens (2018) stated that the value of a piece of equipment retrogrades with age and the extent of use.

TABLE 1
DIGESTER TRANSMISSION UNIT'S COSTS COMPONENTS PER REPLACEMENT

Year of Replacement	Price of New Unit (₦)	Scrap Value (₦)	Maintenance Cost (₦)
1999	3,000	800	2,000
2002	5,000	1,500	2,200
2006	8,000	2,500	2,500
2011	12,000	5,000	3,500
2014	14,000	7,500	5,000
2018	20,000	9,500	7,000
2020	30,000	11,000	7,500

Scrap value of the transmission unit was ₦800.00 in the 1^{st} year of the 1st unit's use; 1999. In the year of 1^{st} replacement; 2002, it was ₦1,500.00. It was ₦2,500.00 in the 2^{nd}; 2006, ₦5,000.00 in the 3^{rd}; 2011, ₦7,500.00 in the 4^{th}; 2014, ₦9,500.00 in the 5^{th}; 2018 and ₦11,000.00 in 6^{th}; 2020. The price of the scrapped unit was continually increasing as the years progressed, most probably due to inflation and market forces. The model describing the salvage values (S) with the corresponding years (x) is shown in Equation 3. The R^2 value was 0.9572.

$$S = 625.78e^{0.4519x} \quad (3)$$

Higher scrap values reduce the cost implication of bringing in a new unit. Scrap parts and metals are purchased by local foundries and recycling plants, and do not attract much price. The progression could be as the result of inflation and market forces.

For the first transmission unit in use, the maintenance cost for the 1st year used (1999) was ₦2,000.00. It was ₦2,200.00 for the 2nd unit's 1st year of use (2002), ₦2,500.00 for the 3rd unit; (2006), and ₦3,500.00 for the 4th; (2011). The cost was ₦5,000.00 for the 5th unit; (2014), ₦7,000.00 for the 6th unit; (2018) and ₦7,500.00 for the 7th unit; (2020), as shown in the figure. The change in the cost of maintenance increased with increasing years. The rapid increase could be as the result of adverse economy, taxation and change in the market price of commodities. The variation of the maintenance cost (RM) for the first year use with the successive units' replacement period (x) was described by the exponential model in Equation 4. It had an R^2 value of 0.9641.

$$RM = 1378.6e^{0.249x} \quad (4)$$

The unit's scrap value (S) and maintenance cost (RM) were predicted as 2nd order polynomial functions of the new unit's purchase price(P); with R^2 values of 0.9719 and 0.9351 respectively.

$$S = -0.00001P^2 + 0.7865P - 2096.2 \quad (5)$$

$$RM = -0.000004P^2 + 0.3673P - 429.15 \quad (6)$$

The prediction equations did not agree with the recommended estimation machinery salvage value as 10 % of the purchase price (Hunt, 1999). It was also at variance with the practice of allocating 10 % of the purchase price for maintenance budget in some industrial outfits (Amaefule, 2007).

3.2 Transmission Unit Throughput, Diesel Consumed and Depreciation

The annual cumulative quantity of the palm nut digested, the diesel used and diesel cost are shown in Table 2. The unit's ending years of service and their corresponding cumulative throughputs and fuel consumption. For the first unit that was installed in 1999 and replaced in 2002, a total of 1,600 drums of palm fruit; each holding 540 kg of fruit, were handled (digested) during its service life.

TABLE 2
CUMULATIVE DIGESTER THROUGHPUT, DIESEL USED AND COST

Year	Cumulative Throughput (Drums)	Cumulative Diesel Use (Litres)	Cumulative Diesel Cost (₦)
2001	1600	3340	76,060.00
2005	2178	4400	199,330.00
2010	2048	3998	265,050.00
2013	1148	2296	228,660.00
2017	1306	2510	390,650.00
2019	709	1262	315,500.00
2020	302	602	156,520.00

3,340 litres of diesel was consumed in the processing, which amounted to a diesel cost of ₦76,060.00. The second unit installed in 2002 and replaced in 2006 handled 2,178 drums of palm nut and consumed 4,400 litres of diesel; which cost ₦199,330.00. The third unit was in service from 2006 to 2010 and handled a total of 2,048 drums; for which 3,998 litres of diesel was consumed at a cost of ₦265,050.00. For the fourth unit that was in service from 2011 to 2017, within which a total of 1,310 drums was handled, consuming 2,510 litres of diesel at a cost of ₦390,650.00.

The fifth unit was used from 2018 to 2019, and handled a total of 709 drums, consuming 1,262 litres of diesel at a cost of ₦315,500.00. The sixth unit came into service in 2020; the last year covered in the study. A total of 302 drums was processed during this 1 year captured by the study, and consumed 602 litres of diesel at a cost of ₦156,520.00. There was no trend in the quantity of palm nuts processed. The amount was based rather on the customers patronage. The diesel cost however maintained an increasingly upward trend, but for the temporal ditch in the 2011 to 2013 value; that has equally low diesel consumption. The continual increase in diesel price increase could be responsible for this. Government policies; like partial removal of petroleum products subsidy, and inflation could have affected the price of diesel.

The depreciation of the unit for the various years of operation is shown in Figure 1. For each span of the service years, the depreciation decreased for the successive years. Higher values of depreciation are shown for the earlier years of the units use and for high new unit prices. Units with longer span of service have more gradual decrease in their annual depreciation, while those with higher new unit prices had less gradual decrease. The corresponding years' depreciation increased with successive units use, reflecting the previously discussed purchase price increases, and the dependence of depreciation on purchase price.

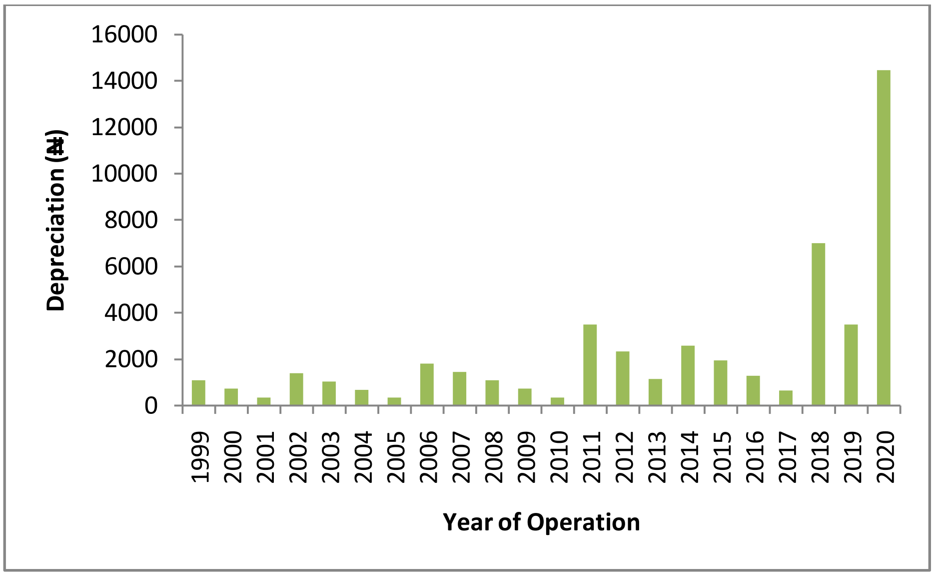

FIGURE 1: Annual Depreciation of Digester Transmission Unit

Figure 2 shows the variation of the various units first year's maintenance cost with the corresponding digested nut output. The highest maintenance cost, ₦7,500.00 was incurred for the 7th unit in 2020 (see Figure 1) with only 302 drums production. The lowest, ₦2,000.00 was obtained for the 1st unit in 1999 with 537 drums production. A maintenance cost of ₦7,000.00 was obtained for a production of 307 drums during the 6th unit's first year 2018 and cost of ₦2,200.00 with 602 drums production in 2002.

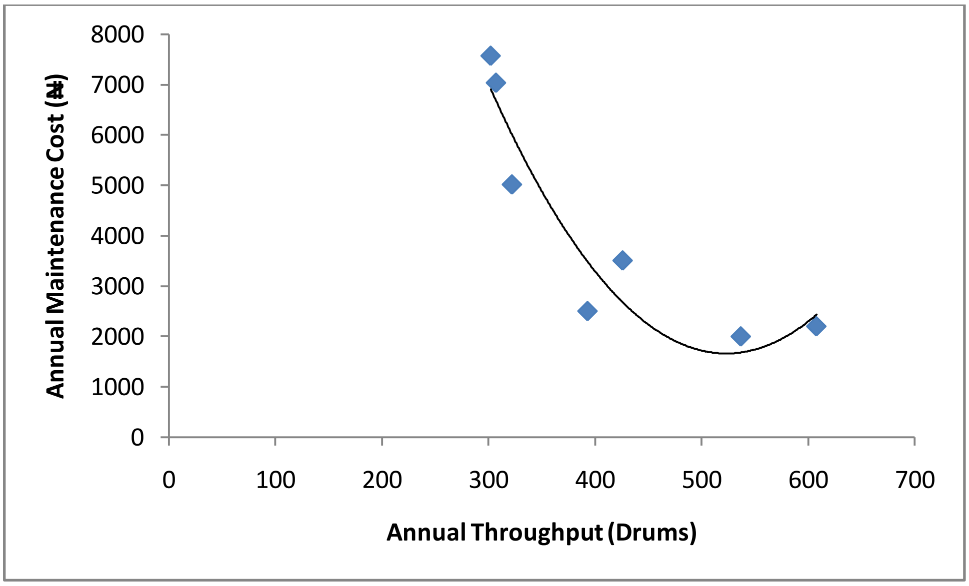

FIGURE 2: Transmission Unit Maintenance Costs versus Machine Throughput

Higher values of the maintenance cost coincided with lower annual output. The variation of the cost (RM) of the units for their first year use with the annual output (u) was described by the second order polynomial model in Equation 7. The R^2 value was 0.8963. The seeming higher maintenance costs with even low production values could be attributed to inflation.

$$RM=0.107u2-112.16u+30999 \quad (7)$$

The (close-to-new) state of the transmission units will also affect maintenance cost. According to Hartman and Rogers (2006) increases in equipment age correlates with decreased equipment utilization, and increases in total operation and maintenance costs. This they attributed to reduced equipment availability as a result of increased equipment down time. Hunt and Wilson (2015) and Oluka and Nwani (2013) reported power models for evaluating accumulated repair and maintenance cost from accumulated use hours.

IV. CONCLUSION

The digester's transmission unit was found to be in upward purchase price, energy and maintenance costs, scrap value and annual depreciation increases for successive units changes. This was considered to result from inflation and market forces. The new units price could be predicted as a function of the replacement period (x). The scrap value and maintenance cost were also predictable as functions of the new units price. Equally, the annual maintenance cost was predictable as functions of change period and price of new unit. The findings of the study could not support the evaluation of the scrap value as 10% of the machine price; suggested commonly for unknown salvage values by some researchers (Field and Solie, 2007 and Hunt and Wilson, 2015). Since the overall goal of machinery management should be profit optimization rather than mere cost minimization (Schueller, undated), the mills competitiveness will be enhanced with the proper application of these costs' knowledge. A good understanding of these transmission unit's costs dynamics can therefore assist in sound management of our local oil palm digesters and oil milling

NOTATIONS

D = depreciation charged for the the year in question, monetary value

L = machine life, yr

n = age of the machine, yr

YD = sum – of – the years digits, yr

P = price of the machine, monetary value

S = salvage value of the machine, monetary value

Y = New transmission unit purchase price, monetary value

RM = transmission unit repair and maintenance cost, monetary value

u = annual output, drums (equivalent to 540 kg)

x = transmission unit change period, years

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A Review - Cowpathy and Vedic Krishi to improve Soil Health

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Abstract— *The goal of this study is to assess the effectiveness and efficiency of some cowpathy and vedic krishi input. Organic farming uses the following systems to safe guard soil health and enhance the biological performance of crop plants. These systems are Vrkshayurveda, Panchagavya, Kunapajala, Beejamrit, Jeevamirit, Compost tea, Matka khad, Vermiwash and Amrutpani. In vedic krishi and cowpathy, low input costs are complemented by ecological and socioeconomic conditions that suit the needs of vast segments of farming communities composed of small and marginal farmers. All of the Cowpathy and vedic krishi inputs have been shown to significantly boost the productivity of many crops and suppress a wide variety of plant pathogens. Plants that are grown with Panchagavya and the beneficial microorganisms it contains are better able to fight off pathogens and provide nutrients without chemical fertilizers / pesticides. Vermiwash, Beejamrit and Jeevamirit all proved effective as foliar treatments in enhancing the productivity and preventing the spread of disease.*

Keywords— Cowpathy, Vrkshayurveda, Panchagavya, Kunapajala, Beejamrit, Jeevamirit, Compost tea, Matka khad, Vermiwash, Amrutpani.

I. INTRODUCTION

Cowpathy and vedic krishi techniques require low input costs and adapt well to the ecological and socioeconomic conditions of small and marginal farmers. They have been found to be quite effective in increasing agricultural productivity. By producing antibacterial and antifungal compounds, hormones and siderophores, cowpathy and vedic krishi inputs were shown to be highly effective in enhancing the productivity of different crops and suppressing the growth of various plant pathogens.

In Vedic farming, the cow and farm life were deeply connected. The “original organic fertilizer” was called “Panchakavya” (Panchagavya) meaning five substances [cow manure, cow urine, milk, yogurt and ghee]. These same ingredients when mixed with water, the product is called “Amrit -pani”. This nutritious nectar is then used to water the plantings, yielding bountiful, healthy crops. The Rishis taught that seeds should first be coated in ghee an d honey before sowing to help them germinate, making them strong and resistant to disease for their lifetime. Additionally cow urine and bitter neem are bottled, kept in the sunlight, and sprayed over crops for an effective, natural pesticide against insects.

1.1 Cowpathy

In Cowpathy, cow products are used for healing purposes. It has emerged as a modern offshoot of traditional Ayurveda. It largely utilizes the top five products derived from cows. Milk, urine, dung, ghee, and curd are the five components of cow origin used in cowpathy healing system. Panchagavya Therapy and Cow Urine Therapy are the two variants of Cowpathy that are currently used.

1.2 Vedic krishi

During the Vedic period, the Vedic people used leaf litter, cow dung, and other trash to add fertility to their land by decomposing it. This made the soil more fertile and allowed them to plant good crops.

Historically, Maharshi Vasishtha served the divine cow Kamdhenu, and Maharshi Dhanvantari offered a wonder medicine, Panchgavya, to mankind as a wonder medicine. In Sanskrit, these five products are individually called "Gavyas" and collectively, "Panchgavyas". Cowpathy has many beneficial effects on the body. By utilizing bio-fertilizers derived from cow urine and dung, it is possible to restore soil fertility and prevent food from being contaminated with certain chemicals, which can pose health risks. There is no other fertilizer as cheap and as harmless as dung fertilizer. Traditionally, Vedic people grew wheat, barley, and other eatable nut which were the primary food items Vedic people's another achievement was Manuring. During the Vedic period, people used waste items like leaves, cow dung, and other materials to aid in the decomposition of the agriculture land. The process increased the fertility of good crops on the land.

Some vedic inputs are- Panchgavya, Vermiwash, Compost Tea, Matka khad, Beejamrit and Jeevamrit.

- Vermiwash give high yield.
- A study found that Panchgavya was most effective in controlling cauliflower stalk rot.
- For seed treatment, beejamrit was found to be the most effective.
- Compost Tea, Matka khad, Jeevamrit is used as foliar sprays to control plant pathogens.

The dung is excellent farmyard manure, and if processed into vermicompost, a very small amount is sufficient for a large field. Even though there are many claims made, they need to be validated scientifically. For cowpathy products to be accepted and popular worldwide in terms of agricultural, energy resource, and nutritional applications, scientific validation of the products is required in order to maximize the power that cowpathy can offer to humanity. Although it hasn't been scientifically validated, people are using it and getting benefits from it. There are multiple threats to food security including undernourishment and overconsumption, rising food prices, population growth, rapid diet transitions, threats to agricultural production, inefficient production practices and supply chains, and declining investment in food system research. Food insecurity causes widespread human suffering along with degradation of natural resources, migration to urban areas and across borders, and political and economic instability. As the global population grows to 9 billion people by 2050, the food system is under additional pressure. Agricultural practices such as land clearing and inefficient fertilizer and organic residue use contribute significantly to greenhouse gas emissions. Further, refrigeration and other supply-chain activities contribute to greenhouse gas emissions from the farm gate to consumers. Many agricultural systems are depleting soil fertility, biodiversity, and water resources as the global demand for food, feed, and bio-energy crops increases. The gap between potential and actual crop yields is wide in many regions. It is estimated that 12 million hectares of agricultural land a year are lost to land degradation, which could produce 20 million tonnes of grain. In the global food system, one third of food produced for human consumption is lost or wasted.

The heavy use of chemicals in agriculture has weakened the ecological base, as well as degrading soil, water, and food quality. A growing awareness has exposed the benefits of implementing "organic farming" as a remedy to modern chemical agriculture. Panthagavya (cowpathy), Jeevamruth, and Beejamruth are eco-friendly, cheaper preparations made from cow dung, urine, milk, curd, ghee and milk. Plant growth stimulants such as Panchagavya are efficient at enhancing agricultural efficiency. Fruits and vegetables are increased in nutritional value when using it because it protects them against diseases and activates soil.

II. INPUTS OF VEDIC KRISHI AND ITS PREPARATION

2.1 Panchgavya

Panchagavya is an organic manure product. Cow dung, urine, milk, Desi cow ghee, and curd are the main ingredients. Organic farming uses Panchagavya because it plays an active role in plant growth as well as increasing immunity. Panchagavya is known for increasing immunity and promoting plant growth. Cow urine and dung are the main ingredients. Mixing it with water and spraying it on fields is the most common way to irrigate them. As the most favourable organic manure for agricultural fields, panchgavya is a crucial aspect of organic farming practices. As a result, it eliminates the need for synthetic fertilizers, pesticides, insecticides, and antibiotics. Panchgavya may not be as cost-effective or beneficial as any other manure. By acting as an organic fertilizer, it is able to enhance soil fertility, enhance earthworm quality, and promote crop health.

Preparation Method

The procedure described by Natarajan (2002) is as follows:

Mix fresh cow dung (7 kg) and cow ghee (1 kilogramme) well before incubating for two days. After that, combine 3 litres of cow urine with 10 litres of water and stir thoroughly for one week in the mornings and evenings. Then, at a 1:6 ratio, add sugarcane juice (3 litre) or jaggery mixed in water. 2 litres cow milk, 2 litres cow curd, 3 litres tender coconut water, 100 g yeast, ripe banana (12). For three weeks, stir the solution vigorously and properly in the mornings and nights.

Finally, Panchagavya is complete and ready to use.

Recommended dosage-

- Spray system: A 3 percent solution was determined to be the most effective when compared to the other concentrations tested. All crops benefit from three litres of Panchagavya per 100 litres of water. Power sprayers with a 10 litre capacity may require 300 ml per tank. Sediments must be filtered when using a power sprayer, and when using hand driven sprayers, a nozzle with a larger pore size must be utilised.
- Flow system: The Panchagavya solution can be blended with irrigation water at a rate of 50 litres per acre and applied via drip irrigation or flow irrigation.
- Seed/seedling treatment: Soak the seeds or dip the seedlings in a 3 percent Panchagavya solution before planting. It is sufficient to soak for 20 minutes. Turmeric, ginger, and turmeric rhizomes.
- Seed storage: Dip the seeds in a 3 percent Panchagavya solution before drying and storing them.

2.2 Vermiwash

Vermiwash is an organic drainage made from vermicompost units. All dissolved substances are carried by the water that flows through the vermiculture, resulting in the washing of live and dead earthworms, soil microorganisms, and decomposed organic debris. It is a valuable source of plant nutrients in organic agriculture since it is high in dissolved minerals and amino acids.

Vermiwash is a natural product made from organic matter vermicomposting by a large population of earthworms (Aghamohammadi et al., 2016; Thakur and Sood, 2019). Depending on the raw organic matter utilised for vermicomposting, the content and quality of vermicompost/vermiwash varies. Vermicompost and vermiwash made from the same organic matter have nearly identical compositions. Hormones, mucus, enzymes, vitamins, proteins, various macro and micronutrients, and a huge variety of bacteria are among the substances that separate the two products (Das et al., 2014; Nadana et al., 2020). Due to the presence of key antimicrobial and anti pest compounds, it can be used as a fertiliser to increase crop output as well as for disease suppression and pest control (Kanchan et al., 2013; Thakur and Sood, 2019; Nadana et al., 2020).

Many nutrients, vitamins, and growth hormones are found in vermiwash/vermicompost, which function as disease and pest suppressants (MacHfudz et al., 2020). When compared to solid vermicompost, its liquid form (vermiwash) is more ideal because of its bioavailability, which allows it to reach the targeted area surrounding the roots of plants quickly (Sulaiman and Mohamad, 2020). The more it liquefied the more bioavailable and easily absorbed it became by plants for disease suppression. There was a study indicating the effect of vermiwash and mucus extracted from Eisenia fetida on Fusarium graminearum dramatically prevented the pathogenic fungus's growth, which had a major impact on wheat (Triticum aestivum L.) quality and productivity (Akinnuoye-Adelabu et al., 2019).

Vermiwash is a natural substance that can be used in a way that is environmentally friendly. As a result, we've gone over the importance of vermiwash in disease control, disease suppression mechanisms, vermiwash components used in disease suppression, and pest control in order to apply these scientific facts in agriculture to improve crop output. (Triticum aestivum var. aestivum L.) (Akinnuoye-Adelabu et al., 2019).

Prepration method-

Vermiwash is a liquid that is derived from vermicompost, which is made by feeding earthworms raw materials such as leaf litter, cow manure, or other organic materials (Tharmaraj et al., 2011) Vermiwash/vermicomposting could be made in batch or continuous manner on larger and smaller scales. The batch mode of preparation necessitates the inoculation of verms/worms on a regular basis, whereas the continuous mode of preparation necessitates the continual manufacture of goods once the worms have been inoculated with a continuous supply of raw materials (Munroe, 2007). To generate vermicompost/vermiwash, Tharmaraj et al. (2011) used Lampito mauritii, an anecic endemic earthworm to India, as well as two foreign species Eisenia fetida and Eudrilus eugeniae. Tharmaraj et al. (2011) used (2 2 2m) (length, width, and depth) to make the vermipits, with the strata being arranged from bottom to top. The bottom layer was filled with stones or coconut shell to absorb excess water from the composting pit, which was added from the top. The second layer was filled with sandy soil to prevent excess water from accumulating in the medium, and the third layer was made up of organic soil and old compost that had been inoculated with earthworms. In the fourth layer, cow manure and leaf litter were mixed in a 1:2 ratio and added to the pit. Finally, coconut fronds were utilised to cover the pit on the top layer to protect it from direct sunlight and keep the medium moist enough.

2.3 Compost tea

We can make compost tea, either aerated compost tea or non-aerated compost tea, by mixing compost with water and culturing for a short amount of time. Non-aerated compost tea and/or actions that boost microbial population densities during the manufacturing process. It's possible to add more nutrients and adjuvant. The application system determines whether or not compost should be filtered. Tea should be had prior to application. Leaching produces compost tea, which is a liquid. Nutrients and bacteria, fungus, nematodes, and protozoa extraction After being aerated, finished compost is placed in a mesh or nylon bag and steeped in water for a length of time. Typically, a form of sugar is used as bacteria by an air pump. It's made from compost. Compost teas are utilised for their plant-friendly properties. Compost is steeped in water for a period of time while being aerated in a mesh or nylon bag. Typically, a form of sugar is used as bacteria by an air pump. It's made from compost. Compost teas are utilised for their plant-friendly properties. When applied as soil drenches or foliar sprays, compost teas help to prevent plant disease. Compost tea is being considered as a possible replacement to synthetic chemical fungicides. Disease suppressive effects can be found in a variety of agricultural systems, although their effectiveness varies.

Compost tea is a product made by extracting microorganisms and nutrients from compost. Specific forms of compost help to maintain a healthy balance of fungal organisms, which live in the soil. A healthy soil food web's organisms serve to:

- Protect roots and other plants from infections and
- Plants require nutrition.
- Plants' general health will improve.

2.4 Matka khad

Using a mud pot, prepare organic manure. The materials used to make such manure are readily available at home or at the local market, and the majority of the materials used are entirely domestic. In organic farming, his organic manure serves as a substitute for chemical fertilizers. In organic farming, its organic manure serves as a substitute for chemical fertilizers. In comparison to chemical fertilizers, the absorption rate of nutrients by the plant is much higher in this manure. It can be used as a drenching agent in crops that grow at a distance, such as cotton and vegetables. It will produce fantastic results. Vegetative growth, flowering, and fruiting will all be outstanding. It is a very effective method of fertilizing the crop naturally if the farmer practices organic farming.

Preparation method

Make a good bacterial culture by mixing 10 litres indigenous cow urine, 10 kilogrammes fresh cow dung, half kilogramme jaggery, and one kilogramme gramme flour in a big pot for 5-7 days. In a damp or rainy field, mix the Matka compost with 200 litres of water and sprinkle well per acre between the crops in any crop. Every 15 days, repeat the process. The crop will be good, the output will be higher, the land will be better, and no fertiliser will be necessary. In this method, the farmer can be self-sufficient and produce tasty and healthy poison-free, chemical-free vegetables. 5. You can use irrigation water or drip irrigation to apply this Matka compost. By mixing one Matka compost well in 400 litres of water and putting the solution near the plant (1 Matka per acre), good results can be obtained. If this solution is sifted through cotton fabric and sprayed on crops, the plants will produce more flowers and fruits. (Tajindera Pal singh; 2021)

2.5 Beejamrit

Beejamrit is an ancient organic compound frequently used in organic and natural farming in India as a seed treatment. Cow dung, cow urine, and forest soil, which is frequently mixed with limestone, make up this low-cost input. In organic agriculture, incubating seeds in Beejamrit prepared overnight before sowing in the field is a traditional practice among the agricultural community. Beejamrit refers to Beej (seed) that has been dipped in Amrit (meaning magical liquid). It's a natural organic fertilizer that's manufactured from cow dung and urine. Overnight, virgin forest soils and, in some circumstances, limestone are added to the input (Sreenivasa et al. 2009; Sharma et al. 2021). This organic tonic is also advised as a foliar spray on the agricultural farm, notably for vegetables and fruit crops, in addition to its possible role as a seed protectant (Chadha et al. 2012). The Beejamrit formulation, as previously said, is made up of a variety of microflora, including various plant growth-promoting bacteria capable of creating plant growth regulators.

Preparation method

The Beejamrit input was made as described before (Bishoi et al. 2017), with the exception that the cow dung, cow urine, and lime were mixed at predetermined proportions. Cow manure and cow urine were gathered from indigenous Sahiwal cross breed cattle grazing in India's Narendrapur Ramakrishna Mission Ashrama for this study. Collecting these elements from indigenous cow breeds is a ritual in India. In comparison to the previous procedure, Gurukul protocol called for adding 5-times more limestone or 250 grammes every 20 litres of Beejamrit preparation (Bishoi et al. 2017). After that, forest soils were added to the mixed components. It's worth noting that forest soils are thought to be critical for enriching this input with microbial load. Forest soils were gathered in Rajabhatkhawa forest village in North Bengal, India, for this study. The Beejamrit solution was incubated for various periods after mixing all of the above ingredients (0-day as control, 1-day, 2-days, 3-days, 4-days, 5-days, 6-days, and 7-days). After a certain number of days of incubation, the Beejamrit samples were collected and processed through a fine muslin cloth to obtain the final results.

2.6 Jeevamrit

It is an organic fertilizer that works well as a substitute for chemical fertilizers. It's a great supply of biomass, natural carbon, nitrogen, phosphorus, calcium, and other nutrients that plants need to grow and develop. It is a liquid fertiliser made from natural ingredients. It's prepared by combining water, cow dung, and urine with mud from the same location where the manure would be spread later. Food is subsequently added to help the microorganisms grow faster, such as jaggery or flour.

Preparation method-

Cow dung (20 kg), cow urine (20 litres), gramme flour (Besan) (1-2 kg), jaggery (1-2 kg), soil (from trees near the field), and a handful of water (200 litres) are the ingredients in Jeevamrit. These components should be thoroughly combined and stored in a cool, dry location away from direct sunlight. For 4 days, the mixture must be stirred a few times (10 minutes each time). After the ingredients have fermented, Jeevamrit is ready to use. It can now be used for a period of two to three days.

After the eighth day of preparation, the number of bacterial colonies in the liquid begins to decrease. 200 litres of solution are applied to one acre of land by irrigation water or direct soil application.

2.7 Amrutpani

Amrut is a divine beverage that refreshes the gods and has the ability to resuscitate the dead. Amrutpani invigorates living soil and transforms dead soil into living soil in the same way. Amrutpani is liquid manure made using the Rishi-Krishi Despande process, which is ahimsak. Amrutpani, like Panchagavya, is used to promote soil fertility (TNAU 2016)

Prepration method

Ingredients-

- 1/4 kilo of butter from cows (ghee)
- 12 kg honey
- 10 kilogramme cow manure
- 200L of water
- Mix a quarter kilo of ghee with 10 kilos of cow manure well. Mix in half a kg of honey and 200 litres of water while constantly swirling. Amrutpani is the result of this process.

How to use

After dipping into Amrutpani, sugarcane, turmeric, ginger, and other plants should be planted. The roots of transplanted seedlings can be soaked in Amrutpani before planting in cases when the seedlings are transferred. Amrutpani can be mixed in the main watering channel while watering sugarcane and other crops with canal or well water, stirring constantly. Seed dressing is required for rain-fed or monsoon crops. Amrutpani should be soaked into the soil while it is moist. Not directly on the plants, but between the rows. The minimal amount of water required soaking the space around seedlings of crops such as chilli, tobacco, or fruit trees should be Amrutpani. Amrutpani in excess is always helpful and will not hurt the body (TNAU 2016)

III. FARMING COMES UNDER VEDIC KRISHI-

3.1 Vriksharyurveda (vrkshya farming)

The ancient science of plant life is known as Vrikshayurveda. Its name directly means to "Ayurveda for Trees." Vrikshayurveda is concerned with the healthy growth and productivity of all tree species. Vrikshayurveda improves plant yield and eliminates the need for pesticides to combat pests and illnesses. Because of their high nutritional content and quick decomposition, leguminous tree leaves have long been employed as green leaf manures in agriculture; and the significance of plant extracts in growth promotion, pest and disease management has been studied by the author for the past ten years. It is past time to completely study the knowledge available in ancient texts in order to find a new path out, and this paper summarises a decade of scholarly work done along these lines. Under the auspices of this type of research, the methodology and procedures used to cultivate various crops have been compiled and a new name, Vrikshayurvedic Farming, has emerged. Vrikshayurvedic farming is a scientific reorientation of India's eco-friendly ancient agricultural system by returning to traditional and natural ways of food production and adopting traditional and indigenous practices and methods for crop cultivation; by utilising trees, plants, and animal products, by products, extracts, and other means with the goal of improving food quality. 2012 (Swaminathan). This is the first time in history that the author has coined a definition.

3.1.1 Scope of vrikshyaryuveda

The importance of understanding Vrkshayurveda in modern scientific agriculture must be highlighted because food consumers are becoming more aware of the environmentally devastating and harmful effects of various agrochemicals used for pest control, disease management, crop nutrition, growth regulation, and promotion. A thorough understanding of Vrkshayurveda, as well as knowledge of commonly used trees and plant species and methods for soil health building, crop growth enhancement, pest and disease control and management, and extending the shelf life of food grains, would be extremely beneficial to agricultural scientists of various disciplines.

According to Anbukkarasi and Sadasakthi (2013), Albizia lebbeck+ Annona squamosa had the best performance for physiological measures such as dry matter production, crop growth rate, and relative growth rate, as well as the maximum uptake of N, P, and K among the treatment combinations. Albizia lebbeck and Annona squamosa had the lowest occurrence of pests and illnesses. Annona squamosa was found in Albizia lebbeck. Swaminathan and Premalatha (2014) found that soil incorporation of fresh leaves of tree species Albizia lebbek (vagai), Senna siamea, Gliricidia sepium, Leucaena leucocephala, Delonix regia (Gulmoher), at a rate of 10 tha1 was done 45 days prior to sowing of green gramme and this served as basal nutrition to the crop, followed by or foli Gliricidia was discovered to be good for leaf integration, and Aegle marmellos was shown to be the best growth booster, followed by Morinda tinctoria.

3.1.2 Vrkshayurveda for pest management

Annona squamosa (sugar apple) leaf and seed extracts, as well as their powders, were found to have insecticidal, antifeedant, and repellent properties against a variety of insects and pests (Vijayalakshmi et al., 2002).

Boomiraj and Christopher Lourduraj (2006) found that spraying herbal leaf extract with a high concentration of poultry manure and neem cake reduced the number of leaf hoppers, whiteflies, and aphids in bhindi.

Hot water and petroleum ether extracts of Ipomea carnea(bush morning glory), according to Rahuman et al. (2009), have the potential to be employed as an optimal eco-friendly strategy for the control of the primary lymphatic filariasis vector. Pest and weed incidence were also very low in the Albizia lebbek (silk plant) + Annona squamosa combination, which contributed to improved maize output (Nandhakumar, 2010).

Due to a decrease in the nematode populations that cause root gall, Artemisia nilagirica (mugwort or indian woemwood) was found to have longer shoots and greater shoot weight (Sukul et al., 2001). They also found that foliar spraying with Acacia auriculiformis (Auri) extract enhanced the number of leaves per plant, leaf and root protein content, and reduced the number of root galls, nematode population in roots, and rhizosphere soil when compared to the control.

Vrkshayurvedic farming is a method of farming that primarily uses trees and plants in whole or in part, as well as extracts, decoctions of parts of trees and plants, and smokes produced by burning tree parts, and avoids the use of harmful chemicals such as chemical fertilizers, pesticides, and herbicides for crop growth, soil health building, pest and disease control, and to maintain ecological balance and provide stability in production levels without poaching. With the growing popularity of Indian systems of medicine such as Siddha, Ayurveda, and Unani for body wellness, agriculturists, farm scientists, and scholars will turn to one of the traditional time-tested traditions known as Vrkshayurvedic farming to assure higher food quality.

3.2 Yogic Agriculture

Yogic Agriculture is an approach that includes seed empowerment (through meditation), farmer mind and heart growth (by meditation), and integrated organic farming (via meditation). Farmers' ability to make a positive impact on their crops through meditation improves as their confidence grows.

Yogic farming, a psychoenergetic strategy for increasing agricultural output and nutritional content, is widely used in India, although only a few studies have been undertaken to demonstrate that it increases crop yield and nutritional content. Farmers from farming families who were also experienced meditators made up the first group. As a result, the impact on agricultural production was overwhelmingly good. The seeds, or a sample of the seeds, are deposited in a residence where meditation is regularly practiced. Seeds are routinely empowered for 10 days before sowing, 15-45 minutes in the morning and evening. The farmer imbues the seeds with thoughts of peace, love, and strength.

Countries such as Greece, Italy, South Africa, and others are conducting research on yogic farming techniques (Girme et al., 2019), which have been used in India since ancient times. The BKRYM approach is one of the resurrected ways that is now being used all around the world according to scientific evidence. Kumari et al. (2012) found that old Vedic practises are based on agroecology and are particularly successful for enhancing crop output, seed vigour, crop yields, and soil quality with low input costs. Vedic insights and comprehensive wisdom have been proven correct in every way. Yogic Agriculture is a type of agriculture that helps the ecology by achieving a powerful and elevated metaphysical condition through Raja yoga meditation, as well as eliminating the use of chemical pesticides and hazardous synthetic fertilisers (Ndiritu, 2015). It aids in the comprehension of various aspects of farming, resulting in enhanced self-esteem, increased productivity, improved soil health, a decrease in farmer suicides, and reduced family violence (Ramsay, 2012). In India's Finance Budget (July 2019), an endeavour was taken to propose and implement zero budget natural farming (ZBNF) (Anonymous, 2019). The primary goal was to make farming more inexpensive; lower overall costs, and supply people with clean and healthful agricultural goods. The concept of Brahma Kumaris' yogic agriculture technique including organic farming is also being promoted by the Indian Council of Scientific Research, the Indian Council of Agricultural Research, and the Union agricultural ministry (Girme et al., 2019).

By 2022, the government of the National Democratic Alliance wants to increase farmers' income and increase agricultural yields. Yoga farming, according to Union Agriculture Minister Radha Mohan Singh, can play a big part. He also claims that the Centre will encourage yogic farming to help boost the country's agricultural output. "We would support the concept of yogic farming under the Prampragat Krishi Vikas Yojana, which also encourages organic farming," Singh said during an organic farming event.

Traditional agricultural practices, like as organic farming, are being supported, according to the government, because excessive use of pesticides and fertilisers has deteriorated soil quality. Professor Sunita Pande of the Govind Ballabh Pant University of Agriculture and Technology's Agronomy Department reports that continuing wheat research using yogic farming practices has yielded promising results.

IV. EFFECT OF SHASYAGAVYA AND KUNAPAJALA ON CROP YIELD

Some of the earliest documented records of liquid organic manures like Kunapajala and Shasyagavya and their usage in ancient India may be found in Vedic literature. The **Kunapajala-** Kunapajala Sanskrit term kunapa means "dead body odour," "smell," while "jala" means "water." Kunapajala is a word that means "dead body water." It primarily consists of cow dung, cowurine, water, and any animal flesh, such as the flesh of fish, poultry fowl, or other animals. Fresh cow dung, cow urine, animal waste, and water are combined in a bucket according to the following ratios 1:1:1:2 Then, in a shady location, allow this combination to ferment for 25 -30 aerobically (stirring twice in a day). Following filtration, a percent aqueous solution of Kunapajala is sprayed on the standing crop at - day intervals, preferably in the evening. Any aromatic leaves like lemon, lemongrass, etc., or peels of lemon, orange, sweet orange, etc., should be applied 1 - 2 days before spraying to eradicate the bad odour of the items.

The nutrients in these liquid organic compounds are absorbed by plants through their roots, leaves, and stems. These encourage biological activity in the soil, as well as nutrient availability for crops. Molasses/rice washed water, pulse powder; ripe fruits, yeast culture, and other ingredients can be added to any of these liquid organic goods.

4.1 Shasyagavya

Cow dung, cow urine, vegetable waste/crop residues, and water are the elements in this example. Vegetable waste and crop wastes are chopped first. Then fresh cow dung, cow urine, chopped organic waste, and water are mixed appropriately in a 1:1:1:2 ratios and aerobically fermented for 10-12 days (stirring twice in a day). The fermented Sasyagavya will be sprayed on standing crops as a 5 percent and 10 percent aqueous solution up to 30 days of germination and 30 days after germination, respectively, after 10-12 days of preparation. It's also used to soak soil with irrigation water before sowing and/or after sowing.

4.2 Effect on crop yield

Shasyagavya 10 and 20 percent and Kunapajala 5 and 10 percent produced higher yields in black gm. Shasyagavya produced the highest yield of 20%. (0.11 kg m-2). The only yield parameter that differed significantly between treatments in mustard was 1,000 seed weight. The average 1,000 seed weight in Shasyagavya 10% spray was maximum (2.56 g) and least (1.5 g) in control. It's worth noticing that Kunapajala (3%) produced better results for the majority of the characters than the other therapies. Charcoal outperformed glycerol among the two carriers evaluated. In addition, we discovered that carrier-based preparations could be stored for at least three months without losing quality.

When compared to the control and chemical fertilizer groups, Asha (2006) found that Kunapajala treated Langali (Gloriosa superba Linn) plants produced exceptional results in terms of overall plant growth and fruiting. Improved adjustments in the formulation of Kunapajala by adding Panchagavya provide great effects when applied to plants, according to Narayanan. Mishra researched paddy development using Kunapajala for 10 days and found significant increases in plant height, leaf length, inflorescence length, number of grains per inflorescence, and other growth indicators. When compared to plants with artificial fertilizer cultivated without Kunapajala, Bhat Ramesh and Vasanthi (2008) found that plants grown with Kunapajala have a higher number of branches, higher yield, fruits with fewer seeds, and lower susceptibility to illnesses.

According to Deshmukh et al. (2012), kunapajala therapy outperforms both conventional and organic farming in terms of physiological, biochemical, and enzymatic enhancement in tomato leaves in organic farming conditions. Chadha et al. (2012) discovered that using vermiwash increased yield by 60, 10, 26, and 27 percent in Knol khol (211.67qha-1), onion (177.81qha-1), French-bean (16.3qha-1 seed yield), Pea (16.3qha-1) and rice (28.45qha-1), respectively, as compared to control. Panchagavya, Matka Khad, Vermiwash, and Jeevamrt were also found to be useful as foliars in increasing crop productivity and treating numerous plant infections.

4.3 Cow urine's (Cowpathy) Efficacy as a Plant Growth Enhancer and Antifungal Agent-

Various pathogens, such as bacteria, fungus, viruses, nematodes, and mycoplasma, cause illnesses in vegetable plants. Fungi are the most active pathogens among them, producing both qualitative and quantitative damage. Methi and Bhindi damping off and wilting are linked to fungi such as Fusarium oxysporum, Rhizoctonia solani, and Sclerotium rolfsii (Okra). Plant diseases have a vital role in agriculture, both in terms of productivity and cost. Chemical compounds are one of the most extensively utilised ways for controlling plant diseases. Overuse and abuse of these chemical agents, on the other hand, resulted in certain dangerous side effects. The high cost, toxicity to nontarget organisms, residual issue, and development of disease resistance are all disadvantages of these compounds. This circumstance increased people's interest in looking for other disease-control options. Natural compounds, particularly those derived from plants, may be promising candidates for usage against phytopathogenic fungus. When compared to manufactured compounds, the usage of these substances is risk-free. Cow urine was highly regarded in ancient Ayurveda for its medicinal value. Okra contains nutrients that may have a variety of health benefits, including a lower risk of a variety of significant medical issues.

[1]. Cow urine is one of the constituents in "Panchagavya" (urine, dung, milk, curd, and ghee), which has various therapeutic characteristics and is the best therapy for fungal and bacterial infections [2]. It contains antibacterial, antibiotic, and germicidal properties. Cow urine, as a result, has the ability to eliminate a wide range of pathogens while simultaneously boosting immunity [3]. Cow urine has a variety of helpful ingredients, such as chemical qualities, potentialities, and constituents that aid in the removal of all infectious-agent-induced ill effects and body imbalances. 95 percent of cow urine is water, 2.5 percent is urea, and the remaining 2.5 percent is salts, hormones, enzymes, and minerals. [4]. Cow urine has been proposed as a biofertilizer and biopesticide in agricultural operations [5], since it may destroy a variety of pesticide and herbicide resistant bacteria, viruses, and fungus. Cow urine is combined with plant extracts to make a disinfectant that is biodegradable, environmentally safe, and effective against germs [6]. Cow urine is used by the majority of people in India to

treat a variety of disorders due to its medicinal properties. Antioxidant, antidiabetic, anticancer, antiprotozoal, and insecticidal properties have been found in cow urine.

4.4 Increase in yield and soil health with cowpathy-

Cowpathy enhances fertility by boosting organic matter content, macronutrients, and micronutrients, as well as increasing plant nutrient intake. It also promotes the growth and reproduction of beneficial soil microbes. Panchagavya has been reported to aid in the improvement of soil physical qualities by increasing porosity and preserving aggregate stability. Panchagavya has a significant impact on soil chemical characteristics because of its neutral pH, which functions as a pH moderator in both alkaline and acidic soils (6.82). It also improved soil nutrient status and increased nutrient uptakes due to higher solubilization.

In terms of leaf size, plants sprayed with panchagavya grow larger leaves and a denser canopy. The photosynthetic system is turned on to boost biological efficiency and allow for the production of more metabolites and photosynthates. The trunk of the stem develops side shoots, which are strong and capable of carrying the maximum number of fruits to maturity.

The amount of branching is relatively considerable. The rooting is profuse and dense in the case of roots. Furthermore, they keep for a long period. The roots were also seen spreading and growing into deeper strata. All of these roots aid in nutrition and water absorption.

The yield parameters of Abelmoschus esculentus were raised in 3 percent panchagavya spray as compared to control and other concentrations, according to Rajasekaran and Balakrishanan,. Similarly, groundnut (Ravikumar et al., 2012) and black and green gramme (Brito and Girija,). In Arachis hypogaea (Subramaniyan) and Vigna radiate, Vigna mungo, and Oryza sativa (Tharmaraj, 2011), photosynthetic pigments such as chl. A, chl. B, and carotenoid were elevated in 3 percent panchagavya spray and decreased in control. When compared to control in Coleus forskohili, Kanimozhi, observed that application of Panchagavya at 4% spray was superior in terms of root yield

According to Palekar Jeevamruth includes a large quantity of microbial load that multiplies in the soil and functions as a tonic to boost microbial activity.

According to Swaminathan, Panchagavya improved crop biological efficiency as well as the quality of fruits and vegetables produced. It also improves the fertility of the soil. Similarly, Sanjibani improves soil fertility, agricultural productivity, and product quality while simultaneously acting as a pest repellant. Higher microbial load and growth harmones, according to Vasanthkumar and Devakumar et al. , may have promoted soil biomass, hence sustaining the availability and uptake of applied as well as native soil nutrients, resulting in improved crop growth and production.

According to Vennila and Jayanthi (2008), applying the full recommended fertiliser dose together with the panchagavya spray (2%) improved the number of fruits per plant, fruit weight g fruit-1, and fruit output q ha-1 of okra. According to Sreenivasa , Panchagavya, Beejamruth, and Jeevamruth made from cow products are known to contain beneficial microflora such as Azospirillum, Azotobacter, phosphobacteria, Pseudomonas, lactic acid bacteria, and Methylotrophs in large numbers, as well as some useful fungi and actinomyctes. Reddy et al. (2010) found that applying biodigester liquid manures to numerous field crops resulted in increased production levels. Similarly, Siddaram (2012) showed that rice yields increased when biodigester liquid manures were used. Spraying with Panchagavya has a substantial impact on capsicum yield per acre.

V. EFFECT OF VEDIC KRISHI ON SOIL-

Mulching the soil surface with organic materials makes the soil soft, crushed, and humid, which encourages beneficial microorganisms to maintain bulk density and porosity in the soil. Organic farming has a spatial and temporal component to the enhancement of soil physical attributes. High amounts of organic matter and permanent soil cover, such as cover crops or mulch, improve water penetration and retention capacity, reducing the quantity of water needed for irrigation. Organic farming is better in places with excessive rainfall due to higher water absorption and less run-off in the field. FYM enhances total nitrogen and organic matter in the soil, which is a major substrate of cationic exchange and the warehouse of most of the available nitrogen, phosphorus, and sulphur. Microorganisms' primary source of energy, and a fundamental influence of soil structure. It is definitely a key controlling element for the C:N ratio, total and accessible nitrogen, N mineralization, soil moisture, microbial activity, and soil texture (Agehara and Warncke,Cabrera) . When comparing organically managed plots to nonorganically managed plots, significant differences and greater values of soil organic carbon, carbon stocks, and carbon sequestration rate were discovered.

Soil microbial biomass and microbial activity are critical for soil production to be sustained. A balanced ratio of microbial biomass and activity in soil is required to ensure regular delivery of nutrients to plants (Pandey and Singh, 2012) . In numerous crops, organic fertiliser treatment boosted nodule dry weight, photosynthetic rates, N2 fixation, N accumulation, and N concentration (Jannoura et al., 2014). Organic agro-ecosystem management, on the other hand, was found to have a significant impact on soil nutrients and enzyme activity while having a minor impact on soil microbial populations (Bowles et al., 2014).

VI. IMPACT OF COWPATHY ON SOIL

Panchagavya, Jeevamruth, and Beejamruth are organic concoctions made from cow products that are environmentally friendly. Crop growth, yield, and quality improve when organic liquid products like Beejamruth, Jeevamruth, and Panchagavya are used. Cow dung, urine, milk, curd, ghee, legume flour, and jaggary are used to make these liquid organic solutions and Sreenivasa et al. (2010) found that they contain macronutrients, vital micronutrients, several vitamins, necessary amino acids, growth stimulating substances such as IAA and GA, and helpful microbes. According to Nileemas and Sreenivasa (2011), applying liquid organic manure to the soil stimulates biological activity and increases the availability of nutrients to the tomato crop. In comparison to control, Shivaprasad and Chittapur (2009) found that applying panchagavya at 3% for 10 days resulted in considerably greater yield per plant (86.95 g), yield per plot (1.220 kg), and yield per hectare (21.95 q). This is owing to a superior source-sink connection, which includes higher vegetative growth, more blooming, and more fruits that mature. This could be related to panchagavya's hormonal action, as well as an increase in plant photosynthetic activity, resulting in a better source-sink connection in chilli. According to Amalraj et al., (2013), panchagavya application can improve plant development by nitrogen fixation, growth hormone production, and phytopathogen suppression in a variety of plantation crops. Sakhubai et al., (2014) found that RDF increased plant height (103.10 cm), number of leaves per plant (75.62), leaf length (9.52 cm), and leaf breadth (9.03 cm), and yield parameters such as days to 50% flowering were earlier in T10 (VAM + Panchagavya + Amritpani (3 percent Drench and Spray) .

VII. CONCLUSION

Panchgavya has proven its ability to benefit humanity and is a promising treatment for a variety of human illnesses. Although scientific efforts are needed to evaluate biological activity and safety, as well as create standards, the effects of Panchgavya should not be limited to ancient literature. To validate the composition, chemical behaviour, pharmacological activity, safety, toxicity profile, and mechanism of action of the active ingredients, each product must undergo extensive testing. It is also critical to educate the public and market Panchgavya items in order to draw international attention to India's rich heritage and literature.

Cows play an important role in our lives and biodiversity. Its offspring and cowpathy have a wide range of applications, including sustainable agriculture, human health and nutrition, biofertilizer production, non-conventional energy production, and ecosystem biodiversity preservation. Different local formulations were found to be effective in various crops, resulting in improved plant development and, as a result, agricultural output. All of these conventional agricultural inputs have a bright future in agriculture and the production of safe and nutritious food. Crops sprayed with Panchagavya and Kunapajala yielded substantially more than controls. Various plant diseases have also been reported to be suppressed by compost tea. Small farmers produce less than their potential due to a lack of adoption of best practises, which contributes to low productivity. Depending on their natural resource base, land quality, and links to local and regional markets, farmers' demand for technology varies. Using scientific approaches to develop best practises in agricultural production, such as adding organic inputs based on soil testing and optimising water use with micro-irrigation devices, can assist enhance productivity. Small farmers have a lot of room to improve their long-term productivity. To promote cowpathy's extremely valuable attributes and wide range of uses, an integrated approach is required.

As a result, Cowpathy, a fresh version of ancient science, appears to be a potential formulation in the next years. As a result, educating people about the advantages of cows and cowpathy can help solve problems such as a lack of food grains, fuel, nutrition, and soil health, as well as give an alternative source of energy. The harmful effects of fertilisers and pesticides, as well as the use of these environmentally friendly traditional agricultural inputs, provide alternative production technologies to organic farmers and new vistas to the scientific community for further validation and refinement of age-old Vedic Krishi practises in the current scenario to improve food and nutritional security, as well as save soil health and the environment. More research is needed to determine the best combinations for certain agro-ecological and farming systems.

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Land Cover/Land Use Dynamics in Arid Mediterranean Fragile Ecosystems and its implications on Economic and Environmental Imbalances, southern Tunisia

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Abstract *- The Tunisian arid environment has been the scene of profound territorial transformations characterized by a speculative agricultural influence on fragile steppe ecosystems. The Skhira region is a typical example through which this work proposes to follow these transformations and analyze their socio-economic and environmental impacts. To do this, a GIS database was created on QGis software, using two satellite images (from 1996 and 2020). Land cover/Land use maps obtained were supplemented by forty farmers' field surveys and interviews with decision-makers involved in agricultural activity. The results showed an extension of irrigated crops by 14.4% to the detriment of steppes and rainfed cereal crops. This intensification was the result of an incentive policy undertaken in the region since 1993 and originally aimed at small farmers but which, after 2011, was taken over by a group of large farmers who intensified the exploitation of limited resources. This has resulted in a degradation of biodiversity with the disappearance of several vegetation species, overexploitation of water resources which reached 216% in 2020, groundwater and soils salinization and greater exposure of crops to the harmful effects of climate change and desertification. On the social level, and although several productions have declined following the degradation of resources, the profits have been mainly drawn by the large farmers. This agricultural extension, especially the irrigated one, has failed to limit inequalities between social categories. On the contrary, the economy of Skhira' peasants is increasingly precarious and the social situation risks breaking out for this marginalized rural population.*

Keywords- Land cover/Land use dynamics, resources overexploitation, Desertification, socio-economic inequalities, Skhira, Tunisia.

I. INTRODUCTION

Elementary natural resources (water, soil, vegetation...) are today the object of all human lusts. Their exploitation often exceeds all limits in several countries of the World. According to Schultz (2017), the world population is expected to reach 11.2 billion by the end of the century, which will mean an increase in demand for food products (cereals, water, oils, sugars...). As a result, farmers will have to produce much more food in a competitive environment, which will require increasing farm sizes and shifting to higher-value crops. Small-scale farming will also play an important role, especially as the number of small-scale farmers grows.

In response to this demand, the world's irrigated agricultural area has already increased considerably, especially from the second half of the 20th century. Average irrigated crop production and yields have also quadrupled or quintupled to provide more than 45% of the world's food. In addition, this irrigated agriculture accounts for about 70% of the world's freshwater withdrawals (FAO 2000, Shultz 2017). In Tunisia, in 2006, it took up nearly 80% of water resources, and the overall rate of mobilization reached 91%, which constitutes an extreme limit (Bessaoud & Montaigne 2009, FAO 2018).

In the face of this situation, studies and reports prepared by international organizations (UNESCO, UNEP, UNDP, FAO, etc.) have constantly alerted countries to the gravity of the pressures their resources are under. All the ecological indicators put forward by specialists on the levels of consumption of terrestrial resources (The Earth Overshoot Day, Ecological Footprint, Living Planet Index, etc.) agree that over a year, the Earth reaches its limits more and more sooner and is therefore forced to draw on its reserves, often non-renewable (Cannet & Wackernagel 2018). For the "The Earth Overshoot Day"[1] indicator, for example, it coincided in 2021 with the date of 29 July, while it corresponded in 2000 to 1st November and in 1986 to 31 December (Saab 2012). Although widely criticized for its reliability and accuracy, this indicator leaves no doubt that natural resources are being degraded at a giant pace and that humanity is increasingly drawing irreversibly from Earth's reserves. Moreover, this pressure is most pronounced in regions with very few resources to provide, such as arid and desert regions (Abaab *et al.* 1995, Nedjraoui & Bédrani 2008, Hourizi *et al*. 2017, Nasser 2019). Studies and work that have studied this issue have always emphasized the limited capacity of the natural resources of these regions for intensive and sustained land use (Colloff & Baldwin 2010, Dougill *et al.* 2010, Linstädter *et al.* 2016). They have also shown the low resilience capacity of existing ecosystems (Floret *et al.* 1989, Neffati *et al.* 2016, Lipoma *et al*. 2021). In comparison, they have relied on traditional land use through which man has shown ingenious know-how and exceptional abilities to exploit resources in a rational manner enabling them to be sustainable and ecosystems to be resilient (Pontanier *et al.* 1995). Other studies have shown that resources pressure leading to natural balances breaking, has been carried out essentially in the last few decades of "peace" and "prosperity", during which man turned to a market economy based on high consumption in order to increase his profits without much concern for natural resources sustainability and for ecosystems resilience (Robert & Ross 1993, Greenwood & Smith 1997).

In arid Tunisia, the accelerated pressure on fragile natural resources has taken place in particular since the 1960s after the country's independence and the establishment by the Government of an agricultural development policy in order to create wealth among the peasant populations and to limit massive rural exodus during the years 1960-1970 (Elloumi 2015). In this region, while arboriculture has traditionally been practiced mainly in the mountains behind the *jessour*[2], the privatization policy will encourage its extension in plains at the expense of rangelands, promoted by the implementation of several national strategies for agricultural and rural development (Elloumi 2009, Guillaume *et al.* 2006). This has led to a rapid transformation in resources exploitation and land use supported by the Government. The results have often been catastrophic for arid ecosystems and natural resources with the degradation of the steppe, the spraying of fragile soils and the spread of desertification (Hanafi 2000, 2010). Today, the warnings issued by specialists and international organizations for nature conservation and sustainable development (FAO, IUCN, etc.) do not seem to be able to hinder public and especially private actions to make the most of resources and increase rural populations' incomes, despite the uncertainties surrounding ecosystem balances and the threats of a possible return to desertification.

It was in this context that this study was carried out in the delegation of *Skhira*, which has experienced an unprecedented Land use dynamics for the last twenty four years. The aim is to detect, using GIS tools, the changes that have taken place in this steppe landscape since the late 1990s and the early 2000s, and which is manifested by the extension of dry and irrigated olive orchards. The impact of this dynamic on the environment and on the existing rural society needs to be studied further.

II. STUDY AREA

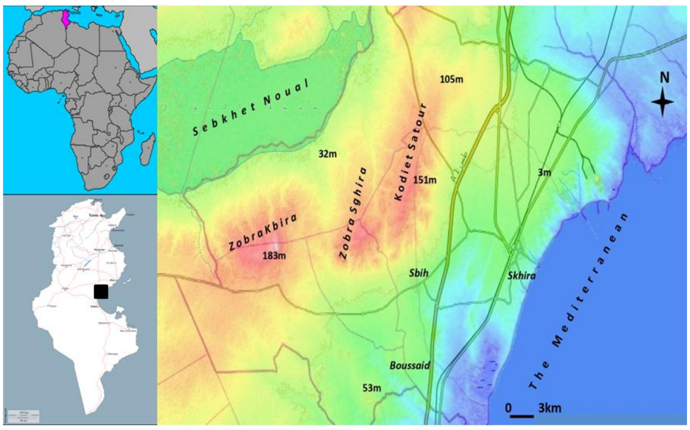

FIGURE 1: Study Area
(Source: Author personal work)

[1] The Earth Overshoot Day is an ecological indicator that has been set up by the American NGO *Global Footprint Network*. It corresponds to the date of the year from which humanity is supposed to have consumed all the resources that the planet is capable of regenerating in one year (Cannet & Wackernagel 2018).

[2] *Jessour* is the plural of *jesser* which constitutes a small traditional hydraulic structure (elevation in raised soil in the wadi-bed), designed in the arid mountains of southern Tunisia to retain the excess water and soil collected by impluviums and their exploitation for agriculture. A *Jesser* consists of an impluvium, a wadi and a soil elevation also locally called *tabia* or *katra* (Bonvallot, 1986, 1992).

The study area corresponds, in part, to the administrative division of the delegation of Skhira and belonging to the governorate of Sfax (Fig. 1). It covers 107,731 ha and lies between the parallel 34°10' and 34°32' North and the meridians 9°40' and 10°15' East. It is bordered by sebkhet Noual to the northwest and the Mediterranean Sea to the southeast.

2.1 Characteristics of the natural environment

2.1.1 A relatively flat topography with eroded and infertile soils

The study area consists of a set of plains and hills below 200 m of altitude with a slight slope generally towards the Mediterranean Sea. All these landscape units form the junction between the eastern end of the *Southern Low Plains* belonging to the Atlasique domain and the southern part of the *Tunisian Sahel* belonging to the Pelagian platform (Sghari *et al.* 2009, Hezzi 2014). The hills form what is called the *Sidi M'hadheb* subdesert plateau which represents a stripped glacis with gypsum overlaps of Pleistocene age (Fig. 2).

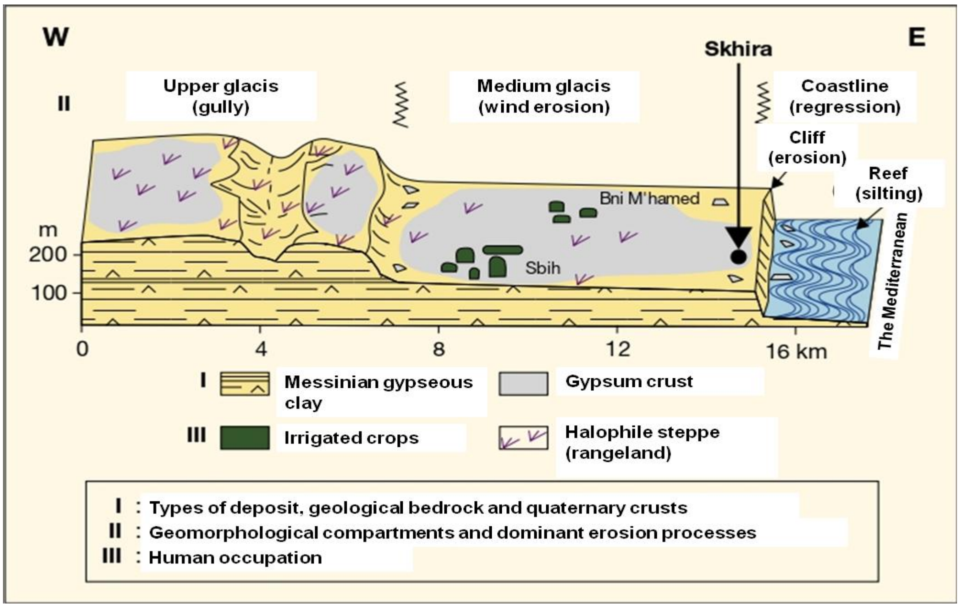

FIGURE 2: Main Topographic Units of the *Skhira* Region
Source: Sghari et al. 2009

The geological layers are essentially of recent and current Quaternary age made up of alluvium, sandy dunes or sandy loam. On the hills, the gully revealed tender clay-gypsum formations of the Mio-Pliocene and hard formations of white chalky limestone of the Upper Senonian age. The entire pattern is covered by recent stony formations, locally called *hamadas*, dissected by streams dominating an alluvial plain (medium glacis); it is also sealed by a gypsum-to-limestone gypsum crust (Zairi *et al.* 2005, Missaoui *et al.* 2013, Hezzi 2014, Chiab 2019).

Given these geomorphological conditions, the study area has a diversity of soils, which are generally characterized by low fertility. This weakness is explained by the strong presence of limestone and gypsum in the substrate or in the form of crusts. Widespread water and wind erosion, low vegetation cover and drought are factors that exacerbate this phenomenon. According the *Sfax* Governorate Atlas data (Missaoui *et al.* 2013) and the report of the Regional Commissariat for Agricultural Development (CRDA) of *Sfax* in 2017, the study area comprises four main soil types:

- Skeletal soils: They are part of non-fertile soils where the aridity prevents pedogenesis and promotes salinization (Yousfi 2013). This type of soil is most often associated with gypsum crusts. It is widespread throughout the study area, particularly in the upper glacis.

- Gypsum soils: They are also located on the upper glacis, notably in the *Sidi M'hadheb* sector. They are derived from soft evaporative rocks and have high levels of calcium sulfate (Karray 2006). As a result, they are most often covered with gypsum crusts and subjected to the actions of desertification favored by the long dry season,

- Isohumic soils: They are located in particular on the wadi-beds and correspond to the old red soils, to the colluvium of the Cretaceous marno-limestone formations (Chiab 2019). They are relatively rich in organic matter but highly exposed to gully erosion and wind deflation,

- Halomorphic soils: They are located on the edge of *sebkhet Noual* and near the coast. They are dominated by marl and clay with high salt content and are generally deposited by runoff. In the dry season, they are most often exposed to wind deflation.

2.1.2 A constraining arid climate

The study area is characterized by an average annual rainfall of 170 mm. With their weakness, these quantities show a high degree of monthly and seasonal variability, rising to over 26 mm in January and falling to only 0.2 mm in August (Table 1).

TABLE 1
AVERAGE MONTHLY RAINFALL AND TEMPERATURE AT *SKHIRA* STATION FOR THE PERIOD 1962-2016

Month	J	F	M	A	M	J	J	A	S	O	N	D	Total
T°C	12.1	12.9	15.8	18.1	21.9	25.8	27.6	27.9	26.1	22.9	17.6	13.8	**20.2**
P mm	26.3	21.1	16.2	9.2	4	2.3	1.1	0.2	9.3	38	17.6	24.8	**170**

Source: I.N.M., 2017

On an inter-annual scale, the *Skhira* station also records a large rain irregularity (Fig. 3). In a series of 50 years of observation (1968-2018), this station recorded two to three times the average rainfall, the cases of 1990 with 469.5 mm, 1996 with 395.8 mm and 2007 with 434 mm (I.N.M. 2017). However, some other years were very dry during which the average was divided by two or three, the cases of 2008 and 2005 which recorded only 38.5 mm and 36.5 mm, respectively. In addition, this great irregularity of rain is often accompanied by a torrential character since the station often records daily rain intensities around 30 mm (Bousnina 1997).

For temperature, the annual average is around 20.2°C, but it is not significant since it hides a very variable seasonal pattern with at least six hot to very hot months. Indeed, Table 1 shows that the heat settles in the region from the end of April and remains until the end of October with three relatively hot months (July, August and September) during which the average temperature reaches 27.9°C; the absolute value could exceed 40°C (Bousnina 1997). These high temperatures are related to the warm Saharan advections carried by the *sirocco*, a very hot local wind blowing especially from the southwest and southeast in spring and summer. This wind, which blows for about fifteen days a year, often causes significant damage in the agricultural sector, while causing excessive increases in the demand for drinking water and crops.

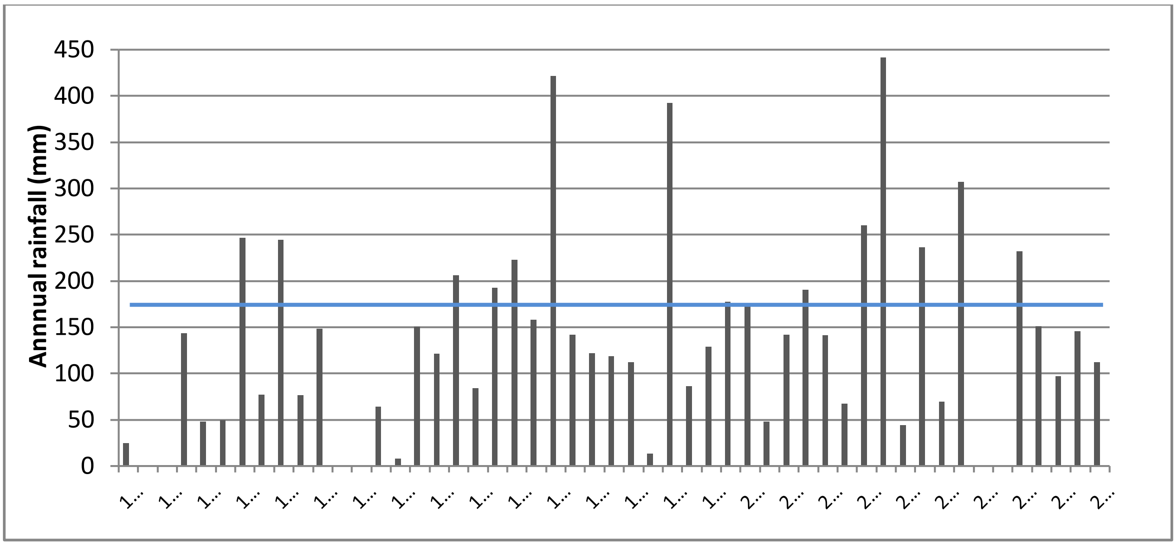

FIGURE 3: Inter-Annual Rainfall Variability at *Skhira* for the Period 1968-2018.
(Sources: I.N.M., 2017, CTV Skhira, 2018)

All of these characteristics can link the study area to the lower arid Mediterranean floor with moderate winters. This bioclimate is characterized in the region by a long and vigorous dry season, as humidity is virtually absent and the heat is often intense. The water deficit is therefore significant since the Potential Evapo-transpiration is around 1400 mm/year, which generates an average daily loss of water of around 3.8 mm while the daily intakes do not exceed the average of 0.5 mm (Ben Boubaker *et al.* 2003, Zairi *et al.* 2005). On an interannual scale, this bioclimate is characterized by the frequent and successive dry years (Fig. 4).

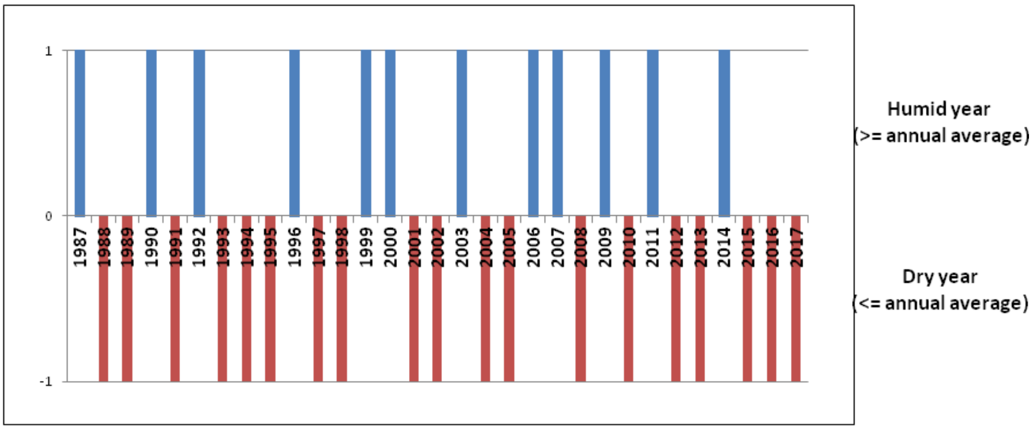

FIGURE 4: Alternating Dry and Humid Years at *Skhira* Region between 1987 and 2017[3].
(Sources: I.N.M., 2017, CTV Skhira, 2018)

This Fig. shows that during the 30 years of observation, 19 years were dry, more than 61% of the cases. In addition, this drought is most harmful to natural vegetation and agriculture when dry years are successive. However, the Fig. 4 shows that only three dry years are isolated from each other. The other dry years were successive, either to form binomials in 5 cases or to form trinomials in 2 cases. According to Floret and Pontanier (1982), the last years of these groups are the most damaging to natural vegetation and crops. For the 12 humid years, 8 of them were isolated and only 4 years formed 2 pairs. Floret and Pontanier (1982) concluded that for Tunisian arid regions, on average 3 out of 5 years could be dry, which really prevents any improvement in natural vegetation and extension of rainfed agriculture. Furthermore, the frequent sandy Saharan winds accentuate the aridity of the environment by accelerating the soil drying and the drop of groundwater piezometric level as well as the loss of soil fertility under the influence of wind erosion, which represents the main aspect of desertification (Floret and Pontanier 1982, Daoud 2003).

2.1.3 Limited and low-renewal water resources

Given the low amounts of rain, surface water resources are very limited. This is all the more true since the study area is almost flat and the *Skhira* watershed is small (64,200 ha) and drains a set of small wadis. According to Zairi *et al.* (2005), this watershed has a fairly compact appearance with a *Gravelius compactness coefficient* of 1.3. The runoff, calculated by the formula of Ghorbel (1991) is about 4 mm, which corresponds to an average annual volume of accumulated water of 2.6 Mm^3. Rainy years are most often used to accumulate and infiltrate a much larger volume of water, thanks to a large CES techniques installed in the region since 1993[4].

Groundwater is subdivided into semi-deep aquifer and deep aquifer. The first is considered one of the most important in the *Sfax* Governorate. It is housed in sandy clay layers of the Villafranchian and Mio-Pliocene (Karray 2006, Ben Cheikh 2013, Hafedh 2015). Its potential is estimated in 2020 at 4.23 Mm^3, i.e. approximately 10.7% of the total semi-deep aquifer resources of *Sfax* (Khanfir *et al.* 2017, CRDA 2020a). However, this aquifer suffers from a slow, weak and irregular supply given the weakness and irregularity of precipitation. As for the deep aquifer, it is estimated in 2020 at about 4.4 Mm^3, or 13.7% of the total deep aquifer resources of *Sfax* governorate (Hafedh 2015). In 2006, all of these resources had a relatively acceptable quality since the salinity and solid residue content were around 3 to 4g/l (Karray 2006).

2.1.4 Degraded steppe vegetation

The study area is characterized by a steppe vegetation landscape. This plant formation, characteristic of arid and desert regions, is very fragmented, essentially located at the encrusted interfluves where agricultural activities are scarce. Indeed, the original steppe has long been under severe human pressure, leading to intense quantitative and qualitative degradation (Chiab 2019). Harsh climatic conditions and young and rugged soils have often exacerbated this situation. Often used as rangeland, the remaining steppe shreds are often of low cover, dominated by post-cultivation, spiny and non-palatable

[3] This figure is based on the interpretation of the *Skhira* station's rainfall data for the period 1987-2017 (I.N.M. 2017).

[4] This is a set of techniques that have been installed in the region since 1993 as part of the "*Sidi M'hadheb Development Project*" funded by the Tunisian Government, the Islamic Development Bank and the International Agricultural Development Fund. The objectives of this project were (i) to increase farms production, (ii) to improve soil fertility and water runoff mobilization and (iii) to fight against flooding (Zairi et al. 2005).

species (Chaieb and Zaâfouri 2000). In consequence, and regarding this environmental conditions, the study area has the following main types of vegetation:

- Gypsum-limestone steppe with *Hammada schmittiana, Gymnocarpos decander* and *Helianthemum kahiricum* which extends at hills with limestone outcrops,

- Sandy steppe with *Rhanterium suaveolens* and *Artemisia campestris* characterizing sandy plains with a strong presence of the spiny species *Astragalus armatus*,

- Lime-limestone steppe with *Artemisia herba-alba, Stipa tenacissima* and *Hammada scoparia* which extends over the calcareous encrusted hills,

- Gypsum steppe with *Anarrhinum brevifolium* and *Zygophyllum album* that characterizes the plains and hills encrusted by gypsum,

- Wadi-beds steppe with *Ziziphus lotus* and *Retama raetam* and that show a significant presence of post-cultivation species such as *Artemisia campestris* and *Devera tortuosa*,

- Gypsum-halophytic steppe with *Nitraria retusa, Salsola vermiculata* and *Suaeda mollis* which extends on the edge of *sebkhet Noual* and near the Mediterranean coast.

2.1.5 Characteristics of the human environment

The region of *Skhira* bears witness to an ancient human presence with the existence of some ancient remains scattered here and there on the hills and around the ancient water points (Chiab 2019). Moreover, the Arab period has left its mark in particular with the distribution of the inhabitants over several tribal fractions, the most well-known being that of *Sidi M'hadheb* (Belghith 2017). Today, and according to the estimation of the National Institute of Statistics (I.N.S.), the *Skhira* delegation has about 36,265 inhabitants in 2020 with a very low urbanization rate of around 38.3% (Table 2).

TABLE 2:
EVOLUTION OF POPULATION NUMBERS IN *SKHIRA* BETWEEN 1994 AND 2020.

Year	1994	2004	2014	2020
Inhabitants	25 795	29 616	34 673	36 465
Urbanization rate %	31,9	34,2	36,8	38,3

(Sources: I.N.S. 1994, 2004, 2014, 2020)

Although *Skhira* has experienced a significant increase in its number and urbanization rate since 1994 (Table 2), this Delegation has remained, for the most part, rural, despite the presence of large industrial sites (SIAPE, TIFERT, TRAPSA, TANCMED), which are supposed to promote the creation of an urban center around the city. This is one of the poorest delegations in the region with a Regional Development Indicator of 0.467 in 2018, lower than the national average of 0.486 (Boussida *et al.* 2018). The inhabitants have a strong relationship to the land since most of them practice an agropastoral activity even if they have another activity in parallel. The traditional agropastoral production system is characterized by rainfed arboriculture combined with episodic dry cereal cultivation and extensive breeding of small herds of sheep and goats. In addition, irrigated agriculture has developed in the region since the 1990s, focusing in particular on olive and vegetable crops. It took place in a context which aimed to limit agricultural production fluctuation and animal production weakness as well as the improvement of the inhabitants' incomes (Zairi M. *et al.* 2005).

III. MATERIAL AND METHODS

In order to study the landscape changes in *Skhira* following the agricultural extension that has occurred since the 90s-2000s as well as its impacts on the environment and on the economy of the inhabitants, a spatialized and qualitative approach was adopted. It was based on a diachronic Land cover/Land use mapping between 1996 and 2020. The use of this mapping is a relevant tool for detecting the changes that have occurred and for identifying the direct and indirect impacts on natural habitats, biodiversity and landscapes (Al-Bilbisi 2017, Aladekoyi *et al.* 2016, Ebro *et al.* 2017, Habte *et al.* 2020, Mohamed *et al.* 2020). Furthermore, monitoring and mapping Land cover/Land use changes are essential for environmental management, resource sustainability and to facilitate regional planning decision-making.

The choice of the date of 1996 is relevant since it corresponds to the first results of the "*Sidi M'hadheb Development Project*" undertaken by the Government since 1993 and materialized, among other things, by encouraging the agricultural land development. A first window was then extracted from a Landsat/TM satellite image with a spatial resolution of 30 m and dated 28 April 1996, and a second window was extracted from a Sentinel-2 image dated 16 May 2019 with a spatial resolution of 20 m.

In this regard, high-resolution multi-date and multi-spectral satellite imagery can be well adapted to map Land cover/Land use dynamics in the steppe region. Landsat and Sentinel-2 images have already been used to map broad classes of land cover, such as croplands, grasslands, shrubs and trees, in sparsely vegetated environments, and also to monitor land cover in several regions of the world (Hanafi 2000, Malatesta *et al.* 2013, Gil *et al.* 2014, Belgiua & Csillik 2015, Kraemer *et al*. 2015, Aladekoyi *et al.* 2016, Nino *et al.* 2017, Khebour Allouche *et al.* 2018, Gxokwe *et al.* 2020, Henchiri *et al.* 2020, Chouari 2021, Dashpurev *et al.* 2021). In addition, the spatial resolution of Landsat TM (30 m) and Sentinel-2 (20 m) images are perfectly suited to the average size of the agricultural fields in the study area. Finally, the free access to historical archives with multi-date satellite images makes it possible to reconstruct the land use.

The two retained images were then georeferenced and then they were integrated into the QGis software, in free access, in order to achieve, through a visual photo-interpretation, a delimitation of the homogeneous zones. The GIS database created was also fed by the 1:200,000 topographic maps of *Sfax, Mahares* and *Meknassi*, each covering, in part, the study area (Kaim *et al.* 2014). In order to improve the quality of the photo-interpretation for 2020, it was also necessary to work on an extract of the satellite platform Google Earth©.

Following this cartographic work, and with the aim of validating the interpretation of the first results obtained, a field mission was carried out in March 2020. It allowed, through the visit of a hundred points spread over the entire study area, to verify the delimited units and to validate their content. Interviews were also carried out with about thirty small agro-breeders and about ten large farmers[5] in order to understand their motivations, their problems in relation to the farms in possession as well as their perceptions of their natural environment, the resources at their disposal and finally their awareness of challenges and risks they incur in relation to their farm management and their methods of exploiting the available resources. Some meetings are also realized with local and regional decision-makers involved in agricultural activity (CRDA of *Sfax*, Territorial Cell of Vulgarization - CTV of *Skhira*).

With regard to the data from 1996 and following years, it was necessary to use regional and local services reports as well as the main bibliographic sources that have worked on the region and the neighboring regions (Auclair *et al.* 1996, Chaieb and Zaafouri 2000, Hanafi 2000, Talbi et al 2000, Karray 2006, Sghari et al 2009, Yousfi 2013, Chiab 2019). However, since it was difficult to carry out a detailed cartography of this period and in order to be able to establish a reliable comparison between the two chosen dates, a simple occupation typology was preferred, summed up in 4 main types:

- Dominant natural or post-cultural steppe
- Mainly dry farming (cereals, legumes, etc.)
- Mainly dry arboriculture (olive, almond, etc.)
- Irrigated arboriculture + irrigated vegetable cultivation.

The cartography of these types of occupation fairly representative of field reality in the two chosen dates made it possible to obtain two maps of Land cover/Land use and to fully appreciate the landscape dynamics *Skhira*.

IV. RESULTS AND DISCUSSION

4.1 Land cover/Land use dynamics between 1996 and 2020

4.1.1 Profound landscape change

A review of the 1996 and 2020 Land cover/Land use data (Table 3, Fig. 5 and 6) shows that in twenty four years the landscape of *Skhira* has undergone a significant change. Indeed, the steppes experienced a quantitative degradation of 8.5% with a decline in their area from 45,660 ha in 1996 to 36,549 ha in 2020, and with an average annual rate of decline of about 0.34%. This annual steppe degradation rate is almost comparable to neighboring regions (0.45% in *Menzel Habib* and 0.41% in *Jeffara*) (Hanafi 2000, 2010).

[5] It should be noted here that, unlike small agro-breeders, it has been difficult to meet and collect information from large-scale farmers and managers of agricultural development enterprises. Many of them are absentees, while others refused to provide information on their holdings.

TABLE 3:
LAND COVER/LAND USE DYNAMICS IN *SKHIRA* REGION BETWEEN 1996 AND 2020

Year	1996		2020		Evolution 1996-2020
Type of occupation	**Area in ha**	**%**	**Area in ha**	**%**	
Dominant natural or post-cultural steppe	45 660	42.4	36,549	33.9	-8.5
Mainly dry farming (cereals, legumes, etc.)	21,562	20.0	6.205	5.8	-14.3
Mainly dry arboriculture (olive, almond, etc.)	25,419	23.6	34,358	31.9	8.3
Irrigated arboriculture + irrigated vegetable cultivation	15,090	14.0	30,619	28.4	14.4
Total	**107 731**	**100**	**107 731**	**100**	**-**

(Sources: Topographic maps at 1/200.000 of Mahares, Meknassi & Sfax; Satellite images Landsat/TM & Sentinel-2; Chiab, 2019; Author's Field Work, 2020)

It should be noted, however, that this rate of decline is much greater for former dry farming land (-14.3%) which is located mainly on foothills and encrusted sandy-loamy-gypsum plains as well as in the wadi-beds with loamy-sandy soils that receive extra water from surface runoff during rainy years. As a result, these lands were cultivated episodically (at least two years out of five) by rainfed cereals (barley, durum wheat, etc.) associated with dry vegetable crops (lentils, peas, broad beans, chickpeas, onions, garlic, carrots, etc.). Today, the land lost by these crops and by the steppes has been recovered by irrigated crops and dry arboriculture.

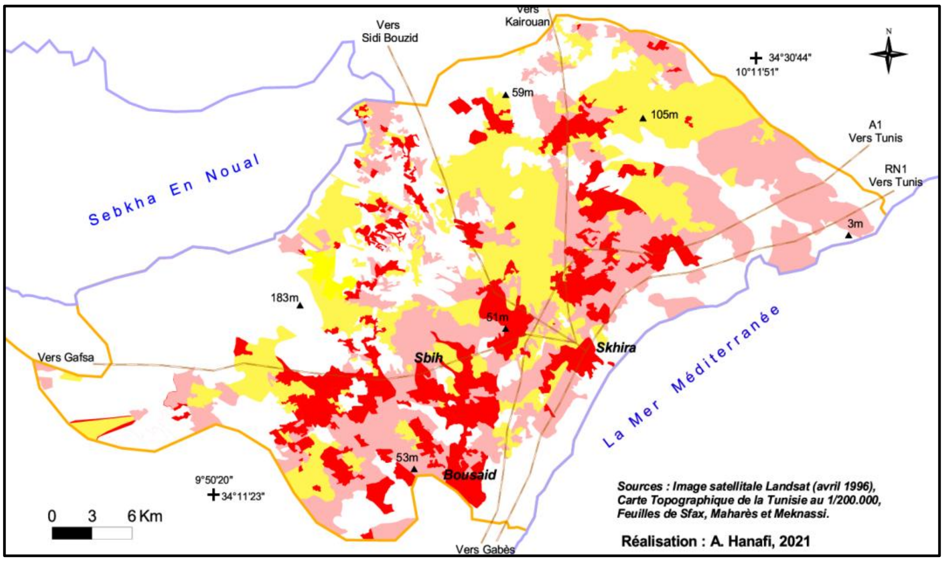

FIGURE 5: Land Cover/Land Use in the *Skhira* Region in 1996.

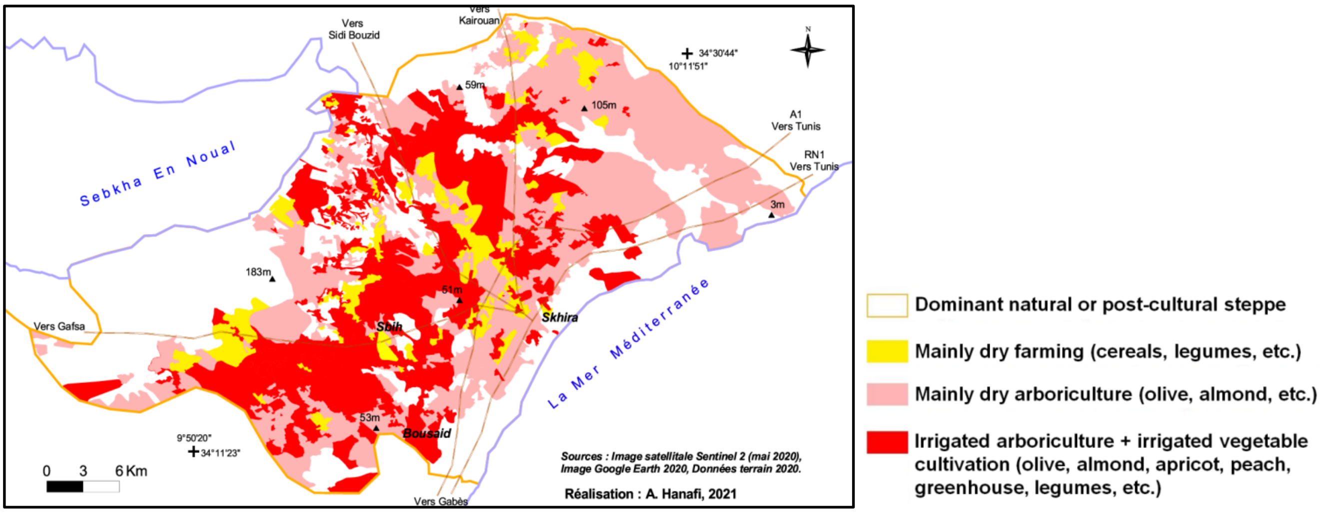

FIGURE 6: Land Cover/Land Use in the *Skhira* Region in 2020.

As for the increase in arboriculture, it is essentially based on olive cultivation. This speculation, which accelerated after 2011, was implemented by investors mostly from outside the region. They became interested in olive cultivation following the surge in olive oil prices and the increase in its demand on the national and international markets (Chiab 2019). Moreover, this agricultural influence took place, first at the expense of the degraded steppes with encrusted gypsum-calcareous soils, then at the expense of the rainfed cereal cultivation.

A: Irrigated olive tree B: Pepper greenhouse cultivation

FIGURE 7: Importance of Irrigated Crops in the *Skhira* Region in 2020.

(Source: Author's field work)

4.1.2 A preponderant place for irrigated crops

In 2020, the total area of arboriculture reached 64,977 ha (Table 3) with more than 18,000 ha characterized by olive monoculture (CRDA 2020b). This activity, which dates back to the late 1990s, was first concentrated on the coastal plains and around *sebkhet Noual* where the gypsum crust is discontinuous and the soils are rather sandy-loamy to sandy. Subsequently, and during the last decade, it has spread to the detriment of steppes of the central hills with rugged and crusted soils. These new lands acquired for irrigated olive cultivation (Table 4) have proliferated thanks to the implementation until 2020 of 105 agricultural development projects whose owners are, for the most part, non-farmers by profession[6] (Chiab 2019, CRDA 2020b, *Author's Field Work*). These projects were undertaken by companies which, originally, were intended for the export of olive oil, and which converted into production companies taking advantage of Government subsidies for the development agricultural land and olive plantation (Fig. 8).

TABLE 4

EVOLUTION OF AGRICULTURAL DEVELOPMENT PROJECTS IN THE SKHIRA DELEGATION BETWEEN 2000 AND 2020.

Period	Number of projects	Area in ha
2000-2005	02	30
2005-2011	23	1 054
2011-2015	42	1 625
2015-2020	38	2 486
Total	**105**	**5 195**

(Sources: Chiab 2019, CRDA, 2020b, Author's Field Work 2020)

FIGURE 8: Irrigated Olive Plantations Extension over Several Hectares in *Skhira* Region

(Source: Chiab, 2019)

6 We cite for example the agricultural projects implemented by the companies *Yakin, Chabane, TODOLIVO, El Eutha and Syala-Donia* (*Author's Field Work*).

On the north-western side of the *Skhira* region at the level of the *Hmila* sector, persistent disputes between the inhabitants belonging to different tribal fractions (*Ghrayra, M'hedhba* and *Beni Zid*) have encouraged rights holders to plant the land in order to assert their ownership (Chiab 2019). The desire of these inhabitants, to accelerate and increase their gain has encouraged most of them to resort, first, to irrigate the olive tree in order to increase the chances of its success, and then, to plant introduced varieties known by their entry into production after 3 to 4 years, the case of the Spanish *Arbequina* variety (Karray *et al.* 2019, *Author's Field Work*). For this variety, used in intensive cultivation systems, it can be planted at a height of 200 vines / ha. As for local varieties planted dry with a density of less than 50 vines / ha, and which come into production after an average of 10 years (*Injassi, Hchichina, Chemlali* and *Ghraiba*), they are less and less cultivated (Allalout and Zarrouk 2013). Thus, in a few years, the constraints of rainfed agriculture in *Skhira* (poor and crusted soils, scarce and poor quality water resources, etc.) have been transformed into profits thanks to this activity guided by speculators, like several other neighboring regions (*Regueb, Menzel Chaker*, etc.).

In addition to irrigated olive cultivation, the landscape has seen an increase in irrigated vegetable crops mainly around urban agglomerations (*Skhira, Sbih, Jerouala, Khadhra, Boussaid,* etc.). This activity has also increased since the 2000s, either through the acquisition of new land, or through the intensification of old dries production systems. The CRDA of *Sfax* (2020a), showed that the area of these pure crops in the *Skhira* delegation increased from 4,643 ha in 2000 to 8,215 ha in 2020, an increase of around 77%. Dominated by greenhouse cultivation, this activity is largely monopolized by farmers from the region who have taken advantage of the increased demand for food products and the improvement in prices, as well as Government support for digging surface wells to intensify their cropping systems.

According to Chiab (2019), the rise of the *Skhira* region in several products from this agricultural activity is national. In two decades, *Skhira* has become a real center for fruits and vegetables production, taking advantage of its position between two major consumption centers, namely the city of *Sfax* 55 km to the northeast and the city of *Gabès* 53 km to the south. This is how melon, watermelon, peas, peppers, tomatoes and onions have become the specialty of the region. In 2020, *Skhira* delegation counted about 48% areas of melon and watermelon areas in *Sfax* governorate, about 39% of tomato and pepper areas and about 36% of onion areas (CRDA 2020a, *Author's Field Work*). In the same date, watermelon production was estimated at 22,820 tons, or about 51% of total production in the entire governorate.

4.2 Impacts of Land use dynamics on natural resources

It is sometimes very difficult to assess and monitor the true extent and impact of agricultural encroachment on resources, as farmers often mask the effects of degradation by converting their land to less demanding uses or by increasing the levels of compensatory inputs (Scherr & Yadav 1996). There is rarely an unequivocal relationship between the degree of degradation and the effect on yields. For example, on relatively deep soil, erosion can be quite severe for long periods of time before there is a measurable effect on crop yields. There is little empirical evidence of the critical thresholds at which degradation processes produce economic or environmental effects for different soil types, climates and crops (Bourque 2000). Most measurements have traditionally been taken at the parcel level, which may not always be appropriate for drawing conclusions at the farm level or the policy implemented. To make economic assessments of the impact of land degradation, various approaches are used such as calculating the replacement the cost of replacing lost nutrients, the value of lost yield, the value of increased agricultural inputs needed to maintain yields, or the cost of returning the parcel to its previous state. More aggregate estimates of degradation costs should be taken with caution, as these aggregates are mostly based on standard formulas linking certain levels of degradation to estimated yield losses. Based on these losses, the market value of lost output is determined, as well as the amount of inputs needed to raise productivity to previous levels (Scherr & Yadav 1996, Daoud 2003, Doukpolo 2014, Lavorel *et al.* 2017).

According to Scherr and Yadav (1996), the most important effect of land degradation on farms is the reduction in potential yields. But the degradation of agricultural land can also have significant negative effects off the farm. Examples include soils depletion through the transport of fertility, the pulverization of the most fragile soils and their transport and accumulation around CES, the overexploitation of water and competition for it with other economic sectors, the biodiversity loss, the landscape and ecosystems fragmentation, the economic income fluctuation and the persistence of production systems precariousness, etc. These impacts that will be analyzed here based on field data and reports drawn up by the various regional and local services in the *Skhira* region.

4.2.1 Environmental impacts, an ever-threatening desertification

4.2.1.1 Increasing demands on water resources

For several years, many studies have alerted the various actors of the Tunisian agricultural sector to the need to limit the use of water resources. According to Massin *et al.* (2016), the irrigable areas of the country will have to stabilize in the coming years and the new areas that will be developed in the future will just have to compensate for the losses caused by several factors, in particular by the reduction in water availability following overexploitation of some aquifers. For these authors, if the national average water consumption per hectare for irrigation is high compared to the potential (around 5,500m³), it would be much higher in the Tunisian arid environment around 15,000m³ / ha. In the *Skhira* region, although the record of the exploitation of aquifers is more than alarming, farmers do not seem to be in a position to respect the alerts (Table 5, Fig. 9).

Indeed, since the 1990s, farmers of *Sbih, Boussaid, Khadhra, Rouibta, Sidi M'hamed Nouigues*, etc., who were not concerned about the scarcity of this resource, have irrationally intensified its exploitation by multiplying wells digging and practicing submersion irrigation of vegetable crops (greenhouses). In the 2000s, and despite the implementation of the policy to encourage CES techniques[7], a frantic increase in well digging was recorded, since the number of wells increased from 1,582 in 2002 to 2,768 in 2020. With this figure, *Skhira* ranked 1st in the number of wells in the governorate of *Sfax*, far ahead of *Jebeniana* (CRDA, 2020a). In addition, this increase was accompanied by an upsurge in the annual quantities exploited, which raised from 6.25 Mm³ to 9.48 Mm³ during the same period, reaching an exploitation rate of more than 216% in 2020.

TABLE 5:
EVOLUTION OF GROUNDWATER EXPLOITATION IN *SKHIRA* REGION BETWEEN 2002 AND 2020

	2002	2004	2011	2016	2020
Potential resources in Mm³	4.52	4.51	4.48	4.44	4.39
Number of wells	1582	1775	1872	1963	2768
Annual volume used in Mm³	6.25	7.4	8.38	9.02	9.48
Exploitation rate (%)	138	164	187	203	216

(Sources: CRDA 2020a, Chiab 2019)

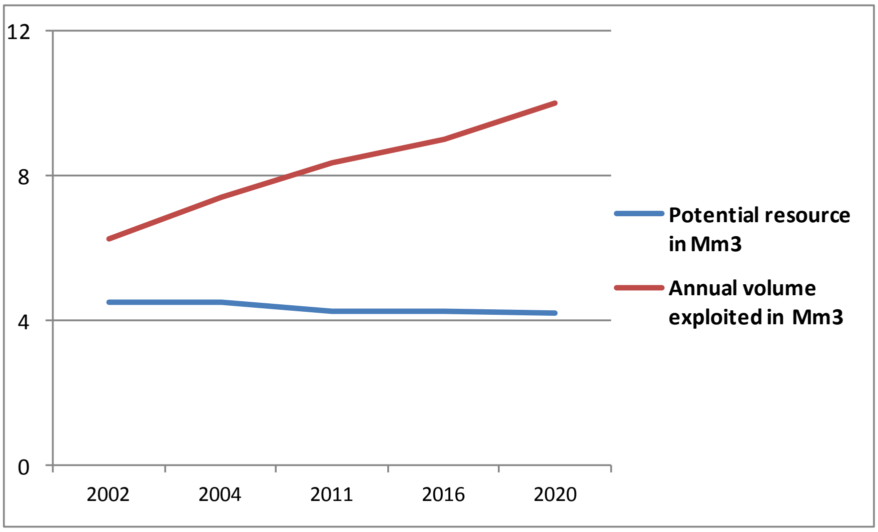

FIGURE 9: Overexploitation of Phreatic Aquifer in *Skhira* Region.
(Sources: CRDA 2020a, Chiab 2019)

[7] According to FAO 2018, incentives for the use of CES techniques include the recovery of 60% of farmers' costs; 20% of the amount in the form of a grant and 40% in the form of a loan.

This overexploitation has led to an acceleration of the aquifer salinization as a result of the intrusion of marine waters. The figures given by the CRDA of *Sfax* (2020a) indicate that the aquifer salinization has reached, in some places, 8g/l. However, it should be noted that this degree, although it is very limiting for several crops, especially since salinization seems to increase from year to year, it remains relatively tolerable for the olive tree (Palluault & Romagny 2009a, Khanfir *et al.* 2017). To compensate for its losses in fresh water, the aquifer benefits during good rainfall years from a quantity of water recharge which is around 800,000 m³ thanks to CES techniques. Moreover, it also feeds from the semi-deep aquifer with which it communicates easily, taking advantage of the semi-permeability of the clay-sandy layers that separate them (Hafedh 2015). But even this situation is not guaranteed, since the semi-deep aquifer has not been spared from exploitation, especially since 2011, following the digging of several illicit wells by new irrigated olive cultivation projects owners. According to Chiab (2019), more than 28% of the wells dug in these projects exceed the authorized depth of 50 m. Government control over these wells is very limited or even non-existent since many of these projects use solar energy to power their motor pumps, which does not allow the authorities to control their electricity consumption.

In addition to salinization, the *Skhira* groundwater aquifer suffers from a rapid decline since the piezometric level decreased by about 12 m between 1995 and 2020 (CRDA 2020a). This situation has led to the drying up of several surface wells owned by small farmers who cannot afford to dig them further. Some other farmers may have illegally overdug these wells beyond the authorized depth (Khanfir *et al.* 2017).

4.2.1.2 Agriculture affected by climate change

Although the figures on climate change in Tunisia are not precise, the reports of competent national and international organizations agree on the fact that this phenomenon has affected the country for several years and that it is constantly growing, thus threatening human activities particularly agriculture (Rubio *et al.* 2009, Troudi 2013, Gafrej 2016, MALE 2020, Yousfi 2020). This phenomenon is all the more serious as the Tunisian climate is intrinsically characterized by a pronounced variability and aridity, which would further increase the environmental and socio-economic vulnerability of the country and in particular its arid part.

In the *Skhira* region, this phenomenon has been felt for several years as dry periods are increasingly recurrent and vigorous, aggravated by *sirocco*. And it is agriculture that pays the cost, especially since most irrigated crops have a life cycle of about 6 months between February and July, which coincides with the onset of heat. In addition, they are very water-intensive plants and require frequent irrigation. This is probably one of the reasons why these crops have, for several years, experienced a decline in production and a decrease in their area (Fig. 10), a phenomenon that has particularly affected small farmers who have found themselves increasingly deprived of water resources and, therefore, of financial income (Chiab 2019). Only tomato production has increased from 480 tons in 2000 to over 23,800 tons in 2020 (CRDA 2020a & 2020b, *Author's Field Work*).

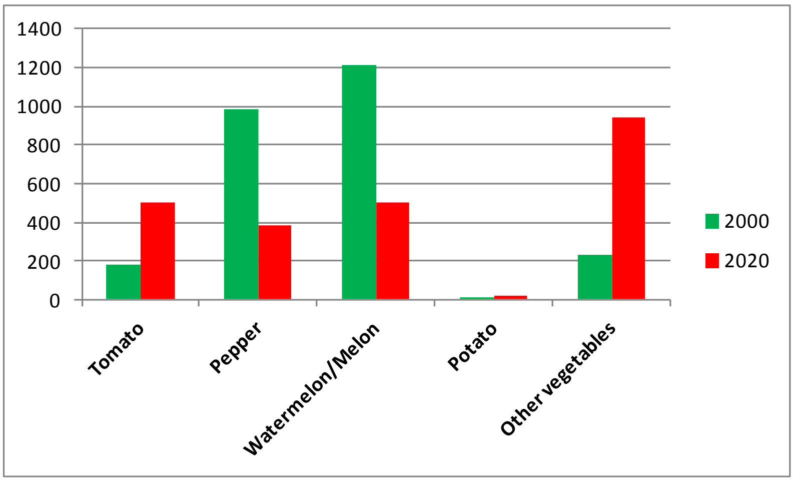

FIGURE 10: Evolution of Some Vegetable Cultivated Areas (In Ha) in *Skhira* Region
(Sources: CRDA 2000 & 2020b, Author's Field Work)

4.2.1.3 Soils affected by salinization, crusting and loss of fertility

Like the entire Tunisian arid environment, the soils best suited for crops in *Skhira* are those sandy to sandy-loamy and which benefit from coastal influences or from CES techniques (Massin *et al.* 2016). However, the intensification of agricultural activity did not respect this restriction, since crops, especially irrigated ones, were widespread on most types of soil. Indeed, intense irrigation with high-salt water, particularly in the presence of gypsum crusts, has led to soil structure degradation that is sometimes irreversible. This phenomenon is often exacerbated by the hydromorphy caused by submersion irrigation, which is very often used for certain crops such as peppers, tomatoes, watermelons and melon. According to Massin *et al.* (2016), about 60% of soils in public irrigated perimeters and about 86% of private perimeters in Tunisia are moderately to strongly sensitive to secondary salinization.

Moreover, the irrigation of gypsum soils rich in Calcium sulfate generates an accelerated concentration of salts at their first horizons which easily indurate during dry years. During these periods, soils are exposed to wind deflation, following the uprooting of woody plants and land plowing. In addition, the fertility decrease of irrigated soils constitutes a dominant form of degradation in relation to the modification of physical, mineralogical, chemical or biological soil properties (degradation of the structure due to lack of organic matter, loss of major fertilization elements, etc.). Furthermore, chemical pollution is increasingly strong in these irrigated areas as a result of the excessive or inappropriate use of mineral fertilizers and phytosanitary treatment products for crops (Chiab 2019).

4.2.1.4 Unbalanced ecosystems with a loss of biodiversity

The strong agricultural extension in the *Skhira* region has taken place at the expense of already fragile steppe ecosystems. Woody extraction, crust breaking, plowing with polydisks and soil spraying, etc. are all actions that have profoundly altered the old traditional balances based on a relatively acceptable floristic richness and ecosystem diversity as well as on a more or less rational management of territories (agricultural and pastoral) and resources (vegetation, water, soil).

Today, after twenty four years of intense agricultural activity, the ecological bill seems to be increasingly heavy with a significant loss of species richness and ecosystem diversity. Indeed, plant diversity based on more soil-conserving steppe species with good pastoral value (such as *Helianthemum kahiricum, Helianthemum sessiliflorum, Gymnocarpos decander, Stipa lagascae, Anarrhinum brevifolium, Rhanterium suaveolens, Pennisetum setaceum ssp. Asperifolium*, etc.), has been replaced by a floristic homogeneity dominated by post-cultural, ubiquitous, thorny, nitratophilous species of low to no pastoral value (notably *Astragalus armatus, Deverra tortuosa, Asphodelus tenuifoliosus, Ononis natrix ssp. Polyclada, Peganum harmala, Haplophyllum tuberculatum, Cleome amblyocarpa*, etc.) (Hanafi & Jauffret 2008, Hanafi 2010).

Around crops, natural vegetation is scarce; only weeds can grow with extra irrigation water. However, their valorization by livestock is difficult since most of perimeters are fenced in order to protect plantations. The animals are then forced to move away and concentrate on the remaining strips of steppes, which lead to extensive overgrazing (Fig. 11), biodiversity destruction and habitats fragmentation.

FIGURE 11: Some Ecological Indicators of Ecosystem Degradation in *Skhira* Region.
(Sources : Chiab 2019, Authors' Field Work)

The generalization of crops in the *Skhira* landscape has also led to the degradation or even disappearance of several natural ecosystems. This is the case of the ecological system of wadi-beds with *Ziziphus lotus* and *Retama raetam* with sandy-loamy soils and which has been characterized, in addition to the rich and well-conserving steppes of the water and soils, by dry crops that optimized the use of water and soil resources without eradicating woody trees. However, since the region has experienced agricultural intensification, the soils of this ecosystem have increasingly shown signs of amplified salinization due to irrigation. The steppe has completely disappeared to be replaced by crops, which has led to sand deflation and its accumulation around the fields. The situation is even worse in the more fragile ecosystems of *Hammada schmittiana, Gymnocarpos decander* and *Helianthemum kahiricum* with gypsum-calcareous soils, located in hills, and whose plowing has favored the deflation of gypsum and limestone and their dusting in lowlands.

It is important to note here that the development project of *Sidi M'hadheb* implemented in the region during the period 1993-2002 had as its main objectives the water and soil conservation, the groundwater load improvement and the fight against ecosystems degradation and desertification. Twenty four years later, it seems that this project has not achieved these objectives, on the contrary, the encouragement for agricultural development and supplementary irrigation that it has provided has degenerated to produce an alarming finding as regards environmental balances and the risk of desertification. The severe drought that has occurred in the region over the past two years (2020-2021) is a witness to this, since it has resulted in serious damage to water aquifers, soils and consequently crops. Even the olive tree, which is supposed to be very rustic, has sometimes been completely dried out despite the proximity of the sea and its moisture (Fig. 12).

Even if the ecosystems natural balance is, today, replaced by another artificial balance based on a heavy device of installations and an almost continuous presence of farmers to maintain their fields, it is clear that farmers are powerless to cope with drought and desertification if they are there. In order to save the tree and its production during very dry years, some farmers are forced to resort to exceptional measures such as supplementary irrigation by towed tanks of the oldest and the most vulnerable olive trees, the protection of fields against wind deflation, the over-fertilization of impoverished soils, etc. But since droughts are recurrent, these measures supposed to be exceptional, are more and more practiced, thus contributing to increase in the bill for farmers' expenses. In addition to this supplementary cost, several studies have shown the limits of these practices, particularly with regard to the irrigation of old olive trees (Ben Rouina 2016, Jackson *et al.* 2016).

FIGURE 12: Drying Up of Olive Tree Due to the 2021 Drought in *Skhira* Region
(Source: Chiab, August 2021).

4.2.2 Socio-economic impacts: low viability of production systems and precarious family economies

On a socio-economic scale, the acceleration, since the 1990s, of the *Skhira* landscape dynamics, has been accompanied by profound changes in the production systems and by a landscapes fragmentation. Moreover, and although agricultural production and income are attractive in good years, the high exposure of irrigated agriculture to climatic hazards has increased their fluctuation.

4.2.2.1 A trend towards spatial fragmentation and landscape heterogeneity

As it has been observed in similar regions in the Tunisian arid environment (*Menzel Habib, Jeffara, Tataouine,* etc.), the acceleration of agricultural area and diversification of its forms has, most often, given rise in addition to the quantitative and qualitative loss of steppe, to a landscape fragmentation and a greater heterogeneity of its units under the effect of a significant intervention of local and regional actors as well as the Government. According to the classic scheme proposed by Hanafi (2010) and valid for the entire Tunisian arid environment, the landscape experienced a dynamic that is summarized in 4 stages (Fig. 13).

This dynamic is characterized by a transition from the pure steppe (Stage 1) to a steppe-crop mosaic with a dominant steppe (Stage 2), favored by a land tenure transition from a family or collective status to a private status and the clearing of a large part of the steppes. The second process is characterized by an increase of agricultural activities with the generalization of CES techniques and the increase in dryland plantations to the point of outpacing steppes in terms of area (Stage 3). The steppes remain in the landscape but are confined to the rugged and encrusted "bad land", or at the graveled bottom of wadis. Contrary to the first two phases which do not last long, the landscape, once it reaches stage 3, tends to stabilize since the environmental and economic conditions (aridity, rigorous Government control over the groundwater exploitation, farmers' poverty and fluctuation of Government support) do not allow for an easy return to the steppe, nor an easy intensification of activities through the creation of irrigated perimeters. Moreover, the latter are generally very limited in area (Stage 4). In *Jeffara* and *Menzel Habib* the average size of irrigated perimeters does not exceed 1 ha (Hanafi 2000, 2010). Their contribution to the rural families' economies and those of the region is very low.

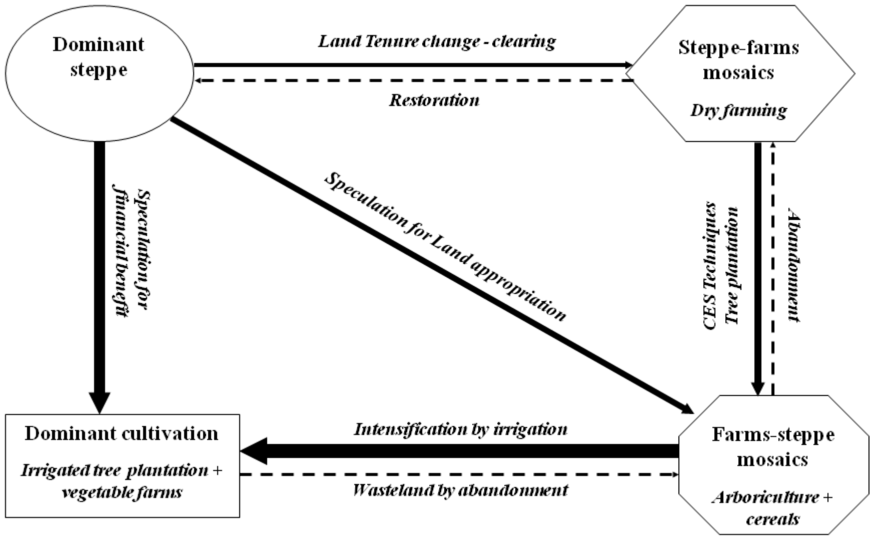

FIGURE 13: Theoretical Diagram of Landscape Dynamics in The Study Area[8]
(Source: Hanafi 2010, modified)

However, and despite many similarities with the rest of the arid Tunisian environment, the landscape of *Skhira* has undergone a relatively different process. Indeed, observations of recent dynamics in this region have shown that the classic evolution based on a passage through all the stages in their respective order, has been curtailed since the pure steppe (Stage 1) has been cleared for several years entirely either for the planting of dry olive trees (Stage 3), or for the creation of irrigated perimeters around wells dug on site (Stage 4). Speculation around olive crops, which began in particular in the 2000s, tends to gain momentum on this dynamic. Moreover, the frantic race to dig wells has increased the chances of passing from the first three stages directly to the last. In short, this dynamic has generated a fragmented, artificial and heterogeneous landscape in which the steppes are either cramped and nested in the crops, or pushed back to their margins at the level of the "worst lands". Furthermore, this extension of irrigated agriculture has led to a socio-territorial restructuring and a spatial disparity between an "economic performance cluster" around *Skhira, Sbih, El Khadhra* and *Boussaid* and marginal sectors with low potential, particularly in the vicinity of *sebkhet Noual*.

4.2.2.2 Fluctuating and uncompetitive production

Like all the Tunisian arid environment, the dependence of a large part of the crops on climatic conditions has led to a fluctuation in agricultural production, despite the research work which has shown the limits of this activity in these regions, especially when it is carried out in a manner that does not respect the fragility of natural conditions (Palluault *et al.* 2009a,

[8] The thickness of the arrows indicates both the magnitude and speed of transition from one stage to another.

Rubio *et al.* 2009, Hanafi 2010, Requier-Desjardins 2010, Ben Rouina 2016, Gafrej 2016, Karray *et al.* 2019). In the case of rainfed crops, such as the olive tree, production at *Skhira* delegation has significantly fluctuated going from single to double, despite the extension of areas over the years. It has, for example, increased from 3,215 tons in 2000 to 5,346 tons in 2010, to drop again to only 3,934 tons in 2020 (Table 6).

TABLE 6:
FLUCTUATION OF DRY OLIVE PRODUCTION IN THE *SKHIRA* DELEGATION.

Year	1995	2000	2005	2010	2015	2020
Production (tons)	870	3 215	2.102	5 346	3 308	3 934

(Sources: CRDA 2020a & 2020b, Author's Field Work)

Faced with these production constraints of dry olive cultivation, farmers have since the early 2000s turned to irrigation, taking advantage of the political and economic context which has encouraged farmers to increase the productivity of olives and olive oil (Chiab 2019). Twenty four years later, most of the crops that made up *Skhira's* agricultural "success story" have seen their production plummet from year to year (Table 7).

TABLE 7:
EVOLUTION OF PRODUCTION AND AVERAGE YIELD OF SOME IRRIGATED VEGETABLE CROPS IN SKHIRA BETWEEN 2000 AND 2020.

	Total production (tons)		**Average Yield (tons/ha)**	
Type	**2000**	**2020**	**2000**	**2020**
Tomato	5 119	16 247	28.6	32.3
Pepper	11 240	2 477	11.4	6.5
Watermelon	56,237	17,862	46.4	35.3
Potato	76	295	15.2	16.4
Other vegetables	2 808	13,782	11.9	14.6
Total / Average	**75,481**	**50,663**	**22.7**	**21.02**

(Sources: CRDA 2000, 2020b & 2021, Author's Field Work)

Indeed, total vegetable production of irrigated crops fell by more than 24,818 tons between 2000 and 2020. This overall decline is even greater in some crops such as watermelon and melon, which saw their production drop from 56,237 tons to only 17,862 tons during the same period. Only tomatoes experienced an increase in their production from 5,119 tons to 16,247 tons. This general drop is explained, in addition to the problems of aquifers drawdown, by the rapid degradation of soil fertility and its rapid salinization following the practice of intensive irrigation. This is, moreover, confirmed by the general decline in yields per hectare of these products. Watermelon and melon, for example, which are very sensitive to salt, saw their average annual yield drop between 2000 and 2020 from 46.4 tons/ha to 35.3 tons/ha. Problems of marketing these products have amplified their difficulties. This is probably the reason why the tomatoes production has increased since they are easily processed into canned foods, and well marketed in the internal and external market.

4.2.2.3 Still precarious production systems and uncertain family incomes

The new orientations of agro-pastoral production systems since the beginning of the 2000s, with in particular the decline in extensive livestock farming, the trend towards specialization in olive, fruit and vegetable farming and the use of irrigation to limit the harms of climatic hazards (Requier-Desjardins 2008, Gafrej 2016), were supposed to bring them more economic stability and greater sustainability. Twenty four years later, paradoxically these systems are economically very unstable and unviable since the breakdown of traditional pastoral and agro-pastoral systems, the transformation of agrarian structures and the organization of farms, the development of a market economy, the increased pressure on resources both quantitatively and qualitatively, the breakdown of traditional family structures, etc. resulted in a significant reduction in complementarity not only between families but also between territories and activities (Hanafi 2010).

This situation is often the cause of a serious family economies precariousness, since a large part of farmers, without substantial and constant incomes, have found themselves deprived of means to cope with climate change harms and to cope natural resources degradation. In addition, their productions, less and less competitive, were exposed to the market law which spared only the strongest of them. The latter are essentially among the large producers who have managed to acquire new land and have intensified their activity to obtain the maximum profit. Composed mainly of businessmen and liberal professions, these investors have taken advantage of the crisis in peasant agriculture since the beginning of the 1990s with the entry into force of the Agricultural Structural Adjustment Plan (PASA) and the Government Disengagement (Elloumi 2015). As for the small agro-pastoralists who plunged into a socio-economic crisis, they first of all abandoned, in part, their activities to seek employment elsewhere. Worse still, many of them were forced to sell their land at low prices (Daoud 2010). According to interviews with farmers, the average price of a hectare of uncultivated land has increased from around 500 TND in 2000 to more than 8000 TND in 2020[9].

Equipped with significant financial resources and supported by the regional authorities, the owners of large farms in *Skhira* were able to profit from their farms (Table 8). According to the estimates of the CRDA of *Sfax* and the CTV of *Skhira*, the average yield in olive trees (in tons per hectare) and the average income of the large farmers are more than three times what the small farmers in the region produce and earn. Factors that explain this variation include the difference between techniques and means of production used, density of trees planted and their varieties, techniques and schedule of irrigation, quantities and types inputs used, etc.

TABLE 8:
YIELD AND INCOME VARIATION OF OLIVE CROPS ACCORDING TO FARM'S TYPE IN SKHIRA REGION IN 2019

	Dry olive growing	Irrigated olive cultivation
Average production of small farm (tons/ha)	0.25	0.92
Average production of large farm (tons/ha)	0.52	2.10
Average income of small farm in 2020 (TND/ha)	262	966
Average income of large farm in 2020 (TND/ha)	624	2 520

(Source: CRDA 2020 & 2020a, Author's Field Work)

Moreover, the difference in yields and incomes also lies in the better position that large farmers have to negotiate the selling price, since they are, in most cases, producers-traders capable of controlling the entire economic chain and thus optimizing their expenses and earnings. In 2020, while the average price per kilo of olives sold locally was between 1 and 1,1 TND for small farmers, it was between 1,1 and 1,4 TND for large farmers (*Author's Field Work*, CRDA 2021). This explains the difference in average income per hectare between farms. It should also be noted that the figures presented in Table 8 only concern 2019, which was a pass agricultural year, but during bad agricultural years such as 2021, the incomes of small farmers is rudimentary or even non-existent.

V. CONCLUSION

It emerges from this analysis that the balance of the territorial dynamics initiated in the arid plains and hills of *Skhira* since the end of the 1990s, is more than mixed, since this Land use dynamics has not taken into account the limits of natural resources availability, natural hazards, and above all, climate change. Originally considered as a tool for the private appropriation of collective land and for improving the living conditions of *Skhira's* peasants, the quick development of olive cultivation turned into an opportunity to develop the earnings of a group of speculators unconcerned about resources fragility. It is for this purpose, for example, that irrigation has moved from relatively rational governance in the hands of local authorities and small farmers to a management that is almost monopolized by these private investors. Irrigation, which was then supposed to reduce economic inequalities in this region, has become a factor of disparity between social categories (Elloumi 2009).

In order to overcome their handicaps and maintain their farming activities, small farmers are often forced to go into debt with banks and/or input retailers or agri-food companies, which leads them to increased dependency and impoverishment (Requier-Desjardins 2008, 2010; Yousfi 2020). This indebtedness is all the more serious for them as the annual fluctuation of yields and selling prices do not help them to get rid of it, especially in the absence of an effective mechanism to cover the

[9] In 2000, a Tunisian dinar (TND) was worth about 0.665 euros, while in 2020 it was worth about 0.306 euros.

risks of climatic and economic hazards. As a result, the agricultural activity that was supposed to boost their economies and improve their living conditions has turned into a burden, sometimes dragging this population dramatically into precariousness. The result is an accentuation of the rural exodus, especially of young graduates, to seek employment in big cities such as *Sfax, Gabès* and *Tunis*. At the imadat[10] of *Noual*, the migration balance was negative by -9.5% between 2004 and 2014 as it registered a departure of 138 young people in 10 years (INS 2004, 2014).

The crisis in these marginal sectors in an already marginal delegation is accentuated by an unfavorable trend in agricultural prices, by the fragmentation of properties and increasingly restricted access to land, sold to speculators at low prices, by a small farmers exclusion from financing and credit system and finally by the inefficiency of the support services. The current economic uncertainty that hangs over the country, affecting all social categories more closely, and in particular small farmers, implies that all possible environmental and rural social events in *Skhira* are to be expected. Let us remember here that neighboring regions with similar conditions, such as *Sidi Bouzid*, experienced the same situation in the 2000s, which led to the outbreak of the 2011 revolution. Today, despite the multiplication and the diversity of strategies and programs[11] implemented by the central and regional authorities, it seems that their effect is not immediate, whereas the environmental and economic crises are. Moreover, it seems that most of these programs are "tailor-made" to favor large farms more (Bessaoud and Montaigne 2009, Palluault & Romagny 2009b, Bouarfa *et al.* 2020).

Furthermore, this agricultural intensification and the monopolization of resources accentuate the threat of desertification. Past experiences in neighboring regions have often led to the same result and have cost the Government and international funds enormous sums to limit its consequences, the cases of *Menzel Habib, El Hamma, Bled Ségui, Sidi Makhlouf* , etc. (Floret and Pontanier 1982, Auclair *et al.* 1996, Hanafi 2000, Jauffret 2001). This environmental result is accompanied by a deterioration of the population living conditions despite their continuous attempts to solve their economic difficulties.

It is therefore important today that the central and regional authorities pay more attention to the implementation of a planning and development policy that is really oriented towards the environment and the peasant society of *Skhira* and the other arid regions, which are more affected by the impacts of climate change. This policy must be spread over several periods ranging from the immediate to the long-term and must really target farmers and their environment from a perspective of sustainability. To this end, Tunisia has acquired a number of achievements in this area[12] that should be implemented. This sustainability must affect the environmental (soil, water and biodiversity conservation) and human aspects, in particular with sustainable agriculture that reconciles the environment, the economy and society (Massin *et al.* 2016, Benoit 2017) and which favors the peasants and small farmers of today and tomorrow within the framework of a social and solidarity economy capable of creating employment and wealth and of conserving a share of resources for future generations.

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[10] *The Imadat* is the smallest administrative subdivision in Tunisia. It is generally a small urban (city) or rural area (village, *dachra, douar*) with the surrounding land.

[11] In order to solve the problems related to the crisis of agriculture and peasantry in Tunisia, the Government has implemented several programs which have affected, in part, the *Skhira* region. Examples include the National Climate Change Strategy (NCCS), which has been implemented by MARHP and GIZ since 2012, the Agricultural Land Management and Conservation Strategy (ACTA) developed by MARHP in 2017 and which includes CES actions geared towards 'the development of sustainable and climate-resilient agriculture by 2050' (MARHP, 2017) and the National Action Program to Combat Desertification 2018-2030 (Tounsi 2020). On a local scale, the *Sfax* CRDA has already implemented since 2016 a program that has aimed to develop more than 1500 ha in *Skhira* with a total cost of around 1,285,000 TND (CRDA, 2020b, 2021). The actions undertaken mainly concerned the control of groundwater (salinity, piezometric level, exploitation, etc.), the improvement of water retention techniques, the extension and the promotion of water economy.

[12] According to the report of the General Direction of Sustainable Development - DGDD (2011), the achievements of Tunisia in terms of sustainable development have mainly concerned the environmental pillar with the extension of organic agriculture over more than 200,000 ha, the extension of conservation agriculture over about 10,000 ha, the intensification of water saving programs that reach more than 80% of irrigated areas, the development of alternative resources such as the extension of the use of non-conventional water, the desalination of water in the South and the use of treated wastewater in irrigation, the intensification of environmental protection and natural resource management programs (CES strategies), the setting up of several pilot projects to exploit waste and the development of renewable energies, including solar energy. On a social scale, these achievements have included, inter alia, the establishment of sustainable consumption and production, the promotion of a well-functioning social economy, the strengthening of social equity and the fight against regional disparities, etc.

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Effect of Untreated and Alkaline Treated Melon Husk Diets on the Hematological Indices and Blood Chemistry of Broilers, Metabolic Trial, and Muscle PH

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Abstract— *The high cost of feed ingredients is one of the most significant hurdles to livestock production in underdeveloped countries. This study examined the effect of untreated and alkaline treated melon husk diets on the hematological indices and blood chemistry, metabolic trial, and muscle pH of broilers. The five diets contained a control diet of 0% level of inclusion of melon husk, 10% and 20% of untreated melon husk; 10% and 20% level of inclusion of Alkaline treated melon husk as a replacement for maize. The value obtained for the single effect of level of inclusion for ether extract and the nitrogen-free extract was significantly affected (P < 0.05). However, the highest value of the interaction for feed intake was recorded in the treated diet while the control diet recorded the highest value. The pH values obtained two hours after slaughtering for control, untreated, and treated diets were found to be significantly affected (P < 0.05), and the pH value obtained four hours after slaughtering was not significantly affected. Therefore, blood parameters were found to be superior in the diet containing melon husk to control diet while the muscle pH is not adversely affected.*

Keywords— blood chemistry, hematological, melon husk, metabolic trial, muscle pH.

I. INTRODUCTION

The high cost of feed ingredients is one of the most significant hurdles to livestock production in underdeveloped countries. Unfortunately, nearly all agricultural by-products and plant protein sources have high fiber and anti-nutritional elements that must be removed using particular processing processes in order for them to have optimal nutritional value. According to many researchers [1, 6, 3, 2, and 5], water soaking, autoclaving, and cooking in boiling water, steaming, radiation, and acid or alkaline treatment are among the most common processing procedures used to improve nutritive value. As a result, efforts should be focused on lowering feed costs, which account for roughly 70% of total production costs [7]. Alternative feed additives for chicken have been evaluated by researchers in a concentrated effort [8]. As a result, such alternatives should be less expensive than traditional component sources, have comparable nutritional value, and be widely available. In the search for cheaper feed components, researchers are looking into replacing traditional feedstuffs with less expensive alternatives in the formulation of chicken feed.

Due to the caustic nature of sodium hydroxide and its expensive cost, however, organic waste ash has been used as an alternate source of alkali for the treatment of crop residues. It has been explored whether cocoa pod ash may be used as an alkali for the treatment of cocoa husk [9]. Although, a previous study confirmed that melon husk that has been alkaline treated can be utilized to substitute maize for up to 20% without affecting the birds' performance or carcass characteristics

[4]. This study, therefore, aims at investigating the effect of untreated and alkaline treated melon husk diets on the hematological indices and blood chemistry, metabolic trial, and muscle pH of the broilers.

II. RESEARCH METHODS

The study was placed at the University of Agriculture poultry/feed mill unit at Kotopo, Abeokuta, Odeda Local Government, Ogun State, Nigeria. 180 unsexed day-old broiler chicks were bought from a commercial hatchery in Abeokuta and were brooded for a week before the experiment began (Anak 2002 strain). The birds were brooded together on a deep litter floor and fed the control food from day one to day seven. The birds were randomly divided into 5 groups of 36 birds per treatment and 12 birds per replicate at the end of the 7-day brooding period. Each set of 36 birds was fed five (5) different experimental diets, one of which included melon husk, which was purchased from the University of Agriculture Abeokuta's Research Farm. The Husk was sun-dried for 5 days before being alkaline treated. Four kilograms of sun-dried melon Husk were burned to ash and one kilogram of ash was delivered. 300 grams of ash were well mixed with 3 kilograms of ground melon husk Sand that had been soaked in 10 liters of water for seven days. The solution was stirred three times a day, or every eight hours. The alkaline treated melon husk was drained to eliminate water and sun-dried for 5 days at the conclusion of the 7th day. The alkaline-treated melon husk samples were taken to the lab for proximate analysis. Both sun-dried alkaline treated melon husk and untreated melon husk were utilized to substitute maize in the diet at 10% and 20% untreated, 10% and 20% treated, respectively. Water was provided ad libitum and the diets were made to be isonitrogenous and isocaloric. Each replicate's feed consumption and live weight increase were measured on a weekly basis. As a result, a weekly record was kept. Feed intake was estimated by subtracting leftover feed from the amount of feed provided.

The feed conversion ratio was calculated by dividing the amount of food consumed by the amount of weight gained. 15 birds (3 birds per treatment) were randomly selected for carcass analysis at the end of the seventh week. The birds were individually weighed (live weight), slaughtered, and eviscerated. Slaughtering was accomplished by severing the jugular vein, whereas evisceration was accomplished by cutting through the abdomen region and removing the internal organs, which were then weighed on a delicate scale. The dressed weight was taken, as well as the weight of internal organs such as the gizzard, liver, and heart, as well as the length and weight of the small, large, and caeca intestines. In a complete randomized design, statistical analysis was performed using the analysis of variance using a 2 X 3 factorial arrangement model, and the separation of significant differences among the means was performed using the computer application Minitab release 7.1.

III. RESULTS AND DISCUSSION

3.1 Hematology and Blood Chemistry

The result of hematological indices and blood chemistry are shown in Tables 1 and 2 as influenced by the level of inclusion, treatment, and interaction of the two factors. The value obtained for the single effect of level of inclusion was found to be significantly affected ($P < 0.05$) for all the parameters observed (Table 1), leading to an increase in the concentration of all the parameters observed except the white blood cell count where the concentration was found to be reduced. The effect of treatment did not significantly affect the diet. However, the white blood cell was found to be increased as a result of the treatment (Table 1). The interaction of the two factors (Table 2) showed that the result obtained for TP, Albumin, Globulin, Urea, Creatinine, Packed Cell Volume, hemoglobin, and Red blood cell was not significantly affected ($P > 0.05$) by the diet. The highest value of TP of 55.00 was recorded in both the 10% level of inclusion of untreated diet the and 20% level of inclusion of treated diet. This trend was also observed in the values obtained for albumin, globulin, urea, creatinine, packed cell volume, hemoglobin, red blood, and white blood cell. The control diet recorded the least values for all the parameters observed except the white blood count. It could also be observed that most of the values obtained for all the parameters were higher in the untreated diet at both levels of inclusion than values obtained at both levels of inclusion in the treated diet. However, in the case of white blood count, the highest value of 6600 m1/mm3 was recorded in the treated diet at both levels of inclusion while the least value of 6000 m1/mm3 was recorded in the untreated diet at a 10% level of inclusion.

Furthermore, all the values obtained for white blood cell counts in the experiment were found to be significantly affected ($P < 0.05$) by the diet.

TABLE 1
SINGLE EFFECT OF LEVEL OF INCLUSION AND TREATMENT ON HEMATOLOGICAL INDICES AND BLOOD CHEMISTRY OF BROILER CHICKENS FED WITH UNTREATED AND ALKALINE TREATED MELON HUSK DIET

Parameters	Effect of level inclusion				Effect of treatment		
	Level of Inclusion (%)						
	0	10	20	SEM	Untreated	Treated	SEM
Total Protein (mg/d1)	47.67^{b}	53.00^{a}	54.33^{a}	0.92	52.11	51.22	1.35
Albumin (mg/d1)	28.67^{b}	32.17^{a}	32.83^{a}	0.59	31.44	31.00	0.84
Globulin (mg/d1)	18.67^{b}	20.83^{a}	21.50^{a}	0.42	20.56	20.11	0.58
Urea (mg/1)	24.00^{b}	27.17^{a}	27.83^{a}	0.37	26.33	26.33	0.67
Creatinine (mg/d1)	1.07^{b}	1.23^{a}	1.28^{a}	0.22	1.19	1.20	0.03
Packed cell volume (%)	29.67^{b}	32.67^{ab}	32.67^{a}	0.59	32.33	31.67	0.85
Hemoglobin (mg/d1)	9.09^{b}	10.92^{a}	11.27^{a}	0.17	10.81	10.58	0.29
Red blood cell (ml/mm^3)	3.37^{b}	3.72^{ab}	3.72^{a}	0.59	3.67	3.57	0.09
White blood cell (ml/mm^3)	6400.00^{a}	6000.00^{b}	6600.00^{a}	73.00	6333.30	6533.30	70.50

^{abc} ***Means in the same row are not significantly different (P > 0.05)***

TABLE 2
INTERACTION EFFECT ON HEMATOLOGICAL INDICES AND BLOOD CHEMISTRY OF BROILER CHICKENS FED WITH UNTREATED AND ALKALINE TREATED MELON HUSK DIET

Parameters	Untreated melon husk				Treated melon husk		
	Level of Inclusion (%)						
	0	10	20	0	10	20	SEM
Total Protein (mg/d1)	47.67	55.00	53.67	47.87	51.00	55.00	1.36
Albumin (mg/d1)	28.67	33.33	32.33	28.95	31.00	33.33	0.85
Globulin (mg/d1)	18.67	21.67	21.33	18.84	20.00	21.57	0.58
Urea (mg/1)	24.00	27.67	27.33	24.10	26.67	28.23	0.73
Creatinine (mg/d1)	1.07	1.27	1.23	1.17	1.20	1.33	0.06
Packed cell volume (%)	29.67	34.00	33.33	29.78	31.33	34.00	0.59
Hemoglobin (mg/d1)	9.90	11.40	11.13	9.95	10.43	11.40	0.19
Red blood cell (ml/mm^3)	3.37	3.90	3.73	3.57	3.53	3.80	0.06
White blood cell (ml/mm^3)	6400.00^{a}	6000.00^{b}	6600.00^{a}	6400.00^{a}	6600^{a}	6600^{a}	73.20

3.2 Metabolic Trials

The mean value obtained for the metabolic trials as influenced by the two factors and their interaction is shown in Table 3. The result indicated that the value obtained for the single effect of level of inclusion for ether extract and nitrogen-free extract were significantly affected ($P < 0.05$). Furthermore, the value obtained for feed intake increased as the level of extract, crude fiber, and nitrogen-free extract decreased as the level of inclusion increased. However, the value obtained for crude protein retention increased as the level of inclusion increased though it was found not to be significant. However, the result of the single effect of treatment on all the parameters showed that the values obtained for all the parameters observed were decreased as a result of the treatment except for the value obtained for feed intake and dropping which increases as a result of the treatment. The interaction of the two factors (Table 4) showed that the highest value for feed intake of 1 00.69 g per bird was recorded in the treated diet while the control diet recorded the highest value of dry matter digestibility (81.70%). The highest value of 81.58% crude protein retention was recorded in the control diet while the lowest value of 73.59% was recorded in the treated diet at a 10% level of inclusion, it could also be seen that the values obtained for the crude protein digestibility in the untreated diet were higher than the values obtained in. the treated diet.

The highest value of 98.95% obtained for ether extract was recorded in the untreated diet at a 10% level of inclusion while the lowest value of 96.98% was recorded in the 20% level of inclusion of the treated diet. However, the highest value recorded for both crude fiber and nitrogen-free extract 65.71% and 46,27% respectively was found in the control diet. Furthermore, it could be seen that while the value obtained for crude fiber in the 10% level of inclusion of the treated diet 60.80% was higher than the corresponding10% level of inclusion of untreated diet 48. 69%, the value obtained for nitrogen-free extract at the same 10% level of inclusion of untreated diet 3 5.40% was higher than that of treated diet at the same 1% level of inclusion 32.84%. There was no significant effect (P > 0.05) on all the parameters observed as a result of the interaction between the two factors.

TABLE 3
SINGLE EFFECT OF LEVEL OF INCLUSION AND TREATMENT ON METABOLIC TRIALS OF BROILER CHICKENS FED WITH UNTREATED AND ALKALINE TREATED MELON HUSK DIET

Parameters	Effect of Level of Inclusion				Effect of Treatment		
	Level of Inclusion (%)						
	0	10	20	SEM	Untreated	Treated	SEM
Feed intake g/bird	89.58	81.61	90.61`	3.97	81.51	90.55	2.79
Droppings g/bird	10.97	14.72	20.72	1.44	11.20	15.67	1.14
Dry matter digestibility (%)	81.58	72.25	75.32	1.97	78.74	77.36	1.83
Crude protein digestibility (%)	90.55	88.33	87.14	0.48	88.11	86.47	0.66
Ether extract (%)	98.55[a]	98.57[a]	97.49[b]	0.13	98.48	97.93	0.19
Crude fibre (%)	66.49[a]	54.75[ab]	41.16[b]	2.38	55.19	53.07	4.85
Nitrogen free extract (%)	47.07[a]	34.12[ab]	22.79[b]	4.90	37.72	31.60	6.01

[abc]***Means in the same row are not significantly different (P > 0.05)***

TABLE 4
INTERACTION EFFECT ON METABOLIC TRIALS OF BROILER CHICKEN FED WITH UNTREATED AND ALKALINE TREATED MELON HUSK DIETS

Parameters	Untreated melon husk					Treated melon husk	
	Level of Inclusion (%)						
	0	10	20	0	10	20	SEM
Feed intake g/bird	89.58	81.61	83.61`	89.90	95.50	100.69	5.63
Droppings g/bird	10.97	14.72	20.93	10.99	18.80	20.91	7.51
Dry matter digestibility (%)	81.58	80.90	73.73	81.70	73.59	76.92	2.08
Crude protein digestibility (%)	92.55	91.70	88.66	91.67	89.34	89.66	1.12
Ether extract (%)	98.49	98.95	98.01	98.69	98.18	96.98	0.27
Crude fibre (%)	65.71	48.69	51.17	65.79	60.80	31.15	6.02
Nitrogen free extract (%)	46.27	35.40	31.47	46.37	32.84	14.10	5.42

3.3 Muscle PH

Tables 5 and 6 show the result of the effect of the level of inclusion, treatment, and the interaction of the two factors on the thigh muscle pH of the bird at the expiration of the experiment. The result indicated that as the level of inclusion increased, the pH values obtained also increased. Furthermore, the values obtained two and four hours after slaughtering were found to be significantly affected ($P > 0.05$) thus slightly increasing the pH. The result of the single effect of treatment shows that the pH value obtained at initial, two, and four hours after slaughtering, were higher in the treated than in the untreated diet. The interaction of the two factors showed that the highest pH of 5.78 was recorded four hours after slaughtering in the 20% level of inclusion of the treated diet while the lowest pH of 5.29 was recorded as initial in the 10% level of inclusion of untreated diet. Furthermore, all the pH values obtained two hours after slaughtering for control, untreated, and treated diets were found to be significantly affected ($P < 0.05$). Whereas the pH value obtained for all the experimental diets four hours after slaughtering was not significantly affected.

TABLE 5
SINGLE EFFECT OF LEVEL OF INCLUSION AND TREATMENT ON THE pH OF THE THIGH MUSCLE OF CHICKEN FED UNTREATED AND ALKALINE TREATED MELON HUSK

Hours	Effect of Level of Inclusion				Effect of Treatment		
	Level of Inclusion (%)						
	0	10	20	SEM	Untreated	Treated	SEM
0	5.39	5.43	5.59	0.05	5.38	5.57	0.03
2	5.66	5.51	5.62	0.04	5.52	5.68	0.03
4	5.51ab	5.42ab	5.66a	0.04	5.51	5.55	0.03

a,b,c means in the same row with different superscripts differ significantly (P < 0.05)

TABLE 6
INTERACTION OF EFFECT ON THE pH OF THE THIGH MUSCLE OF BROILER CHICKEN FED WITH UNTREATED AND ALKALINE TREATED MELON HUSK DIET

Hours	Untreated Melon Husk			Treatment Melon Husk			
	Level of Inclusion (%)						
	0	10	20	0	10	20	SEM
0	5.39	5.29	5.44	5.45	5.57	5.76	0.10
2	5.66a	5.31b	5.58a	5.80a	5.71a	5.66a	0.04
4	5.51	5.48	5.55	5.71	5.37	5.78	0.07

a,b,c means in the same row with different superscripts differ significantly (P < 0.05)

IV. CONCLUSION

The results showed that the blood parameters were found to be superior in the diet containing melon husk to the control diet while the muscle pH is not adversely affected. Albumin, globulin, urea, creatinine, packed cell volume, hemoglobin, red blood, and white blood cell levels all followed this pattern. Except for the white blood count, the control diet had the lowest values for all of the parameters measured. It was also noted that the majority of the values obtained for all parameters were higher in the untreated diet at both levels of inclusion than the values obtained in the treated diet at both levels of inclusion. Performance in terms of feed intake and weight gain is as good as in the control diet where there is no melon husk. It is also observed that the effect of treatment greatly increases feed intake in the birds. Conclusively, all the pH values obtained two hours after slaughtering for control, untreated, and treated diets were found to be significantly affected ($P < 0.05$). Whereas the pH value obtained for all the experimental diets at four hours after slaughtering was not significantly affected. From this study, it has been shown that Alkaline treated melon husk can be used to replace maize up to a 20% level of inclusion without adverse effects on performance, hematology, and blood chemistry as well as on the muscle pH of the birds.

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The Effect of Vermicompost of *Perionyx excavatus* to Growth of *Brassica integrifolia* in hydroponic solutions

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Abstract**—** *This study was conducted to evaluate the effect of vermicompost on the growth of Brassica integrifolia. The experiment was arranged in a completely randomized design with hydroponic solutions supplemented with inorganic nutrients and vermicompost with the ratios of 100:0, 75:25, 50:50, 25:75, 0:100, respectively. The agronomic, microbiological criteria and the change of the hydroponic solution were collected and processed to evaluate the effectiveness. The results showed that the treatment with 100% vermicompost solution gave the best agronomic criteria in the studied treatments and was equivalent to the control treatment. Microbiological density conformed to quality standards TCVN 6505-2:1999 on food hygiene and safety. After 30 days to stabilize the nutrient solution, the stability indicators of the hydroponic solution showed that the vermicompost solution (100%) could be used as a substitute for the inorganic nutrient solution.*

Keywords**— *Brassica integrifolia, hydroponic method, Perionyx excavatus, vermicompost.***

I. INTRODUCTION

Green vegetables are an indispensable food source in human's daily life. However, the problem of environmental pollution makes the quality of vegetables not to be guaranteed, while the demand for safe vegetables of people is increasing. With the desire to apply simple techniques for safe vegetable products on a family scale, the hydroponic vegetable method is very suitable with the following advantages: growing a variety of off-season vegetables, without having to work the soil, weeding, no need to use pesticides, the product is completely clean and homogenous... so growing hydroponic vegetable is more and more widely used in modern life today [1].

Earthworms (*Perionyx excavatus*) are commonly used in waste metabolism in the Philippines, Australia and other countries [2]. Currently, earthworm (*Perionyx excavatus*) is increasingly being applied in many fields such as food, medicine, fertilizer. Earthworm manure helps to provide nutrients to plants, increase the germination rate of seeds, promote root development, increase plant weight, contain beneficial microorganisms that contribute to resist plant's disease. In addition, it also restores the fertility of the soil, helping the soil to be loose and aerated. Earthworm manure can be packed and transported in large quantities easily without any loss of quality, and at the same time do not affect the air environment because they have the earthy odor [3]. In addition, earthworms play an important role in organic waste management [4]. The use of vermicompost as fertilizer has been quite widespread, but combined with hydroponic methods is still very little. The application of earthworm manure as vermicompost into hydroponics is a solution to limit the use of chemical nitrogen fertilizers, towards an absolutely safe vegetable growing technique.

II. MATERIAL AND METHODS / EXPERIMENTAL DETAILS / METHODOLOGY

2.1 Material

Kitchen waste and manure were used as food for the earthworms in a ratio of 1:1 volume:volume. Both kitchen waste and manure were precomposted for 21 days before being used as food for the earthworms. 1 kg of vermicompost + 1 liter of water, put in a bag to soak in an air tank overnight to get cheese clot settled for 30 days and got - vermicomposting solution

- Seeds: *Brassica integrifolia* seeds of Trang Nong Co., ltd.

Substratum: coconut fiber is soaked in water, every 12 hours, the water is drained, soaked for 4 days to reduce tannin. Then take it out to dry.

Styrofoam containers are covered with black nylon inside to reduce light intensity and avoid leakage of nutrient solution to the outside. Styrofoam lid is perforated with a plastic pipe (with the same diameter as the mouth of a plastic gabion), punched 6 holes on each foam box lid. Plastic baskets are made with small holes so that when the vegetables grow, they can root out and keep the substrate moist, then stuff the coconut fiber medium into the plastic basket and place it in the pre-punched holes on the lid of the styrofoam box.

Seeds: soak in water for 3-4 hours, then take out to drain, incubate for one night and then sow seeds in a nursery tray with available coir mixed with rice husk ash, sow 3-4 seeds in each tray. After sowing the seeds, water a little and place in a cool place with light sunshine. When *Brassica integrifolia* has real leaves, sow 2-3 seeds in a plastic basket at a depth of about 1cm. Place the lid of the container with the seeded plastic basket on top of the styrofoam container containing the nutrient solution, so that the bottom of the basket is submerged in the solution by 1-2cm

2.2 Experimental details

2.2.1 Arrangement treatments

The experiment was arranged in a completely randomized design consisting of 5 treatments with three replications, each replicate consisted of a styrofoam bin with six sprouted vegetable plants. the treatments are arranged according to Table 1.

TABLE 1
EXPERIMENTAL ARRANGEMENT

Treatment	Inorganic nutrition (%)	Vermicomposting of *Perionyx excavatus* manure solution (%)
Treatment 1(Control)	100	0
Treatment 2	75	25
Treatment 3	50	50
Treatment 4	25	75
Treatment 5	0	100

2.3 Methodology

Nutrient solution mixed with the ratio for each treatment, each treatment 12 liters of solution. The nutrient solution is put in a styrofoam container and left for 30 days to start growing vegetables.

Harvesting *Brassica integrifolia* after 30 days of planting. Harvesting by removing the plastic basket from the styrofoam, removing the plastic basket and growing medium from the vegetables. Cut across the stem to get the product which is the stem and leaves of *Brassica integrifolia*.

2.4 Criteria follow-up assessment

Hydroponic environment: record the criteria every 5 days, starting from the time of growing vegetables to harvesting, including the following criteria: pH, protein content in the hydroponic solution when harvesting *Brassica integrifolia*. (Kjeldahl method)

Agronomic criteria: record the criteria once every 5 days, all *Brassica integrifolia*, starting from the time *Brassica integrifolia* has true leaves for harvesting, including the following criteria: plant height (cm), leaf length (cm), leaf width (cm), root length (cm), number of leaves (leaves/plant).

Harvesting: including the following criteria: total weight (g), trade weight (g); Trade weight/total weight ratio (%)= (trade weight / aggregate weight) x 100.

Determination of density of heat-resistant *Coliforms* and *E. coli* present in vegetables by MPN method.

2.5 Data processing

The data was entered and processed by excel software. The program Minitab 16.0 is used for statistical analysis.

III. RESULTS AND DISCUSSION

3.1 Effect of vermicompost (*Perionyx excavatus*) on the height of *Brassica integrifolia*

The results of Table 2 show that at the time of 10 days after planting, the height of Treatment 5 (100% vermicompost) (10.23 cm) was not significantly different from that of Treatment 1 (100% inorganic nutrient solution) (11.87 cm). Treatment 5 with the result was better than Treatment 2, Treatment 3, Treatment 4 and the difference was statistically significant (P<0.05).

TABLE 2
HEIGHT OF *Brassica integrifolia* IN ALL TREATMENTS

Treatments	Height (cm) of *Brassica integrifolia* in days after planting						
	0 day	5 days	10 days	15 days	20 days	25 days	30 days
Treatment 1 (Control)	1,65a	5,61a	11,87a	21,26a	24,73a	30,56a	37,16a
Treatment 2	1,72a	2,45b	3,16b	4,23b	5,32b	6,27b	7,64b
Treatment 3	1,65a	2,92b	4,07b	5,67b	7,55b	9,84b	12,17b
Treatment 4	1,68a	2,66b	3,7b	4,44b	5,29b	6,52b	8,12b
Treatment 5	1,17a	4,67ab	10,25a	19,35a	22,86a	26,03a	30,72a
Average	0,13	0,93	1,05	2,04	1,85	2,32	3,38
Cv (%)	8,45	25,44	15,87	18,59	14,05	14,63	17,62
P	0,948	0,007	0,00	0,00	0,00	0,00	0,00

Note: Mean values in column followed by different letters are statistically significant differences (P < 0.05)

This result showed that *Brassica integrifolia* can adapt to hydroponic environment with 100% vermicompost and grow equivalent to Treatment 1. Particularly, the height (*Brassica integrifolia*) of Treatment 2 was the lowest (2.45 cm) among the treatments. At the time of 20 days after planting, the *Brassica integrifolia* in Treatment 2, Treatment 3, Treatment 4 grew very slowly, after 10 days from the time of 10 days after planting, the height of *Brassica integrifolia* in Treatment 2, Treatment 3 and Treatment 4 only increased respectively by 2.16 cm, 3.48 cm and 1.59 cm; while the height of *Brassica integrifolia* in Treatment 5 (12.60 cm) and Treatment 1 (12.87 cm) were still developed well.

At the time of harvesting 30 days after planting, the height of in Treatment 5 (30.72 cm) was not statistically different from that of Treatment 1 (37.16 cm) and was significantly higher than that of Treatment 2, Treatment 3, Treatment 4. the growth in height of in *Brassica integrifolia* Treatment 2, Treatment 3, and Treatment 4 were quite slow, with the average height in Treatment 2 (0.19cm/day), Treatment 3 (0.35cm/day), and Treatment 4 (0.21cm/day). While the height growth in Treatment 5 was 0.98 cm/day, and this growth was not different from the control treatment (1.18 cm/day) (table 2).

Tripathi *et al.* [5] showed that unlike NPK levels vermicompost had no effect on plant height of Pak choi but it had significantly increased the leaf number. Vermicompost at 15 t/ha produced highest number of leaf but not significantly different from other levels of vermicompost. But at 45 DAT vermicompost had significantly increase the leaf number per plant

3.2 Effect of vermicompost (*Perionyx excavatus*) on the number of leaves of *Brassica Integrifolia*

Table 3 shows the results in 10 days after planting, the number of leaves in Treatment 5 (100% vermicompost of *Perionyx excavatus*) reached 7.62 leaves/plant, which is higher differently with statistical mean than Treatment 2, Treatment 3, Treatment 4 (P < 0.05), however leaves of *Brassica Integrifolia* in Treatment 5 and Treatment 1 (Control) have the similiar result in statistical mean.

The growth rate of the tree is similar to the height of *Brassica Integrifolia*, by the time of 30 days after planting, the number of leaves in Treatment 2 increased from 3 leaves/plant to 5.67 leaves/plant (average increase of 0.09 leaves/plant/day), Treatment 3 increased from 3 leaves/plant to 6.56 leaves/plant (average increase of 0.11 leaves/plant/day), Treatment 4 leaf count increased from 3 leaves/plant to 5.78 leaves/plant (average increase of 0.09 leaves/plant/day). The growth rate of leaf number of Treatment 2, Treatment 3, Treatment 4 was lower and different from that of Treatment 5 (average increase of 0.29 leaves/plant/day) ($P < 0.05$).

The number of leaves on a plant also plays an important role in the weight of the plant because leaves are the main organ for photosynthesis.

TABLE 3
NUMBER OF LEAVES OF *Brassica integrifolia* IN TREATMENTS

Treatment	Number of leaf (leaf / tree) of *Brassica Integrifolia* in the days after planting						
	0 day	5 days	10 days	15 days	20 days	25 days	30 days
Treatment 1- Control	3	5,21a	7,89a	9,28a	10,68a	12,52a	14,61a
Treatment 2	3	3,22b	4,22b	4,39c	4,84c	5,27c	5,67c
Treatment 3	3	3,4b	4,19b	4,67c	4,94c	6,29c	6,56c
Treatment 4	3	3,15b	4,18b	4,22c	4,89c	5,28c	5,78c
Treatment 5	3	5,39a	7,62a	8,77b	9,22b	10,12b	11,56b
Average		0,38	0,32	0,17	0,36	0,50	0,52
Cv (%)		9,22	5,77	2,74	5,26	6,36	5,86
P value		0,00	0,00	0,00	0,00	0,00	0,00

**Note: Mean values in column followed by different letters are statistically significant differences (P < 0.05)*

Tripathi *et al.*[5] noted that chemical fertilizers release nutrients rapidly and plant utilizes them quickly resulting in significant change in growth and development of a plant. Hence they are more efficient than vermicompost in short run. But in long run or after one month the effects of vermicompost are more favorable than chemical fertilizers. Chemical fertilizers (NPK) were efficient than the organic manures in the short run [14]. In other leafy crops such as cabbage maximum number of loose leaf was found when organic and chemical fertilizers were applied in combination [15,16].

3.3 Effect of vermicompost on the size of leaves at harvest *Brassica integrifolia*

By the time of 10 days after planting, the width of *Brassica integrifolia* leaves in Treatment 1 (Control) and Treatment 5 (100% vermicompost of *Perionyx excavatus*) was not statistically significant. However, the leaf length of Treatment 5 (2.05 cm) was shorter and different from the leaf length in Treatment 1 (5.1cm), while in Treatment 2, Treatment 3 and Treatment 4 has not yet developed the sixth leaf. (Table 4)

At the time of 25 days after planting, Treatment 3 had just started to develop the sixth leaf with leaf length (4.22 cm) and leaf width (0.62cm) much lower than that of Treatment 1 (Control) and Treatment 5 ($P<0.05$). At the time of harvest (30 days after planting), the largest leaf length of *Brassica integrifolia* was found in Treatment1. Leaf length and leaf width were lowest in Treatmnet 2 (1.5 cm and 0.62 cm), although Treatment 3 and Treatment 4 had leaf length and leaf width better than Treatment 2, but there was no difference statistically between these 3 Treatment.

TABLE 4
THE SIZE OF *Brassica integrifolia* LEAVES AT HARVEST IN ALL TREATMENTS

Treatments	The length of leaf (cm)	The width of leaf (cm)
Treatment 1- Control	11,84a	4,08a
Treatment 2	1,50b	0,63b
Treatment 3	6,03ab	1,53b
Treatment 4	2,14b	0,62b
Treatment 5	9,61a	4,33a
Average	2,21	0,75
Cv (%)	35,56	33,42
P	0,001	0,00

****Note: Mean values in column followed by different letters are statistically significant differences (P < 0.05)***

3.4 Effect of vermicompost on root length of *Brassica integrifolia*

At the time of harvest, the root length of *Brassica integrifolia* roots reached 16.38 cm in Treatment 5, this value was not statistically different from that in the Treatment 1 (Control) (18.68 cm). Treatment 2, Treatment 3 and Treatment 4 had root lengths of 7.83 cm, 3.35 cm and 4.99 cm, respectively, 2.4 to 5.5 times lower than that of the control Treatment 1 (P<0.05) and The results of Treatment 5 and Treatment 1 root lengths were not statistically significant. (Table 5)

TABLE 5
ROOT LENGTH AT HARVEST OF *Brassica integrifolia* IN ALL TREATMENTS

Treatment	Root length (cm)
Treatment 1- Control	18,678a
Treatment 2	7,825b
Treatment 3	3,349b
Treatment 4	4,99b
Treatment 5	16,358a
Average	1,946
Cv (%)	19,004
P	0,00

Note: Mean valuesin column followed by different letters are statistically significant differences (P < 0.05)

Tripathi et al. [5] found vermicompost significantly increased the root length of *Pak choi*. Maximum root length was obtained in vermicompost at 15 t/ ha. However, vermicompost at 10 t/ha and 5 t/ha was at par with control. The humic acids in humus stimulate root growth. In a similar study, Tomati et al. [6] and Canellas et al. [7] found that humic acids isolated from vermicompost enhanced root elongation and formation of lateral roots in maize roots

3.5 Effect of vermicompost on the total weight and commercial weight of *Brassica integrifolia*

Among the plants supplemented with vermicompost solution of *Brassica integrifolia*, Treatment 5 had the highest total weight of *Brassica integrifolia* (336.09 g), this result is equivalent to the weight of *Brassica integrifolia* in Treatment 1 Control (369.65 g) statistically significant similar at 5% level (Table 6).

TABLE 6
MASS OF *Brassica integrifolia* AT HARVEST IN ALL TREATMENTS

Treatment	Total Weight (gram)	Trade Weight (gram)	Ratio of Trade Weight/ Total Weight (%)
Treatment 1 Control	369,65a	353,88a	95,71a
Treatment 2	5,84b	3,26b	52,63b
Treatment 3	22,08b	19,43b	87,09a
Treatment 4	27,47b	25,04b	91,43a
Treatment 5	336,09a	325,86a	96,93a
Average	20,32	20,62	10,02
Cv (%)	13,35	14,17	11,82
P	0,00	0,00	0,002

Note: Mean values in column followed by different letters are statistically significant differences (P < 0.05)

The ratio of Trade Weight/Total Weight of *Brassica integrifolia* in Treatment 5 reached 96.93%,it was 1.22% higher than that of the control Treatment. In Treatment 2, the weight of *Brassica integrifolia* reached the value of 5.84 g lower than that of Treatment 3 (22.08 g) and Treatment 4 (27.47 g), but Treatment 2, Treatment 3, Treatment 4 had different results without statistical significance, but significant difference 5% compared with Treatment 5 and Treatment 1.

Tripathi et al. [5] noticed that after harvesting of the crops, the rate of respiration reduced under both chemical fertilizer and vermicompost application indicating decreased activities of soil microorganism. However 15t/ha vermicompost treated plot showed the higher respiration rate as compared to chemical fertilizers.

3.6 Density of heat-resistant *Coliforms* and E. coli in *Brassica integrifolia* in all treatments

Heat-resistant coliforms appeared in Treatment 1 with $0.64x10^2$ (MPN/g) lower than Treatment 2 ($4.3x10^2$ MPN/g), Treatment 3 ($4.62x10^2$ MPN/g) and Treament 5 ($3.74x10^2$ MPN/g). However, compared with the limit specified by "Vietnam Standard" (TCVN 6505–2:1999), these values are within the allowable limit. In NT4, there was no presence of heat-resistant coliforms. According to the results (Table 7), *E. coli* was not present in all vegetable samples of all 5 treatments (Table 7)

TABLE 7
DENSITY OF HEAT-RESISTANT COLIFORMS AND E. COLI IN *Brassica integrifolia*

Treatment	heat-resistant Coliforms (MPN/g)	*E. coli* (MPN/g)
Treatment 1 Control	$0,64x10^2$	0
Treatment 2	$4,3x10^2$	0
Treatment 3	$4,62x10^2$	0
Treatment 4	$0,00x10^2$	0
Treatment 5	$3,74x10^2$	0

In summary, *Brassica integrifolia* in all treatments were within the allowable limits of TCVN 6505–2:1999 on food hygiene and safety.

3.7 Change of solution hydroponics

3.7.1 pH of hydroponic solution

The hydroponic solution is left for 30 days before it can be used to grow *Brassica integrifolia*. At this time, the pH value of Treatment 5 solution is 7.1, within the pH range suitable for leafy vegetables (5.5-7,5), the pH of Treatment 5 is not different from that of Treatment 2 (7.77), Treatment 3 (7.89) and Treatment 4 (7.35), and four Treatments are higher statistically significant difference at 5% level than the pH of hydroponic solution in the Treatment 1 ($P<0.05$) (Table 8).

In general, the pH in four Treatments containing hydroponic solution components analyzed had unstable pH changes. In Treatment 2, the pH at the start of planting *Brassica integrifolia* was 7.77. In 5 days after planting, the pH did not increase significantly (7.79), but by the time of 20 days after planting, the pH decreased to 7.52 and increased to the time of harvesting (30 days after planting), pH value reached 7.59. The pH value in Treatment 3 was similar to that in Treatment 2, at the initial point, the pH value of Treatment 3 was 7.89, decreased to 7.56 at the time of 15 days after planting with pH 7.56, but increased to the time of 20 days after planting (7.59) and until 30 days after planting, pH has a value of 7.53. The pH in Treatment 4 had a negligible change and was less volatile than in Treatment 2 and Treatment 3, at the beginning of *Brassica integrifolia* cultivation, the pH was 7.35, when harvesting was improved (30 days after planting), the pH increased value 7.48. Treatment 5 got pH 7.1 by the initial time was lower than that of Treatment 2, Treatment 3, Treatment 4 but no statistically significant differences at the 5% level with pH in Treatment 4 and different from Treatment 2 and Treatment 3 statistically significant meaning ($P<0,05$). By 30 days after planting, Treatment 5 got pH 7.6 and the difference was not statistically significant compared with Treatment 2, Treatment 3 and Treatment 4, but pH of Treatment 5 was difference from pH of Treatment 1 ($P<0.05$) (Table 8)

TABLE 8
PH OF HYDROPONIC SOLUTION FOR GROWING *Brassica integrifolia*

Treatment	pH of hydroponic solution after planting						
	0 day	5 days	10 days	15 days	20 days	25 days	30 days
Treatment 1 Control	6.21c	6.26c	6.28b	6.27b	6.24b	6.16d	6.34b
Treatment 2	7.77a	7.79a	7.58a	7.52a	7.52a	7.68a	7.59a
Treatment 3	7.89a	7.71a	7.57a	7.56a	7.58a	7.52bc	7.52a
Treatment 4	7.35b	7.31b	7.44a	7.4167a	7.4733a	7.42c	7.4767a
Treatment 5	7.10b	7.60ab	7.53a	7.54a	7.5867a	7.63ab	7.6a
Average	0.1100	0.1200	0.1346	0.1876	0.1136	0.0561	0.0474
Cv (%)	1.51418	1.74859	1.848074	2.583076	1.559865	0.770796	0.648604
P	0,00	0,00	0,00	0,00	0,00	0,00	0,00

Note: Mean values in column followed by different letters are statistically significant differences ($P < 0.05$)

3.7.2 Total nitrogen in hydroponic solution

The initial total protein in the treatments was completely different, the highest amount of protein was in the control treatment (2700ppm), in Treatment 2 the protein value was 2377.8 ppm, Treatment 3 was 2055.6 ppm, Treatment 4 was 1733,4 ppm and the lowest in NT5 is 1411.2 ppm. After 30 days of planting, nitrogen will be absorbed by the plant and reduced in the solution. The residual nitrogen in the control Treatment 1, Treatment 2, Treatment 3, Treatment 4 and Treatment 5 was 1952,1±164.9 (ppm), 2039.6 ±58 (ppm), 1850,0 ± 25 (ppm), 1550.2 ± 43 (ppm) and 1026.6 ± 69.1 (ppm), respectively. Although the amount of protein was completely different, the rate of nitrogen use in Treatment 5 was 27.25%, this value is equivalent to Treatment 1 (27.7%) and the difference is significant statistically compared with Treatment 2 (14.230%), Treatment 3 (10.003%) and Treatment 4 (10.570%) (P<0.05) (Table 9)

TABLE 9
PROTEIN CONTENT IN HYDROPONIC SOLUTION FOR GROWING *Brassica integrifolia*

Treatment	The initial total of protein (ppm)	Total of protein after harvesting (ppm)	Used protein (ppm)	Used protein ratio (%)
Treatment 1	2700,0	1952,1a	747,90a	27,70
Treatment 2	2377,8	2039,6a	384,55b	14,23
Treatment 3	2055,6	1850,0a	205,62b	10,00
Treatment 4	1733,4	1550,2b	183,16b	10,57
Treatment 5	1411,2	1026,6c	384,55b	27,25
Average		87,18	87,18	3,88
Cv (%)		5,18	21,27	21,62
P value		0,00	0,00	0,00

Note: Mean values in column followed by different letters are statistically significant differences (P < 0.05)

Other researchers also reported similar results in several other crops. Application of recommended dose of fertilizers and vermicompost indicated maximum yield in Potato [8], rice [9] and significantly influenced various growth parameters in Cabbage plant [7]. Combination of Vermicompost at 10 t/ha + NPK at 25:60:50 kg/ha increased nodulation, plant height and yield in Pea [10]. Similarly, 150 kg N/ha and 12 t/ha vermicompost increased the leaf number in Potato [11] and vermicompost at 15 t/ha significantly increase the growth and yield of Okra [12]. Chemical fertilizer was most effective within a month of application in influencing growth performance in amaranths whereas vermicompost was more favorable than chemical fertilizer after a month [13]. Tripathi et al. [14] noticed that chemical fertilizers were effective in increasing plant growth in short run but suppressed significantly the microbial activities of soil. Vermicompost on the other hand was effective in long run through slow release of plant nutrients and improving soil health by increased soil microbial activities

IV. CONCLUSION

The use of 100% vermicompost that is stabilized for 30 days after planting as a hydroponic solution for growing *Brassica integrifolia* gives the yield and quality equivalent to using a hydroponic solution with chemical nutrients. In addition, the use of vermicompost will contribute to reducing the risk of environmental pollution by minimizing the solution containing inorganic compounds in hydroponic for growing vegetable.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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