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Preface

We would like to present, with great pleasure, the inaugural volume-7, Issue-1, January 2021, 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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Rubber Tree Cultivation and Improvement: Laticifer Ring Count and Latex Yield Assessment of Rubber Species

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Abstract— *Rubber trees (Hevea spp.), the wilderness trees originating from rain forests of the Amazon, have been domesticated outside South America for more than a century. The trees, specifically of the species Hevea brasiliensis, are now widely established in the tropics especially in Southeast Asia. Nevertheless, opportunities to improve the latex yield productivity of these cultivated rubber trees are limited by their narrow genetic base since they have been descended from a small selection of seedlings derived from seeds collected in the 1800's. Commercial rubber trees hence face this genetic vulnerability of inbreeding depression that could hamper progress in crop improvement. To explore the feasibility of broadening the genetic base, various Hevea species, viz. Hevea brasiliensis, Hevea benthamiana, Hevea camargoana, Hevea guianensis, Hevea nitida, Hevea pauciflora, Hevea rigidifolia and Hevea spruceana, were assessed for their possible contribution to the genetic improvement of the cultivated rubber trees particularly in latex yield output. The assessment showed that Hevea benthamiana, and Hevea spruceana to be promising in terms of the number of laticifer rings in the bark and latex yield. They are promising candidates for incorporation into the improvement programmes of the rubber tree in Malaysia.*

Keywords— Hevea species, latex yield, laticifer rings.

I. INTRODUCTION

Key inventions in the 1820s introduced novel uses for natural rubber, Charles Macintosh produced the earliest water-resistant rubberised fabrics while Thomas Hancock invented the rubber masticator that could cut and compressed rubber into moulded solid rubber, Hancock further improved the application of natural rubber latex in various surgical tools, water resistant clothing, footwear, hoses, rubber belts, engine components and rubber inflatables (Barlow, 1978; MRB, 2005; MRB, 2009; Priyadashan, 2011). The demand for natural rubber reached new heights following the introduction of vulcanization by Charles Goodyear in 1839, a process where rubber is heated in the presence of sulphur. This stabilises the rubber at both high and low temperatures while being resistant to melting and able to retain its elasticity, such characteristics being requisite for rubber tyres in the automobile industry. The invention of the motorcar and pneumatic tyres in the mid-1800s was an important factor that triggered higher demand for natural rubber latex as a raw material worldwide (Barlow, 1978; Baulkwill, 1989). The unique properties of rubber and its versatility have resulted in its use in a wide assortment of products.

The demand for rubber latex has led to extensive cultivation of *Hevea brasiliensis* not only in Asia (Malaysia, Thailand, Indonesia, India, Myanmar, the Philippines, Cambodia, Vietnam, China and Sri Lanka) but also in Africa (Nigeria, Cameroon and Ivory Coast). In Malaysia, the natural rubber industry caters to most of the livelihoods of smallholding growers, which is made up of mostly senior residents, who live off the cultivated rubber trees many decades ago.

Latex is produced in laticifers which are cells fused end to end to form continuous vessels. Laticifers are found in all parts of the rubber tree although tapped latex is derived mainly from those in the bark of the trunk. In cross-section under the microscope, laticifers in the bark appear as concentric rings surrounding the trunk. The roles of latex in rubber trees and other plant species have been suggested by Bealing (1965), Hunter (1994), Rudall (1994), Agrawal and Konno (2009), and Kajii *et al*. (2014) to be highly associated with: (1) protection against injury; (2) storage of carbon and its derivatives; and (3) storage of water and the regulation of its supply. Various rubber species, viz. *Hevea brasiliensis, Hevea benthamiana, Hevea* *camargoana, Hevea guianensis, Hevea nitida, Hevea pauciflora, Hevea rigidifolia* and *Hevea spruceana* available in Malaysia (Schultes, 1990). However, these rubber species were not fully utilized in the recent rubber improvement programmes in the country. Thus, these rubber species were assessed for their possible contribution to the improvement of the cultivated rubber trees in latex yield output.

II. MATERIALS AND METHODS

2.1 Laticifer Ring Count

Bark samples from eight different *Hevea* species, viz. *Hevea brasiliensis, Hevea benthamiana, Hevea camargoana, Hevea guianensis, Hevea nitida, Hevea pauciflora, Hevea rigidifolia* and *Hevea spruceana,* were collected from the tree trunk at a height of 1.5 m from ground level, using a bark borer that penetrated at least 6 mm into the bark layer. After the samples were collected, the holes made by the bark borer were covered with Shell petroleum jelly healing compound to assist healing of the wounded bark and allow subsequent bark renewal. In the laboratory, free-hand sectioning was carried out to examine and compare the bark morphological characteristics of the eight *Hevea* species. Ten bark samples of each species were softened with distilled water before cutting free-hand longitudinal sections of about 10 µm thickness using a sharp razor blade. The sectioned samples were stained with Sudan III and mounted on a glass slide for examination under an Olympus BH2 Light Microscope. The number of laticifer rings (laticifers) in the samples were counted and averaged according to different rubber species. Comparisons of means, standard errors and standard deviations were carried out. Analysis of Variance (ANOVA) and Duncan's Multiple Range Test (DMRT) were also performed.

2.2 Latex Yield

A tapping cut was made across half the circumference of the tree trunk (1/2 S) by thin shredding of bark from the sloping cut at an angle of 30°, starting from the upper left and ending to the lower right of the tree trunk. Exuded latex was collected in a 100 ml test tube that attached to each sampled tree. Then, these collected samples were taken out from the test tubes and air-dried for 14 days over wooden racks. Latex yield from the tree was calculated as dry rubber weight and expressed as grams per tree per tapping (gtt). The yield for each species was subjected to comparison of means, standard errors and standard deviations. Analysis of Variance (ANOVA) and Duncan's Multiple Range Test (DMRT) were also performed.

III. RESULTS

3.1 Laticifer Ring Count

The number of laticifer rings in eight *Hevea* species was analysed by a comparison of means, and by an Analysis of Variance (ANOVA), followed by Duncan's Multiple Range Test (DMRT) (Tables 1 and 2). The ANOVA analysis revealed significant differences between the mean number of laticifer rings between the species compared [$F(7, 72) = 13.797$, $p < 0.05$]. *H. brasiliensis* showed the highest mean number of rings at 14.3, followed by *H. benthamiana* at 12.0 and *H. spruceana* at 11.3. On the other hand, *H. camargoana and H. guianensis* had the lowest means among the species, at 6.7 and 3.5 respectively. DMRT analysis indicated that the mean laticifer ring count of *H. brasiliensis* was significantly higher than for the other species, whereas the count for *H. guianensis* was the lowest.

TABLE 1
MEAN, STANDARD ERROR AND STANDARD DEVIATION OF NUMBER OF LATICIFER RINGS IN THE BARK OF EIGHT *HEVEA* SPECIES.

Species	Mean	Standard Error	Standard Deviation
Hevea benthamiana	12.0 ab	1.125	3.559
Hevea brasiliensis	14.3 a	1.317	4.165
Hevea camargoana	6.7 d	0.761	2.406
Hevea guianensis	3.5 e	0.269	0.850
Hevea nitida	9.9 bc	0.706	2.234
Hevea pauciflora	9.4 bcd	0.718	2.271
Hevea rigidifolia	7.5 cd	0.778	2.461
Hevea spruceana	11.3 b	1.174	3.713

**** Means with the same letter are not significant different by DMRT, p<0.05.***

TABLE 2
ANOVA FOR NUMBER OF LATICIFER RINGS IN THE BARK OF EIGHT *HEVEA* SPECIES.

Source of Variation	*df*	*Sum of squares*	*Mean square*	*F*	*P*-value
Between groups	7	802.950	114.707	13.797	*0.000
Within groups	72	598.600	8.314		
Total	79	1401.550			

***P-value: < 0.0005**

3.2 Latex Yield

Analysis of Variance (ANOVA) analysis revealed significant differences [$F(7, 72) = 117.612$, $p < 0.05$] between mean latex yield of rubber species (dry rubber weight) was expressed as g per tree per tapping (gtt) from different *Hevea* species (Table 3 and 4). The results showed that *H. brasiliensis* produced the highest mean yield at 39.7 gtt, followed by *H. benthamiana* and *H. spruceana* with means at 24.7 gtt and 22.8 gtt respectively. *H. guianensis* showed the lowest mean yield at 4.1 gtt. DMRT analysis indicated that the mean yield for *H. brasiliensis* was significantly higher than those for all of the other species. Meanwhile, latex yield from *H. guianensis* was significantly the lowest among the eight rubber species.

TABLE 3
MEAN, STANDARD ERROR AND STANDARD DEVIATION OF LATEX YIELD (gtt) IN EIGHT *HEVEA* SPECIES.

Species	Mean	Standard Error	Standard Deviation
Hevea benthamiana	24.7 b	1.065	3.368
Hevea brasiliensis	39.7 a	1.535	4.855
Hevea camargoana	11.0 d	0.894	2.828
Hevea guianensis	4.1 e	0.379	1.197
Hevea nitida	17.3 c	0.775	2.452
Hevea pauciflora	17.1 c	1.320	4.175
Hevea rigidifolia	9.7 d	0.633	2.003
Hevea spruceana	22.8 b	1.041	3.293

***Means with the same letter are not significant different by DMRT, p<0.05.**

TABLE 4
ANOVA FOR LATEX YIELD (gtt) IN EIGHT *HEVEA* SPECIES

Source of Variation	*df*	*Sum of squares*	*Mean square*	*F*	*P*-value
Between groups	7	8505.00	1215.000	117.612	*0.000
Within groups	72	743.80	10.331		
Total	79	9248.80			

***P-value: < 0.0005**

3.3 Relationship between Number of Laticifer Ring Count and Latex Yield

Pearson's correlation coefficients were calculated to determine the relationships between the number of laticifer rings and latex yield among the eight *Hevea* species. The result showed a positive correlation between number of laticifer rings and latex yield with a correlation coefficient (r) = 0.698, which was statistically significant (n = 80, p< 0.01) as showed in Table 5.

TABLE 5
PEARSON'S CORRELATION COEFFICIENT BETWEEN NUMBER OF LATICIFER AND LATEX YIELD EXPRESSED IN GRAMME PER TREE PER TAPPING (gtt)

		Number of laticifer	Latex yield (gtt)
Number of laticifer rings	Pearson's correlation	1	0.698*
	Number of sample (N)	80	80
Latex yield (gtt)	Pearson's correlation	0.698*	1
	Number of sample (N)	80	80

**** Correlation coefficient at p<0.01.***

IV. CONCLUSION

H. brasiliensis, *H. benthamiana,* and *H. spruceana* showed the highest number of laticifers rings in the bark whereas *H. guianensis* had the lowest laticifer ring count among the rubber species studied. The number of laticifer rings were strongly correlated with latex yield produced in these *Hevea* species. Pearson's Correlation Coefficient indicated that increasing number of laticifer rings would have a tendency to accompany by increasing of latex yield. More attention should, therefore, be paid to laticifer ring count in future rubber improvement programmes. However, this characteristic is not a suitable criterion for the early selection in the nursery for young rubber plants less than 18 months old. In young plants, the laticifers are not fully developed and latex yield at this stage can give misleading results. In a nutshell, *H. benthamiana* and *H. spruceana* showed promising in term of number of laticifer rings and latex yield (dry rubber weight), apart from *H. brasiliensis*, to be considered for incorporation into the rubber improvement programmes in Malaysia.

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REFERENCES

[1] Agrawal AA and Konno K (2009) Latex: A model for understanding mechanisms, ecology and evolution of plant defense against herbivory. *The Annual review of Ecology, Evolution and Systematics* 40: 311-331.
[2] Barlow C (1978) *The Natural Rubber Industry*. Oxford University Press, London.
[3] Baukwill WJ (1989) The history of natural rubber production. In: Webster CC and Baulkwill (Eds.) *Rubber*, Longman Scientific and Technical, UK and John Wiley and Sons, Inc, New York.
[4] Bealing FJ (1965) Role of rubber and other terpenoids in plant metabolism. Proceedings of the Natural Rubber Products Research Association Jubilee Conference, London, 113-122.
[5] Hunter JR (1994) Reconsidering the function of latex. *Trees* 9:1-5.
[6] Kajii C, Morita T, Kuroda K (2014) Laticifers of *Ficus carica* and their potential role in plant defence. *The International Association of Wood Anatomists Journal* 35(2):109-115.
[7] MRB Malaysian Rubber Board (2005) *The evolution of the rubber industry in Malaysia: Navigating and re-inventing the industry*. Malaysian Rubber Board, Kuala Lumpur.
[8] MRB Malaysian Rubber Board (2009) *R&D Achievements: 1980-2005*. Malaysian Rubber Board, Kuala Lumpur.
[9] Priyadashan PM (2011) *Biology of Hevea rubber*. CABI, Wallingford, UK.
[10] Rudall P (1994) Laticifers in Crotonoideae (Euphorbiaceae): homology and evolution. *Annals of the Missouri Botanical Garden* 81(2): 270-282.
[11] Schultes RE (1990) *A brief taxonomic view of the genus Hevea*. MRRDB Monograph No.14, Malaysian Rubber Research and Development Board, Kuala Lumpur.

Phosphorus Waste Production in Fish Farming a Potential for Reuse in Integrated Aquaculture Agriculture

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Abstract— *The development of aquaculture in recent years to become the fastest growing food production in the world is accompanied by a secondary effect on the environment, since considerable quantities of waste can be produced and discharged into the environment, as these phosphorus-rich effluents, over time, can contribute to eutrophication phenomena in the aquatic environment. This pollutant is essentially of food origin and is a necessary macro-mineral for fish. However, current scientific and technical means are far from offering the solution to the environmental problems posed by aquaculture development. However, this effluent is a compound that is necessary for the soil as a fertiliser and has great potential for reuse. In this context, aquaculture systems must therefore be well managed to ensure the environmental sustainability of the sector by exploiting these phosphorus-rich discharges in the system of integrating aquaculture with agriculture. The integration of agricultural and aquaculture production systems is seen as a sustainable alternative and as a way to rationalise the use of water and fertilisers. However, for the optimisation of this integrated system to be justifiable in terms of the exploitation of phosphorus from aquaculture effluents, it is necessary to take ownership of the processes involved in the presence of food-borne phosphorus in these effluents and the possibility of its advantageous use both in aquaponics and in agricultural irrigation, the aim of which is to increase the efficiency and sustainability of both aquaculture and agriculture.*

Keywords— Aquaculture, Agriculture, Integration, Phosphorus, Effluent, Aquaponics, Irrigation.

I. INTRODUCTION

The increase in the size of the world's population, together with the rise in average per capita fish consumption and the demand for fish, the role that aquaculture plays in ensuring food security, and to preserve marine resources has led to development of this sector in the world over the last few decades (FAO, 2020).

One of the consequences of the expansion of aquaculture is the significant increase in the production of faecal and metabolic waste from feed in farming systems. The main pollutants involved in these aquaculture effluents, are phosphorus (P), nitrogen (N) stand out as important contributors to the eutrophication process of the aquatic environment, leading to negative impacts on the environment, (Lazzari and Baldisserotto, 2008). Among the nutrients lost from diets, phosphorus is the most critical, is the main factor of pollution in aquaculture since it influences directly the eutrophication process (Carpenter *et al*., 20O8; Morales *et al*, 2015; Han *et al*., 2016; Wang *et al*., 2017, Sugiura, 2018).

In this context, this forces us to rethink waste management with a sustainable vision, operating systems that allow us to reuse nutrients from effluents generated by fish farming (Carpenter and Bennett, 2011), in order to take advantage of the phosphorus nutrients present in aquaculture effluents, especially as the growing global demand for food results in a steady increase in the demand for P, which is expected to increase the cost of P fertilizers in the future (Ashley *et al*, 2011; Scholz and Wellmer, 2015; Geissler *et al*., 2019).

From this need stems the concept of Integrated Multi-Trophic Aquaculture (IMTA) systems, which allow the co-production of food or other products through the recycling of aquaculture wastes in order to ensure the environmental sustainability of the sector (Troell *et al*., 2009; Barrington *et al*., 2009; Chopin, 2013).

The integration of fish farming systems with the production of vegetables or fruits are commonly cultivated by integrating aquaculture with agriculture; in agricultural irrigation or aquaponics, is already well established in freshwater, is a sustainable and productive approach, in line with the principles of Integrated Multi-Trophic Aquaculture (IMTA), applying ecological concepts and principles of agro-ecology, which can therefore play an important role in building resilience and adapting to climate change, in addition to food security (FAO, 2019). Integrating aquaculture into farming systems can improve productivity, water use efficiency and overall environmental sustainability (Ingram *et al*., 2000), reduce the use of chemical fertilizers (Rejesus *et al*., 2013), and promote ecological, social and economic benefits (Halwart *et al*., 2003; Aba Mustapha and El Bakali, 2020).

Fish feeds contain Phosphorus and are essentially the only significant source of P in aquaculture (Van Ginkel *et al*.., 2017; Strauch *et al*, 2018), although the importance of phosphorus nutrition is well known to fish nutritionists, mainly because of its effect on bone development and energy kinetics in the cell (Lall, 2002 ; NRC, 2011), in addition to its biological importance for fish, it is well established that excess phosphorus in fish feed can promote eutrophication of aquatic environments, few studies are available on phosphorus-rich aquaculture effluents used by plants by integrating aquaculture into agriculture in order to contribute to the sustainability of aquaculture production. Due to the lack of information on mineral nutrition, in particular phosphorus, and its importance for both fish and plants, and for the beneficial use of fish feed waste, we purpose this Review article which aims to gather, analyse and synthesise information on phosphorus nutrition in fish feed, with the aim of presenting guidelines for the use of this mineral responsible for aquatic pollution as a fertiliser in the integrated aquaculture agriculture system.

II. PHOSPHORUS REQUIREMENTS

2.1 Minerals

Minerals are essential elements for the vital processes of all animals, including fish, which need minerals more than land animals for tissue formation, osmoregulation and other metabolic functions (Lall, 2002). Minerals differ from other necessary nutrients because they are not produced by the body and have to be provided by the diet. Minerals are of great importance because they perform various biological functions. These functions can be classified as structural, such as bone tissue and muscle protein; regulatory, such as cell replication and differentiation; physiological, such as its action on osmoregulation and membrane permeability; and they are and are part of energy storage molecules (Cho *et al*., 1985; Bureau and Cho, 1999; Roy and Lall, 2003).

Minerals are classified according to the amount required by the organism and are separated into macro and micromineral groups (NRC, 2011; Antony Jesu Prabhu *et al*, 2016).

- Macroelements are required in relatively high quantities in the body, the main examples of this group being calcium, phosphorus, potassium and sodium.
- Microminerals are relatively small elements required by the animal, such as: molybdenum, selenium, cobalt, copper, iron, zinc and manganese.

Fish have the physiological capacity to absorb some of these minerals from the aquatic environment through ion exchange in the gills. In freshwater, there is generally a sufficient concentration of calcium, sodium, potassium and chloride to meet their needs except for phosphorus, which must be present in the feed (Bureau and Cho, 1999).

2.2 Phosphorus

Phosphorus is a fundamental macromineral for the growth and reproduction of fish; it is widely distributed in all cells of the body, with important functions in several essential metabolic processes. This mineral is present in nucleic acids, phospholipids, enzymes and glycolic compounds. In oxidative phosphorylation, it acts as a covalent moderator, participating in the regulation of many metabolic processes, and being one of the main anions in the crystalline structure of bones (Lovell, 1988; Roy and Lall, 2003; NRC, 2011). In its phosphate form, Phosphorus plays an essential role in all the fundamental biochemical reactions of respiration, photosynthesis, muscle contraction, cell division, transmission of genetic information and fermentation (Lall, 1991).

In nature, phosphorus is widely distributed in combination with other elements. Phosphate is in equilibrium with phosphoric acid (H3PO4), with dihydrogen phosphate ($H_2 PO^-_4$) and with hydrogen phosphate ($HPO^{2-}{}_4$). The predominant form at neutral pH is hydrogen phosphate, as in an acidic medium, phosphoric acid predominates. Pentavalent phosphate is the most common form (PO_4^{3-}), being an essential component of protoplasm, present in plant and animal tissues (Strain and Cashman, 2002). Hydroxyapatite, $Ca_{10}(PO_4)_6(OH)_2$ has the important role of being the main crystalline constituent of bones, giving them rigidity and strength (Lall, 2002).

Free phosphate is also called inorganic phosphate (inorganic phosphorus Pi). Phosphate that is covalently bound to sugars, proteins and other components of the cell is called organic phosphate (P) (NRC, 2011).

Although fish absorb many essential minerals directly from the aquatic environment, most of the phosphorus must be obtained from the feed, as the absorption of phosphorus directly from the water is very low, indicating the need for supplementation of this mineral in the diet (NRC, 2011; Chen *et al*., 2017).

2.3 Source and availability of phosphorus

In aquaculture, feed is the inly source of phosphorus in fish (Roy and Lall, 2003; Chen *et al*, 2017; Verri and Werner, 2019). Phosphorus can be found in different forms and concentrations in the ingredients used in feed formulation, such as: inorganic phosphate, bone phosphorus and organic phosphates of animal and plant origin.

2.3.1 Organic Phosphorus

In order to improve the availability of P in aquaculture feed and to prevent P deficiencies, such as skeletal deformities and reduced growth, supplementation of organic P used in feed is necessary to accurately cover the needs of fish (Lall, 2002; Sugiura *et al*., 2004).

The availability and digestibility of this mineral is also different depending on the feed. Fishmeal has been the main source of protein especially for carnivorous species for many years and has the highest digestibility of phosphorus intake (66-74%). Its importance in the formulation of feeds has considerably decreased, but it still remains a significant ingredient. It is very rich in P in the form of hydroxyapatite and phospholipids (Kaushik, 2005; Vandenberg, 2001).

In the context of the sustainability of aquaculture and the gradual depletion of marine resources (FAO, 2020) the substitution of fish meal by a vegetable protein source is recommended, As an alternative to this ingredient, many authors have recommended the plant based protein ingredients specifically regarding the cost as they seem to be cheaper compared to fish meal (Daniel, 2018).

However, these plant ingredients contain anti-nutritional factors, such as phytic acid, which form complexes with minerals, proteins and lipids, reducing their digestion and bioavailability in the digestive tract (Vielma *et al*., 2002).

One of the minerals trapped by phytic acid is phosphorus, which is the main representative of the structural components of skeletal tissue and is directly involved in energy processes (Akpoilih *et al*., 2017). According to (Kumar *et al*., 2012; Cangussu *et al*., 2018), the incorporation of a synthetic enzyme called phytase could counteract the anti-nutritional factors of phytic acid and improve the bioavailability of minerals and their absorption in the intestinal tract. The opposite, ruminants can produce phytase in rumen by phytate hydrolysis but monogastric animals don’t have phytase available during digestion (NRC, 1993), but for fish, according Hardy (2010), reported that majority of the phosphorus in plant protein cannot be utilized by fish, which are monogastric animals.

Phytase also plays a role in improving the digestibility of plant proteins and the bioavailability of certain minerals, particularly phosphorus (Kémigabo *et al*., 2018). The fish nutrition researchs have suggested the increase of phytase in the feed formulation to increase bioavailability and utilization of the phosphorus in fish feed (Dauda *et al*, 2019).

2.3.2 Inorganic Phosphorus and Food Additives

To ensure the sustainability of aquaculture and the availability of P in fish feeds, inorganic additives to P (Pi) such as monocalcium phosphate (MCP), dicalcium phosphate (DCP) and tricalcium phosphate are generally added to the diets of fish and terrestrial animals to meet P requirements for maximum growth (Yoon *et al*, 2015). Feed manufacturers often add mono or dicalcium phosphate to feed to supplement phosphorus from other feed ingredients (Chatvijitkul *et al*, 2017).

2.4 Phosphorus requirements

Of all minerals considered essential for fish, requirement for phosphorus (P) is the most extensively studied (Antony Jesu Prabhu *et al*., 2013). P is a macro element that is essential for several physiological functions in fish (Kaushik, 2005). Unlike ammonia, phosphorus is not toxic to farmed fish (Wong, 2001).

According to Amirkolaie (2011), information on the dietary phosphorus requirements of each fish species and the availability of this nutrient in the diet is essential for the formulation of diets. In the context of mineral nutrition of fish species of aquaculture importance, the main four groups; salmonids (trout and salmon), cyprinids (carp), cichlids (tilapia) and silurids and (catfish) are well studied compared to the other groups, whose most was widely used old method for estimating the phosphorus requirement in fish nutrition is to study the excretion of metabolic discharges, the level of requirement being the one where an increase in phosphorus excretion is observed.

Currently , that the phosphorus requirement of the fish should be estimated by using the method who use the combination the excretion of metabolic discharges, and digestibilty of phosphorus reported in the works Sugiura (2000) and Kaushik (2005), as a tool to estimate the content of this ingredient in aquaculture feed formulation (Hua and Bureau, 2010).

Most of the required phosphorus (P) is supplied to farmed fish through feeding (Stickney, 1979; Hardy and Gatlin, 2002 ; Roy and Lall, 2003), and the requirement may be variable according to the life stage, phosphorus source and the statistical approach used to estimate the requirement (NRC, 2011). Additionally, that digestive tract differences among fishes may influence the quantitative requirement of phosphorus (Hua and Bureau ; 2010). Data available for teleost fish show that requirements vary between 0.5 and 0.9% (Kaushik, 2005; NRC, 2011) and 0.4 to 0.7% of total P (Hardy and Gatlin, 2002; Kaushik, 2005).

2.5 Digestion and retention of phosphorus

This mineral is present in virtually all food ingredients, in a mixture of inorganic and organic forms. Intestinal phosphatases hydrolyse the organic form, so most absorption is in the form of inorganic phosphorus, with a higher percentage of total absorption in young animals than in adults (McDowell, 1992).

The digestibility of phosphorus depends on its origin: phosphorus from fishmeal is 60% digestible because the digestive enzyme complex of most teleosteans is better adapted to the digestion of products of animal origin, while vegetable phosphorus, in the form of phytic acid, is little useable by fish (0 to 20%) because the latter do not have the enzyme phytase to digest it (Dosdat, 1992). In this context, feeds formulated from plant ingredients are supplemented with inorganic sources of phosphorus to meet the metabolic requirements of the mineral by fish. This strategy increases the cost of production in addition to allowing greater excretion of the mineral into the environment (NRC, 2011; Araújo *et al*., 2012).

Fish assimilate only 20-40% of the applied P (Gross *et al*., 2020), and the ability of fish to digest phosphorus can vary depending on various factors such as the rearing phase, fish species, various organic ingredients and inorganic sources (Quintero-Pinto *et al*., 2011).

The digestibility of P depends on multiple factors and the association between variables, including pH, the anatomy and physiology of the gastrointestinal tract of TIG fish, the interaction between Pi and divalent minerals, and the presence of feed additives (Hua and Bureau, 2006; Hua and Bureau 2010).

The digestibility of P in the diet varies between fish species (Satoh et al., 1997; Hua and Bureau, 2010), the level of dietary inclusion of P (Satoh *et al*., 1997), the interaction with other dietary nutrients (e.g. Ca) and the presence of feed additives (e.g. phytase) (Hua and Bureau, 2006).

Phosphorus from plants is mainly found in forms of phytic acid (inositol exaphosphate), which is poorly hydrolysed in the gut, with low absorption and excreted via the faeces (Steffens, 1987).

III. PHOSPHORUS AQUACULTURE EFFLUENTS

The food provided to the fish on a daily basis is usually based on a ration. The amount of feed depends on the energy and nutritional requirements of the fish. However, fish generally do not regulate their consumption on a daily basis, but rather over longer periods of time depending on their developmental stages (Madrid *et al*., 2009).

But Feed is the main source of waste and is also responsible for most of the environmental impact of aquaculture (Roque d'Orbcastel *et al*. 2009). The quantity and quality of the waste excreted by fish depend on intake, digestion and metabolism of dietary compounds (Bureau and Hua, 2010).

Environmental problems arise when much of the dietary P, because it is not bioavailable or exceeds the physiological needs of fish, ends up in fish farm effluents and is eventually discharged into receiving watercourses (Sugiura *et al*., 2000).

3.1 Phosphorus discharges in aquaculture effluents.

it is well documented that 15-40% of the applied P is retained by the fish, while the rest is excreted and released into the water (Trépanier *et al*., 2002;Roqued'Orbcastel *et al*., 2008; Sugiura, 2018;). There are several routes of P release in fish farms: faeces, uneaten feed, gill and urine excretion, and fish excrete P in soluble and particulate form (Lall, 1991).

3.1.1 Forms of phosphorus excretion

Phosphorus (P) is found in fish farm effluents in two forms, namely (i) a solid or particulate form and (ii) a soluble or dissolved form.

- **Solid Waste**

Solid waste is mainly derived from uneaten feed and faeces from farmed fish excreta (Akinwole *et al*., 2016). The magnitude of the impact of solid waste depends mainly on the amount of faeces produced and the stability/decay rate of the ingested faeces (Brinker, 2007). It has been shown that diet composition can also change the consistency of faecal solids and other physical characteristics of fish faeces (Kokou and Fountoulaki, 2018).

These phosphorus solid wastes, therefore, are the P that has not been ingested and the P that has been ingested but not assimilated. This solid fraction represents the majority of phosphorus discharges from fish and this is confirmed by several studies concerning different fish species (carnivores and omnivores), which have revealed that phosphorus solid wastes represent between 60 and 70% of food discharges in tilapia (Alves and Baccarin, 2005; Montanhini Neto and Ostrensky, 2015;), trout (Boujard *et al*, 2002l, Roque d'Orbcastel *et al*., 2008) and catfish (Nwana *et al*., 2009).

The particulate form settles to the bottom of basins and reservoirs or accumulates in the sediment (Tundisi and Tundisi, 2008; Canale *et al*., 2016), and the average dietary conversion of diets has a major influence on the excretion of the amount of solid P produced by the fish (Bureau and Hua, 2010).

- **Dissolved Waste**

The dissolved form comes indirectly from the food in the sense that it represents the fraction of the portion of P absorbed in excess and then released in the urine primarily and through the gills (Bureau and Cho, 1999b; Ouellet, 1999; Hardy and Gadin, 2002).

Dissolved wastes, both in organic and inorganic forms, result from the excretion of fish and the decomposition of solid wastes (faeces and uneaten food) in the water column (Gowen *et al*., 1991; Yokoyama *et al*., 2009). These wastes are quantitatively more abundant than particles.

According to Numery (2018) dissolved P includes mineral forms of orthophosphate ions, and organic forms in the process of mineralisation of dead matter (phosphoproteins, phospholipids). Phosphorus excretion at the gills contributes to osmoregulation and acid-base equilibrium in fish (Bucking and Wood, 2006), while renal excretion of phosphate is more important than gill excretion and accounts for 90% of excreted blood P (Dosdat, 1992).

Soluble P would be the most problematic form, as current effluent treatment methods would be unable to remove it effectively (Bureau and Cho, 1999b; Lellis *et al*, 2004), but has an advantage as a fertiliser in the system for integrating aquaculture into agriculture (Aba Mustapha and El Bakali, 2020).

3.1.2 Factors influencing phosphorus discharges

According to Bureau (2004), the production of metabolic P waste by fish is determined by many endogenous (biological) and exogenous (dietary, environmental) factors. Nutrition and feeding remain the main factors that have a determining effect on the amount of metabolic waste produced. However, endogenous factors, such as fish species and size/age, can also have very important impacts.

Several factors influence the excretion of P in the body (NRC, 2011). According to Araripe *et al* (2006) and Koko (2007), the 4 main ones are :

- The quality of the feed, which depends on the content and digestibility of the P, on the one hand, and on the balance of the different nutrients and the physical form of the feed, on the other hand.
- The quantity and distribution method of the feed.

- The adequacy of the diet to meet the actual needs of the farmed fish species;
- The physiological state of the fish: in particular the age and state of health.

Phosphorus excretion is favoured by high doses of calcium carbonate, high concentrations of aluminium in the diet or lower water temperature (Lall, 2002). Metabolic wastes of P are mainly excreted as phosphate in the urine (Bureau, 2004), and phosphate excretion is proportional to the increase in plasma phosphate (Bureau and Cho, 1999).

In addition, fish density has a great influence on N and P excretion (Verant *et al*, 2007). Another factor favouring P excretion is that P is excreted in the farmed water mass in stomachless fish species such as carp (Kim and Ahn 1993).

IV. RELATIONSHIP BETWEEN PHOSPHORUS AND PLANTS

Phosphorus is a vital, but limited and non-renewable resource for life on earth. The constant increase in the world's population and the need to feed the billions of people has put the global availability of P at risk (Cordell *et al*. 2011). Of the 89% of the world's phosphorus resources that are used for food production, 7% is used in animal feed and 82% is used as fertilizer (GPRI, 2010).

P plays an essential role in energy storage, respiration, and photosynthesis in plants (Zeitoun and Biswas 2020). With the prospects of a growing world population and the need to increase food production for food security, the agricultural sector requires the application of fertilizers containing phosphorus, nitrogen and potassium on agricultural fields in order to increase crop yields.

Phosphorus (P) is an essential nutrient for a growing agricultural industry (Morawicki, 2012). In the context of agricultural sustainability, a more integrated and effective approach to managing the phosphorus cycle is needed. To this end, over the last decade, fish has become more integrated into an overall agricultural system, where wastes from one system are recycled as inputs into another, resulting in reduced pollution (Corner *et al*, 2020). This nutrient is acquired by plants from the soil solution mainly in the form of $H_2PO_4^-$ and HPO_4^{2-}. Some soils, however, particularly volcanic soils, possess a high capacity to fix phosphate, thus limiting the bioavailability of P (Morales *et al*, 2011)

Systems that integrate agriculture with fish production are gradually being recognised as environmentally friendly practices that combine aquatic and terrestrial crop production while promoting waste recycling (Jamu and Piedrahita, 2002), thereby increasing farm productivity and optimising the use of limited water resources (Ingram *et al*., 2000; Stevenson *et al*., 2010). P-rich aquaculture effluents are causing growing concern worldwide about possible environmental pollution, so the integration of aquaculture into agriculture, through aquaponics (Cerozi and Fitzsimmons; 2017) and the integration of aquaculture into irrigation (Aba Mustapha and El bakali, 2020), holds promise for improving nutrient and water use efficiency and overall environmental sustainability.

Phosphorus deficiency leads to stunted plant growth, while excess phosphorus can lead to antagonistic interactions with micronutrients, particularly zinc (Barben *et al*., 2010). Therefore, to remedy this problem, the fish farmer is obliged to monitor phosphate concentrations in aquaculture ponds in order to determine the values of this mineral.

V. CONCLUSION

The demands of food to ensure food security are combined with the demands for sustainable agricultural production models that consider production systems that have a low environmental impact and require less water or make its use more efficient. Therefore, the aquaculture-agriculture integration system has the potential to reuse aquaculture effluents rich in phosphorus, responsible for the eutrophication of aquatic environments, as fertilizer, and capable of improving the productivity, water use efficiency and overall environmental sustainability of both aquaculture and agriculture for agro-ecology.

REFERENCES

[1] FAO. 2020. The State of World Fisheries and Aquaculture 2020. Sustainability in action. Rome. https://doi.org/10.4060/ca9229en

[2] Lazzari, R. and B. Baldisserotto, 2008. Nitrogen and phosphorus waste in fish farming. Bolet. Inst. Pesca, 34: 591-600.

[3] Carpenter, S. R. (2008). Phosphorus control is critical to mitigating eutrophication. Proc. Natl. Acad. Sci. U.S.A. 105, 11039–11040. doi: 10.1073/pnas.0806112105.

[4] Moraes, Munique de Almeida Bispo, Carmo, Clovis Ferreira do, Ishikawa, Carlos Massatoshi, Tabata, Yara Aiko, & Mercante, Cacilda Thais Janson. (2015). Daily mass balance of phosphorus and nitrogen in effluents of production sectors of trout farming system. Acta Limnologica Brasiliensia, 27(3), 330-340. https://doi.org/10.1590/S2179-975X1415.

[5] Han, D., Shan, X., Zhang, W., Chen, Y., Wang, Q., Li, Z., Zhang, G., Xu, P., Li, J., Xie, S., Mai, K., Tang, Q., & Silva, S.D. (2018). A revisit to fishmeal usage and associated consequences in Chinese aquaculture. Reviews in Aquaculture, 10, 493-507.

[6] Wang, C., J. Li, L. Wang, Zhao Zhigang, Luo Liang, Xue Du, Yin Jia-sheng and Qiyou Xu. "Effects of dietary phosphorus on growth, body composition and immunity of young taimen Hucho taimen (Pallas, 1773)." Aquaculture Research 48 (2017): 3066-3079.

[7] Sugiura, S.H., 2018. Phosphorus, aquaculture, and the environment. Rev. Fish. Sci. Aquac. 26, 515–521. https://doi.org/10.1080/23308249.2018.1471040.

[8] S.R. Carpenter, E.M. Bennett. Reconsideration of the planetary boundary for phosphorus Environ. Res. Lett., 6 (1) (2011), pp. 1-12.

[9] Ashley, K., Cordell, D., Mavinic, D., 2011. A brief history of phosphorus: from the philosopher's stone to nutrient recovery and reuse. Chemosphere 84, 737–746. https://doi. org/10.1016/j.chemosphere.2011.03.001.

[10] Scholz, R.W., Wellmer, F.W., 2015. Losses and use efficiencies along the phosphorus cycle. Part 1: Dilemmata and losses in the mines and other nodes of the supply chain. Resour. Conserv. Recycl. 105, 216–234. https://doi.org/10.1016/j. resconrec.2015.09.020.

[11] Geissler, B., Mew, M.C., Steiner, G., 2019. Phosphate supply security for importing countries: developments and the current situation. Sci. Total Environ. 677, 511–523. https://doi.org/10.1016/j.scitotenv.2019.04.356.

[12] Barrington, K., Chopin, T. & Robinson, S.M.C. 2009. Integrated multi-trophic aquaculture (IMTA) in marine temperate waters. In D. Soto, ed. Integrated mariculture: a global review, p 7-46. Rome, FAO.

[13] Troell, M., Joyce, A., Chopin, T., Neori, A., Buschmann, A.H. & Fang, J.G. 2009. Ecological engineering in aquaculture - Potential for integrated multi-trophic aquaculture (IMTA) in marine offshore systems. Aquaculture 297: 1-9.

[14] Chopin, T. 2013. Aquaculture, Integrated Multi-trophic (IMTA). In P. Christou, R. Savin, B. Costa-Pierce, I. Misztal & C.B.A. Whitelaw. Sustainable Food Production, pp. 184-205. Springer, New York, United States of America: 1869 p.

[15] FAO. 2019. Report of the Special Session on Advancing Integrated Agriculture Aquaculture through Agroecology, Montpellier, France, 25 August 2018. FAO Fisheries and Aquaculture Report No. 1286. Rome.

[16] Ingram, B.A., Gooley, G.J., McKinnon, L.J., de Silva, S.S., 2000. Aquaculture-agriculture systems integration: an Australian prospective. Fish. Manag. Ecol. 7:33–43. http://dx.doi. org/10.1046/j.1365-2400.2000.00182.x

[17] Rejesus, R.M., Mutuc-Hensley, M., Mitchell, P.D., Coble, K.H., and Knight, T.O.. 2013. US agricultural producer perceptions of climate change. J. Agric. Appl. Econ. 45: 701– 718.

[18] Halwart, M., Funge-Smith, S., Moehl, J., 2003. The role of aquaculture in rural development. Rev. State World Aquac. FAO, Rome, pp. 47–58.

[19] ABA Mustapha and El bakali" The Benefits Of The Integration Of Aquaculture And Irrigation For An Efficient Use Of Blue Water In Order To Strengthen Food Safety In Morocco." IOSR Journal of Agriculture and Veterinary Science (IOSR-JAVS), 13(12), 2020, pp. 01-09.

[20] Van Ginkel, S.W., Igou, T., Chen, Y., 2017. Energy, water and nutrient impacts of Californiagrown vegetables compared to controlled environmental agriculture systems in Atlanta, GA. Resour. Conserv. Recycl. 122, 319–325. https://doi.org/10.1016/j. resconrec.2017.03.003.

[21] Strauch, S.M., Wenzel, L.C., Bischoff, A., Dellwig, O., Klein, J., Schüch, A., Wasenitz, B., Palm, H.W., 2018. Commercial African catfish (Clarias gariepinus) recirculating aquaculture systems: assessment of element and energy pathways with special focus on the phosphorus cycle. Sustain 10. https://doi.org/10.3390/su10061805.

[22] Lall, S.P. The Minerals. In: Halver, J.E. & Hardy, R.W. (Eds.). Fish Nutrition, Third Edition, Elsevier Science (USA), 2002. p.259-308.

[23] NRC. Nutrient Requirements of Fish and Shrimp. Washington, DC, USA: The National Academies Press; 2011.

[24] Cho CY, Cowey CB, Watanabe T (1985) Finfish nutrition in Asia. Methodological approaches to research and development. Int Dev Res Cent Publ (Canada), Ottawa, Ontario, 154.

[25] Bureau D, Cho C (1999) Phosphorus utilization by rainbow trout (Oncorhynchus mykiss): estimation of dissolved phosphorus waste output. Aquaculture 179: 127– 140.

[26] Roy, P.K.; Lall, S.P. Dietary phosphorus requirement of juvenile haddock (Melanogrammus aeglefinus L.). Aquaculture, v. 221, p. 451-468, 2003.

[27] Antony Jesu Prabhu P, Schrama JW, Kaushik SJ. Mineral requirements of fish: a systematic review. Reviews in Aquaculture. 2016; 8:172–219. doi: 10.1111/raq.12090.

[28] Lovell, R.T. 1988. Nutritional and Feeding of Fish. Auburn, Alabama. Auburn University. 267 pp.

[29] Lall SP. 1991. Digestibility, metabolism and excretion of dietary phosphorus in fish. Nutritional Strategies and Aquaculture Wastes. Cowey CB, Cho CY, editorsUniversity of Guelph; Ontario, Canada: p. 21–36.

[30] Strain, J.J. & Cashman, K.D. Minerais e oligoelementos. In: Gibney, J.; Vorster, H.H.; Kok, F.J. (Eds.). Introdução à nutrição humana. Rio de Janeiro, RJ: Guanabara – koogan, 2002. p.162-205.

[31] Chen, M. H. et al., Effect of dietary phosphorus levels on growth and body composition of crucian carp, Carassius auratus under indoor and outdoor experiments. Aquaculture Nutrition, v. 23, n. 4, p. 702-709, 2017.

[32] Verri, T. and Werner, A. (2019). Type ii na+-phosphate cotransporters and phosphate balance in teleost fish. Pflügers Archiv-European Journal of Physiology, 471(1) :193–212.

[33] Sugiura, S.H., Hardy, R.W. and Roberts, R.J., 2004. The pathology of phosphorus deficiency in fish–a review. Journal of fish diseases, 27(5), pp.255-265.

[34] Kaushik, S. (2005). Besoins et apport en phosphore chez les poissons. Productions Animales-ParisInstitut National de la Recherche Agronomique-INRA, 18(3) :203. France.

[35] Vandenberg, G. W. (2001). Encapsulation de phytase microbienne : L'influence sur la disponibilité de nutriments chez la truite arc-en-ciel. PhD thesis, Université Laval, Québec, Canada. 278 p.

[36] Daniel, N.. "A review on replacing fish meal in aqua feeds using plant protein sources." International Journal of Fisheries and Aquatic Studies 6 (2018): 164-179.

[37] Vielma, J., Ruohonen, K. and Peisker, M. 2002. Dephytinization of two soy proteins increases phosphorus and protein utilization by rainbow trout, Oncorhynchus mykiss. Aquaculture 204, 145-156.

[38] Akpoilih, B. U., Omitoyin, B. O., & Ajani, E. K. (2017). Phosphorus utilization in juvenile Clarias gariepinus fed phytase-supplemented diets based on soya bean (oil-extracted) and full fat (roasted): A comparison. Journal of Applied Aquaculture, 29(2), 126–151. https://doi.org/10.1080/10454438.2016.1276000.

[39] Kumar, V., Sinha, A.K., Makkar, H.P., De Boeck, G. and Becker, K., 2012. Phytate and phytase in fish nutrition. Journal of Animal physiology and Animal nutrition, 96(3), 335-364.

[40] Cangussu, A. S. R., Aires Almeida, D., Aguiar, R. W. de S., Bordignon-Junior, S. E., Viana, K. F., Barbosa, L. C. B., … Lima, W. J. N. (2018). Characterization of the Catalytic Structure of Plant Phytase, Protein Tyrosine Phosphatase-Like Phytase, and Histidine Acid Phytases and Their Biotechnological Applications. Enzyme Research, 2018, 1– 12.https://doi.org/10.1155/2018/8240698.

[41] NRC (National Research Council), 1993. Nutrient Requirements of Fish. National Academy Press, Washington, DC, USA

[42] Hardy, R. W. (2010). Utilization of plant proteins in fish diets effects of global demand and supplies of fishmeal. Aquaculture Research, 41, 770–776.

[43] Kemigabo, C., Abdel-Tawwab, M., Lazaro, J. W., Sikawa, D., Masembe, C., & Kang'Ombe, J. (2018). Combined effect of dietary protein and phytase levels on growth performance, feed utilization, and nutrients digestibility of African catfish, Clarias gariepinus (B.), reared in earthen ponds. Journal of Applied Aquaculture, 30(3), 211–226. https://doi.org/10.1080/10454438.2018.1439425.

[44] Dauda, A.B., Ajadi, A., Tola-Fabunmi, A.S., & Akinwole, A.O. (2019). Waste production in aquaculture: Sources, components and managements in different culture systems. Aquaculture and Fisheries, 4, 81-88.

[45] Yoon TH, Lee DH, Won SG, Ra CS, Kim JD. Optimal incorporation level of dietary alternative phosphate (MgHPO4) and requirement for phosphorus in Juvenile far eastern Catfish (Silurus asotus). Asian Australas J Anim Sci. 2015;28:111–9.

[46] Chatvijitkul, S., Boyd, C.E., Davis, D.A., 2017. Nitrogen, phosphorus, and carbon concentrations in some common aquaculture feeds. J. World Aquac. Soc. 49, 477–483. https:// doi.org/10.1111/jwas.12443.

[47] P Antony Jesu Prabhu, J W Schrama, S J Kaushik (2013) Quantifying dietary phosphorus requirement of fish – a meta-analytic approach Aquaculture Nutrition 19: 3. 233-249.

[48] Wong, K. B. (2001). Enhanced solids removal for aquacultural racewaysPhD Dissertation. Davis: University of California.

[49] Amirkolaie, A.K. Reduction in the environmental impact of waste discharged by fish farms through feed and feeding. Rev. Aquacult., v.3, p.19-26, 2011.

[50] Sugiura, S. H., Dong, F. M., and Hardy, R. W. (2000). A new approach to estimating the minimum dietary requirement of phosphorus for large rainbow trout based on nonfecal excretions of phosphorus and nitrogen. The Journal of Nutrition, 130(4) :865–872.

[51] Hua, K. and D.P. Bureau. 2010. Quantification of differences in digestibility of phosphorus among cyprinids, cichlids, and salmonids through a mathematical modelling approach. Aquaculture, 308(3-4): 152-158.

[52] Stickney, R.R. Tilapia nutrition feeds and feeding. 1997. In: Costa-Pierce, B.A., Rakocy, J.E. (Eds.) Tilapia Aquaculture in the Americas. Baton Rouge: The World Aquaculture Society & The American Tilapia Association, v.1, p.34-54

[53] Hardy, R. W., Gatlin, D. M., 2002. Nutritional strategies to reduce nutrient losses in intensive aquaculture. In: Cruz-Suarez, L. E., Ricque-Marie, D., Tapia-Salaza, M., GaxiolaCortés, M. G., Simoes, N. (Eds.). Avences en Nutricion Acuicola VI. Memorias deI VI Simposium Intemacional de Nutricion Acuicola. 3 al 6 de Septiembre deI 2002. Cancun, Quintana Roo, Mexico.

[54] Wong, K. B. (2001). Enhanced solids removal for aquacultural racewaysPhD Dissertation. Davis: University of California.

[55] McDowell LR. Calcium and phosphorus. In: McDowell LR. Books. Vitamins in animal nutrition. London: Academic Press; 1992. p. 26- 77.

[56] Dosdat A., 1992. L'excrétion chez les poissons téléostéens. II. Le Phosphore. La Pisciculture Française, 109, 18-29.

[57] Araujo, E.O; Santos, E.F.; Oliveira, G.Q.; Camacho, M.A.; Drech, D.M. Nutritional eficiency of cowpea varieties in the absorption of phosphorus. Agronomia colombiana, v.30, n.3, p.419-429, 2012.

[58] Quintero-Pinto, L. G. et al. Exigências e disponibilidade de fontes de fósforo para tilápias. Veterinária e Zootecnia, v. 5, n. 2, p. 30-43, 2011.

[59] Satoh, S., V. Viyakarn, T. Takeuchi and T Watanabe (1997) Availability of phosphorus in various phosphates to carp and rainbow trout determined by a simple fractionation method. Fisheries Science, 63, 297-300.

[60] Steffens, W. 1987. Further results of complete replacement of fish meal by means of poultry by-product meal in feed for trout fry and fingerling (Salmo gairdneri). Archives Animal Nutrition. 38:1135-1139.

[61] Roque d'Orbcastel E., Blancheton J.P., Boujard T., Aubin J., Moutounet Y., Przybyla C., Belaud A.,2008. Comparison of two methods for evaluating waste of a flow through trout farm. Aquaculture 274,72-79.

[62] Trépanier C, Parent S, Comeau Y, Bouvrette J. Phosphorus budget as a water quality management tool for closed aquatic mesocosms. Water Research. 2002;36:1007-17.

[63] Roque d'Orbcastel E., Blancheton J.P, Boujard T., Aubin J., Moutounet Y., Przybyla C., Belaud A., 2008, Comparison of two methods for evaluating waste of a flow through trout farm. Aquaculture 274, 72–79.

[64] Brinker, A. (2007). Guar gum in rainbow trout (Oncorhynchus mykiss) feed: The influence of quality and dose on stabilisation of faecal solids. Aquaculture, 267, 315– 327.

[65] Kokou, F., & Fountoulaki, E. (2018). Aquaculture waste production associated with antinutrient presence in common fish feed plant ingredients. Aquaculture, 495, 295– 310.

[66] A.O. Akinwole.A .O, Dauda.A.B, Ololade.A.O. Haematological response of Clarias gariepinus juveniles reared in treated wastewater after waste solids removal using alum or Moringa oleifera seed powder. International Journal of Acarology, 6 (11) (2016), pp. 1-8.

[67] Alves, R.C.P.; Baccarin, A.e. Efeitos da produção de peixes em tanques-rede sobre sedimentação de material em suspensão e de nutrientes no Córrego da Arribada (UHE Nova Avanhandava), baixo rio Tietê. In: NOGUEIRA, M.G.; HENRY, R.; JORCIN, A. (Org.). Ecologia de reservatórios: impactos potenciais, ações de manejo e sistemas em cascata. São Carlos: Rima, 2005. p.329-347.

[68] Montanhini Neto, R.; Ostrensky, A. Nutrient load estimation in the waste of Nile tilápia Oreochromis niloticus (L.) reared in cages in tropical climate conditions. Aquaculture Research, v.46, p.1309-1322, 2015. DOI: 10.1111/are.12280.

[69] Boujard T., Vallée F., Vachot C., 2002, Evaluation des rejets d'origine nutritionnelle par la méthode des bilans, comparaison avec les flux sortants. Proc. 4th workshop on fish nutrition INRAIFREMER, 20 Sept. 2002, Bordeaux, pp. 24–27.

[70] Nwanna LC, Adebayo IA, Omitoyin BO. Phosphorus requirements of African catfish, Clarias gariepinus, based on broken-line regression analysis methods. ScienceAsia. 2009;35:227–233.

[71] Tundisi, J.G.; Tundisi, T.M. Limnologia. São Paulo: Oficina de textos, 2008. 631p.

[72] Gowen RJ, Weston DP, Ervik A (1991) Aquaculture and the benthic environment. In Cowey CB, Cho CY (eds), Nutritional Strategies and Aquaculture Waste, Proceedings of the first international symposium on nutritional strategies in management of aquaculture waste (NSMAW). Department of Nutritional Science, Univ. of Guelph, Guelph, Ontario, 1991: 187–205.

[73] Yokoyama H., Takashi T., Ishihi Y. & Abo K. (2009) Effects of restricted feeding on growth of red sea bream and sedimentation of aquaculture wastes. Aquaculture 286, 80–88.

[74] Bucking, C. & C.M. Wood. 2006. Water dynamics in the digestive tract of the freshwater rainbow trout during the processing of a single meal. J. Exp. Biol., 209: 1883-1893.

[75] Numery, J. (2018). Phosphore et eutrophisation. Retrieved : https ://www.encyclopedieenvironnement.org/eau/phosphore-et-eutrophisation/.

[76] Lellis, W. A., Barrows, F. T., and Hardy, R. W. (2004). Effects of phase-feeding dietary phosphorus on survival, growth, and processing characteristics of rainbow trout Oncorhynchus mykiss. Aquaculture, 242(1-4) :607–616.

[77] Bureau. Dominique P. 2004. Factors Affecting Metabolic Waste Outputs in Fish. In: Cruz Suárez, L.E., Ricque Marie, D., Nieto López M.G., Villarreal, D., Scholz, U. y González, M. 2004. Avances en Nutrición Acuícola VII. Memorias del VII Simposium Internacional de Nutrición Acuícola. 16-19 Noviembre, 2004. Hermosillo, Sonora, México

[78] Araripe, M.N.B.A., Segundo, L.F.F., Lopes, J.B. and Araripe, H.G.A., 2006. Efeito do cultivo de peixes em tanques rede sobre o aporte de fósforo para o ambiente. Revista Científica de Produção Animal, vol. 8, no. 2, pp. 56-65.

[79] Koko, K. D. G. (2007). Une stratégie nutritionnelle de réduction du phosphore (p) dans les effluents aquacoles : l'alimentation en phase des truites arc-en-ciel (Oncorhynchus mykiss) avec alternances d'un régime carencé et d'un régime équilibré en phosphore. Master's thesis, Université Laval, Québec, Canada.

[80] Verant, M.L., Konsti, M.L., Zimmer, K.D., & Deans, C.A. (2007). Factors influencing nitrogen and phosphorus excretion rates of fish in a shallow lake. Freshwater Biology, 52, 1968-1981.

[81] Kim JD, Ahn KH. 1993. Effects of monocalcium phosphate supplementation on phosphorus discharge and growth of carp (Cyprinus carpio) grower. Asian Australas J Anim Sci 6:521–526.

[82] Cordell D, Rosemarin A, Schroder JJ, Smit AL (2011) Towards € global phosphorus security: a systems framework for phosphorus recovery and reuse options. Chemosphere 84: 747–758.

[83] GPRI (2010) Global Phosphorus Research Initiative (GPRI) Statement on Global Phosphorus Scarcity. Global Phosphorus Research Initiative, Wageningen.

[84] Reem Zeitoun and Asim Biswas 2020. Potentiometric Determination of Phosphate Using Cobalt: A Review. J. Electrochem. Soc. 167 127507

[85] Morawicki R.O. 2012. "Handbook of Sustainability for the Food Sciences". Wiley-Blackwell, Chichester, UK.

[86] Corner, R., Fersoy, H. and Crespi, V (eds). 2020. Integrated agri-aquaculture in desert and arid Lands: Learning from case studies from Algeria, Egypt and Oman. Fisheries and Aquaculture Circular No. 1195. Cairo, FAO. https://doi.org/10.4060/ca8610en.

[87] Morales A, Alvear M, Valenzuela E, Castillo C, Borie F (2011) Screening, evaluation and selection of phosphate-solubilising fungi as potential biofertilizer. J Soil Sci Plant Nutr 11:89–103

[88] Jamu, D. M. and Piedrahita, R. H. (2002). An organic matter and nitrogen dynamics model for the ecological analysis of integrated aquaculture/agriculture systems: I. Model development and calibration. Environmental Modeling & Software 17: 571–582.

[89] Stevenson KT, Fitzsimmons KM, Clay PA, Alessa L, Kliskey A. Integration of aquaculture and arid lands agriculture for water reuse and reduced fertilizer dependency. Experimental Agriculture, 2010, 46.

[90] Cerozi, B.S. & Fitzsimmons, K., 2017. Phosphorus dynamics modeling and mass balance in an aquaponics system. Agricultural System, 153:94-100.

[91] Barben, S.A.; Hopkins, B.G.; Jolley, V.D.; Webb, B.L. & Nichols, B.A. Optimizing phosphorus and zinc concentrations in hydroponic chelator-buffered nutrient solution for Russet Burbank potato. J. Plant Nutr., 33:557- 570, 2010.

Characterization and Heating value Prediction of Municipal solid waste

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***Abstract*—** *There is an increasing trend of using municipal solid waste as an alternative energy resource, burning and converting it into energy in the form of heat or steam or electricity. The aim of this study is to predict energy value of MSW using compositional and proximate-based analysis of solid waste and compare the reliability of models in predicting the energy recovery potentials from different solid waste components. Physical characterization showed that food, yard, textile, leather, rubber, wood scrap, yard, metal, plastic and paper waste were the constituents of all waste samples in the study area, but in varying proportions. The energy content of combustible solid waste was estimated to be 17.50 MJ/kg for gross heating value, and 9.54 MJ/kg for net heating value, which revealed the suitability of solid waste as energy recovery option. In this study several proposed composition and proximate-based mathematical models have been used to estimate the HHV of municipal solid waste. The average high heating values estimated from some models were found to be 16.27 ± 0.90 MJ/kg (Model II), 16.45 ± 0.43 MJ/kg (Model III), 18.97 ± 0.03 MJ/kg (Model XVIII), and 16.60 ± 0.32 MJ/kg (Model XXIV) which were closely match the value with experimentally determined calorific value as 17.50 ± 0.68 MJ/kg. Therefore, it is concluded that the quantity of energy obtainable from a known amount and composition of mixed solid waste can be estimated using already developed models without conducting calorimetric experiments.*

***Keywords*— Characterization, Heating value; Models, Proximate Analysis, Municipal solid waste.**

I. INTRODUCTION

Municipal solid wastes, collected from cities, have recently thought as one of the important renewable energy resources. Recovering energy by means of a number of energy generation processes such as combustion, pyrolysis and gasification from municipal solid waste is feasible [1]. This method will reduce the quantity of incoming solid waste to dumping site and also open opportunities for new technologies in treating MSW. The first step to understand the feasibility of design energy conversion (incineration plan) is to obtain the basic data regarding to quantity and quality of generated MSW [2].

This research study was primarily motivated by the lack of laboratory facilities in calorific value and ultimate analysis in Ethiopia and this article is a continuation of Fetene et al., [3] and aims to determine the reliability of models in predicting the energy recovery potentials from different solid waste components at Jimma city households. Researchers have developed many empirical models. The mathematic models for the evaluation of heating value from physical and chemical properties have been developed by several researchers, and have reviewed several of these models based on physical composition and proximate and ultimate analysis [4]–[9]. However, given the determination of ultimate analysis data is relatively expensive, therefore, for the practice purpose correlation based on proximate analysis data will be more profitable. This data is the easiest and most widely used in the characterization of fuels mainly solid fuel.

II. MATERIALS AND METHODS

2.1 Sampling Protocol and waste characteristics

Each of the 6 districts/kebeles was sampled at random three times a year in all seasons namely: dry (March), rainy (July), and in between the two seasons (November) [10], [11]. The waste from the assigned households was collected onto a clean, impervious floor where it was mixed rapidly with a shovel and quartered. Finally, components of solid wastes were sorted, weighed and recorded based on the standard procedure [10], [11]. Homogenized samples with appropriate sampling, handling and transportation mechanism were taken to laboratory for proximate analysis and calorific value determination.

2.2 Proximate analysis

The proximate analysis, gives percent of moisture content, ash content, volatile matter and fixed carbon, were determined by putting the samples to different range of temperature (100°C to 950°C). The laboratory methods to measuring the proximate analysis of samples in this study were conducted according to ASTM standards described in [10], [12] [13], [14].

2.2.1 Moisture content (ASTM D 3173)

The sample will be dried in an oven at 105°C for one hour to a constant weight. The percent MC was calculated as a percentage loss in weight before and after drying for each solid waste component.

2.2.2 Ash Contents (ASTM D 3174)

The ash content was determined by drying the samples and burning at 750°C for 1 hour in a furnace.

2.2.3 Volatile matter (ASTM D 3175)

The dried sample will be heated at 950°C for seven minute in muffle furnace. After combustion, the samples were weighed to determine the ash dry weight, with volatile solids being the difference between the dried solids and the ash

2.2.4 Fixed Carbon

The carbon content in the ash sample was determined by removing the mass of volatile from the original mass of the sample using the following equation:

$$\mathrm{FC} = 100 - (\%\mathrm{MC} + \%\mathrm{AC} + \%\mathrm{VS})$$

Where: MC is moisture content, AC is Ash content, VS is Volatile matter

2.3 Prediction of Energy content (calorific value)

Calorific value of solid waste usually described in terms of high heat value (HHV) and lower heat value (LHV), which can be determined either experimentally using Bomb calorimeter or by using mathematical models [15]. The calorific value, expressed as kcal/kg or KJ/Kg, Experimentally energy value is determined using Bomb calorimeter (ASTM D 5865-85) in which the heat generated at a constant temperature of 25^{o}C from the combustion of a dry sample is measured [16] [17], [18].

In case when direct calorific value measurements are not feasible, empirical models can be useful to predict the calorific value of municipal solid waste (MSW) [23]. Several models have been developed to describe and predict the energy content of commingled MSW. The common independent variables in such empirical models are either the elemental composition [23], the physical composition [24] or the proximate composition (i.e., the content in volatile matter, moisture, fixed carbon) of MSW [20]. Some of the models that correlate the energy content of MSW with its composition and proximate analysis used in study presented in Table 1 & 2.

TABLE 1
MODELS SELECTED FROM LITERATURE REVIEW FOR THE PREDICTION OF HEATING VALUE BASED ON SOLID WASTE COMPOSITIONAL ANALYSIS

Models	Models Equation	Basis	Units	References
Model I	$LHV = (23(P_{Fo} + 3.6P_{Pa}) + 160(P_{Pt} + P_{Ru})) \times 2.326$	Wet	kJ/kg	[19]
Model II	$HHV = 112.15P_{Fo} + 183.386P_{Pa} + 288.737P_{Pt} + 5064.701$	Wet	kJ/kg	[20]
Model III	$HHV = 81.209P_{Fo} + 285.035P_{Pa} + 8724.209$	Wet	kJ/kg	[21]
Model IV	$HHV = 112.15P_{Fo} + 184.366P_{Pa} + 298.343P_{pt} - 1.920M + 5130.380$	Wet	kJ/kg	[21]
Model V	$LHV = 6.0P_{Fo} + 22.1P_{pa} + 28.1P_{Pt} + 12.7P_{Wo} + 24.6P_{Te} + 57.4P_{Ru} + 17.2P_{Mi}$	Wet	Kcal/kg	[22]
Model VI	$LHV = (45.2P_{Fo} + 47.3P_{Pa} + 58.6P_{Pt} + 32.4P_{Wo} + 38.6P_{Te} + 62.3P_{Ru} + 50.1P_{Mi})(100-M)/100-6M$	Dry	Kcal/kg	[22]
Model VII	$LHV = (42.21T_{Ga} + 35.19P_{Pa} + 71.17P_{Pt} + 48.06P_{Wo} + 36.24P_{Te} + 44P_{Mi})(100-M)/100-6M$	Dry	Kcal/kg	[22]
Model VIII	$LHV = 2229.91 + 4.87T_{Ga} + 7.9P_{Pa} – 37.28M$	Dry	Kcal/kg	[23]
Model IX	$HHV = 267.0(P_{Pt}/P_{Pa}) + 2285.7$	Dry	Kcal/kg	[24]
Model X	$HHV = [88.2P_{Pt} + 40.5(P_{Fo} + P_{Pa})] (100-W)/100 – 6W$	Dry	Kcal/kg	[24]
Model XI	$HHV = [(100 – W)/100][38.8(P_{Pa} + P_{Fo} + P_{T} + P_{Oc}) + 50.9(P_{Te} + P_{Ru}) + 73.7P_{Pt}] – 6W$	Dry	Kcal/kg	[20]
	P_{Fo}: food waste (wt%); P_{Pa}: paper and cardboard (wt%); P_{Pt}: plastics or plastics and rubber (wt%); P_{Ru}: rubber (wt%); M: moisture (wt%); P_{Wo}: wood waste (wt%); P_{Te}: textile (wt%); P_{Mi}: miscellaneous components (wt%); T_{Ga} : garbage (wt%; textiles, wood, food waste, miscellaneous also included); W: water (wt%); P_T: wood and glass (wt%); P_{Oc}: other combustibles (wt%).			

TABLE 2
MODELS SELECTED FROM LITERATURE REVIEW FOR THE PREDICTION OF HEATING VALUE BASED ON SOLID WASTE PROXIMATE ANALYSIS:

Models	Models Equation	Basis	Units	References
XII	HHV = -0.125M + 17.251	Dry (Wt %)	MJ/kg	[12]
XIII	HHV = 19.44 - 0.258A	Dry (Wt %)	MJ/kg	[12]
XIV	HHV = 2.467 + 0.196VM	Dry (Wt %)	MJ/kg	[12]
XV	HHV = 9.355 + 0.38FC	Dry (Wt %)	MJ/kg	[12]
XVI	HHV = -9.509 +0.259(VM+FC)	Dry (Wt %)	MJ/kg	[12]
XVII	HHV = -30.727 + 0.459VM + 0.716FC	Dry (Wt %)	MJ/kg	[12]
XVIII	HHV = 0.192A + 0.459VM + 0.716FC - 30.727	Dry (Wt %)	MJ/kg	[12]
XIX	HHV = 0.185A + 0.467VM + 0.712FC + 0.056M - 31.723	Dry (Wt %)	MJ/kg	[12]
XX	HHV = 0.226A + 0.519(VM+ FC) -31.916	Dry (Wt %)	MJ/kg	[12]
XXI	HHV = -10.81408 + 0.3133(VM + FC)	Dry (Wt %)	MJ/kg	[21]
XXII	HHV = 19.914 - 0.2324A	Dry (Wt %)	MJ/kg	[8]
XXIII	HHV = -3.0368 + 0.2218VM + 0.2601FC	Dry (Wt %)	MJ/kg	[8]
XXIV	HHV = 0.196FC + 14.119	Dry (Wt %)	MJ/kg	[6]
XXV	HHV = 0.312FC + 0.1534VM	Dry (Wt %)	MJ/kg	[25]
XXVI	HHV = 0.3543FC + 0.1708VM	Dry (Wt %)	MJ/kg	[26]
XXVII	HHV = 356.248VM - 6998.497	Dry (Wt %)	KJ/Kg	[20]
XXVIII	HHV = 356.047VM - 118.035FC - 5600.613	Dry (Wt %)	KJ/Kg	[20]
XXIX	HHV = 44.75VM - 5.85W + 21.2	Wet (Wt %)	Kcal/Kg	[20]

III. RESULTS AND DISCUSSION

3.1 Waste characterization Studies

The composition of household solid waste are not homogeneous, it vary according to changes in commercial activities, population behaviour, consumption patterns and economic growth rates. Food waste that include food left over, egg shells, fruit or vegetable peels, cooked food, and food preparation wastes from residences comprise the largest component of Jimma town HHs MSW stream which accounts 35.14%. Yard waste comprises the second largest components of Jimma town MSW stream (23.65%), which includes grass clippings, leaves, and tree trimmings. Paper and paper products comprise 17.08% of Jimma household MSW stream. This result is in agreement with those results obtained for Ethiopian cities Diriba [27] in

Hawassa town, Cheru [28] in Dessie town where the food and yard waste were found to be the major component of the solid waste stream generated. The products that comprise paper and paperboard wastes are newspapers, magazines, office papers, tissue paper, cigarette packages and towels, paper plates and cups, corrugated boxes, milk cartons. Plastic products comprise 14.3% of the total MSW in Jimma town. Plastic products were found in nondurable goods (plastic plates and cups, trash bags, disposable diapers), and plastic containers and packaging (soft drink bottles, bags, sacks, wraps). The plastic products are consisting mainly of plastic food items, trash bags, milk and water bottles, and soft drink bottles.

Metals comprising 0.07% of the total MSW consists mainly of aluminium (foil), ferrous metals (iron and steel found in appliances, furniture, and corroded metal scrap, containers and packaging materials), and non-ferrous metals (copper, zinc, and lead found in durable products such as appliances and consumer electronics). Glass and ceramics products comprise 0.40% of the total MSW and occurred primarily in the form of containers as soft drink bottles, bottles and jars of food, and other consumer products. Textile (occurred in discarded clothing, footwear) and rubber and leather products (occurred in bicycle tires, Leather (clothing and shoes) were found in Jimma MSW stream in small amount (1.07% and 1.46% respectively). Some hazardous materials (insignificant amount) were also recognized in Household MSW stream of Jimma town such as paint strippers, batteries and paint residues. Accordingly, about 33.31% of total wastes generated have a potential for recycling and consisting of paper products (17.08%), plastic waste (14.3%), wood scrap waste (1.46%), metals waste (0.07%), and glass and ceramics waste (0.4%). Knowing that not whole portion of paper, plastic, wood scrap, metals and glass and ceramics waste are applicable for recycling; a separate study should be conducted to separate all materials into recyclable and non-recyclable portion. In general, household solid waste in Jimma city is characterized by a high organic content and combustible matter consisting of food, yard, textile, paper, and plastic comprising 91.24% of the total waste suggesting that energy and plant nutrients can be recovered.

As Figure 2 shows, the result from quantity of yard waste wasn't consistent during the sampling period and fluctuated from 21.05 to 26.31%. Another main component was the paper and paper which made about 17.08% and 14.3% of the total weight. According to the result from sorting process, the amount of mixed paper, wood, Rubber & Leather, glass & ceramics and metals that comes from residential weren't much different during the sampling period, with an average 17.08%, 0.52%, 1.46%, 0.40%, and 0.07% of total waste per day respectively (Fig. 1).

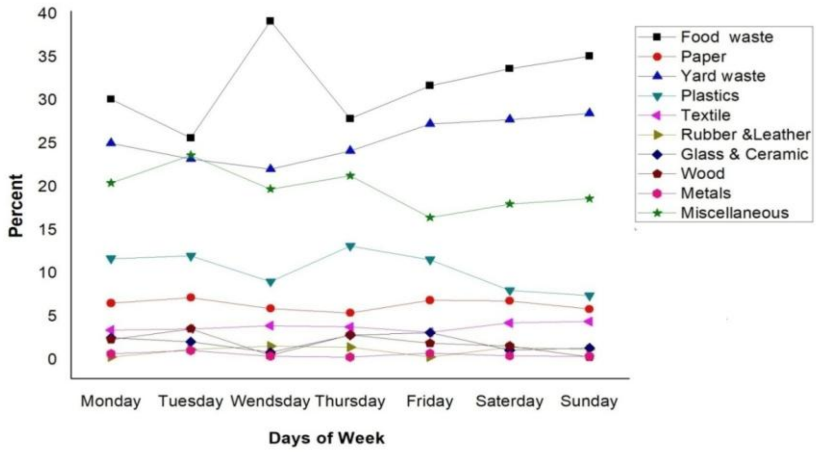

FIGURE 1: Variation of waste categories quantity within a week

3.2 Chemical Waste composition Analysis

Another important parameters used for prediction of MSW heating value is proximate analysis basically it helps in deciding and setting up a good waste processing and disposal facility in the city and in determination of efficiency of a waste treatment process [29]. Proximate analysis involves determination of moisture content, volatile matter, ash content and fixed carbon of sample. The analysis was performed according to ASTM method. In [3] were reported that MSM in Jimma city, containing an average of 63.38% volatile matter, 3.13% ash, and 4.08% fixed carbon in dry basis, and the average moisture content is 39.60%. High moisture content of solid waste has negative and undesirable effect on applicability of the waste for energy recovery as it adds weight to the fuel without adding to the heating value. Result from moisture content analysis directly affected by the quantity of wet basis materials such as yard waste and food waste in waste stream. Higher percentage of yard waste (28.17%) and food waste (34.79%) on Sunday compare with result on Tuesday (yard waste 22.92 % and food waste 25.33%) is the reason of increasing the percentage of moisture content.

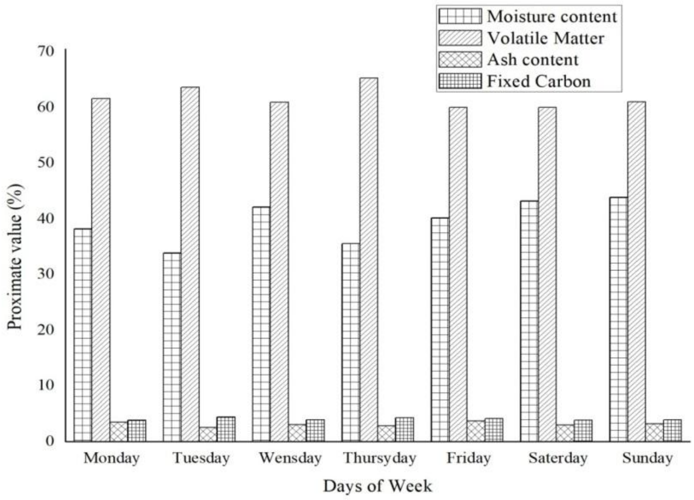

FIGURE 2: Obtained results from proximate analysis of composite household solid waste

The inorganic components including miscellaneous present in the sample (stones, metals, glass, etc.) were removed from laboratory analysis after sorting. Therefore, only the selected organic & combustible fraction of the households MSW was analysed. Based on the above, the results of the analyses of the household MSW are expressed on a per organic fraction basis; that is, the results are expressed per MSW fraction after the removal of the inorganic components (stones, glass, metals), since no calorific value analyses were performed on the inorganic fraction. To express calorific value per total commingled MSW, then the values reported here should be multiplied by [1- inorganic fraction of the commingled MSW]. The inorganic fraction of the commingled MSW used in this research work ranged from 0.16 to 0.23.

3.3 Heating value (Calorific value)

3.3.1 Experimental Result using Bomb calorimeter

Calorific value is the amount of heat generated from combustion of a unit weight of a substance, expressed as kcal/kg (KJ/Kg). The calorific value is determined experimentally using Bomb calorimeter in which the heat generated at a constant temperature of 25˚C from the combustion of a dry sample is measured. Since the test temperature is below the boiling point of water, the combustion water remains in the liquid state. However, during combustion the temperature of the combustion gases remains above 100˚C so that the water resulting from combustion is in the vapor state shows typical values of the residue. The experimental result indicated that the energy content of the Jimma city HHs solid waste was vary from 16.35 to 17.98MJ/kg (Fig. 3) with the average value of 17.5 MJ/kg as dry basis and 9.54 MJ/kg for net heating value which fit the minimum level value required for incineration projects [3]. The acceptable recommended energy recovery range from solid waste suggested by Whiting is 7.50 MJ/kg to 12 MJ/kg [30]. The heating value of composite (mixed) HHs solid waste (9.54 – 17.5 MJ/kg) was approximately about one-half of the calorific value of coal (25 – 30 MJ/kg) and one-third of fuel oil (45 MJ/kg) and Natural gas (54.75 MJ/kg) [3].

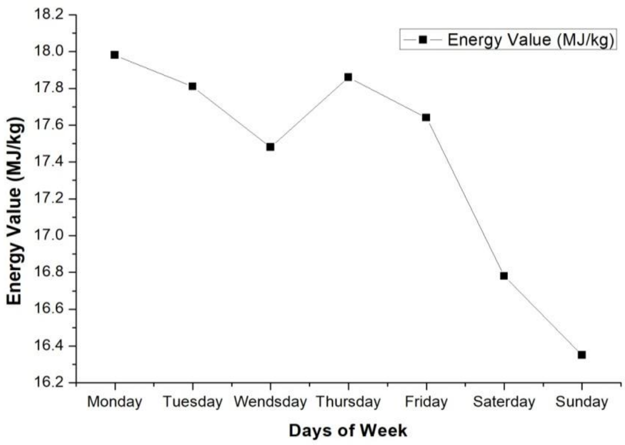

FIGURE 3: HHV values (MJ/Kg) determined from laboratory analysis

3.3.2 Energy values determined using mathematical models

The elemental composition of MSW can significantly vary among countries, regions and cities, as a result of differences of the physical composition of MSW [3], [31]–[33]. The physical composition of MSW is usually dependent on the socio-economic conditions of a country, its population size, the climatic conditions and the national environmental legislation [24]. The knowledge of the calorific value of MSW is necessary to design MSW incinerators for energy recovery purposes [23], [34]. In case of laboratory calorific value measurements are not feasible, empirical models can be used to predict the calorific value of municipal solid waste [23]. For this study some models have been used to predict the calorific value of mixed solid waste [20], [24].

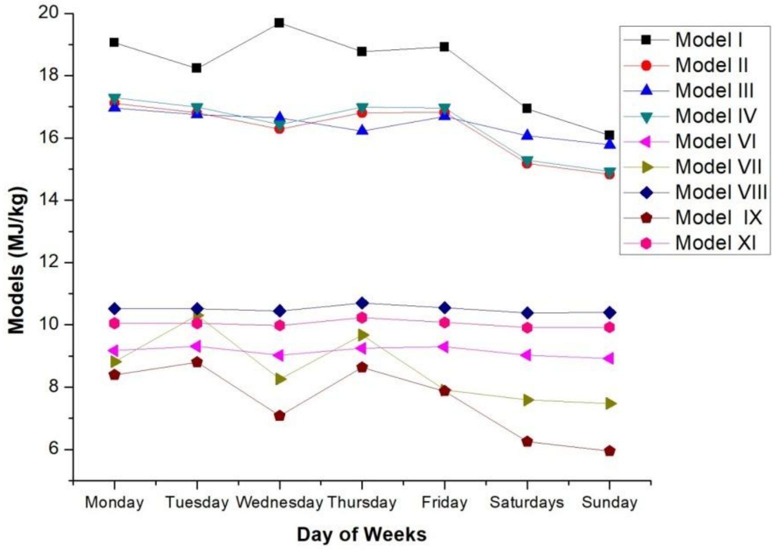

FIGURE 4: HHV values (MJ/Kg) from model based on Composition analysis.

According to thus models (model I-XI) plastics waste (Pl) appears to be the dominant predictor of calorific value. Yard and paper waste do not appear in all of the models, whilst food waste are almost always present, except from some models (model VII, VIII & IX) in which food waste is absent (Table 1). Models (XII - XXIX) are empirical formulas that are based on the proximate analysis of MSW (Table 2) which includes the weight of the organic matter (i.e., volatile matter) as the main predictor, fixed carbon and moisture contents of calorific value. The advantage of using proximate analysis data were that it gave result based on sample sizes where about models [23]. The positive point is that, these models do give an accurate estimation of the calorific values of the samples.

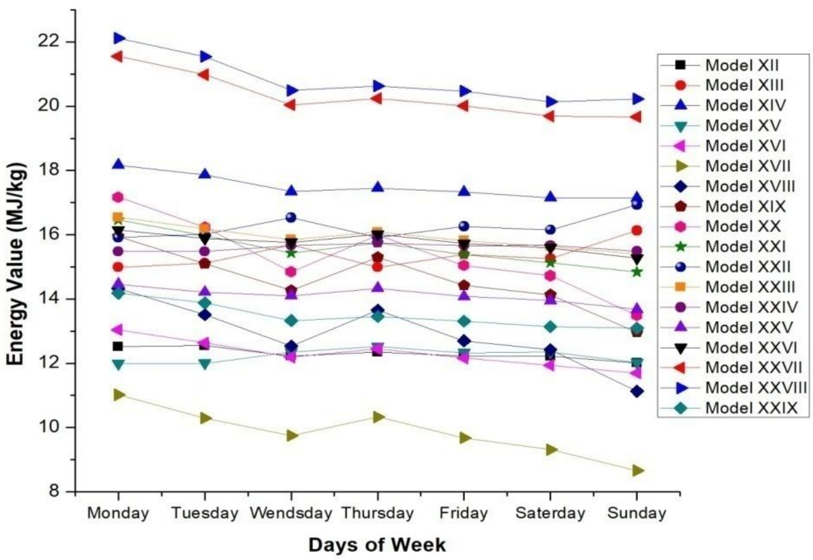

FIGURE 5: HHV values (MJ/kg) from model based on proximate analysis

Based on composition and proximate analysis the predicted HHV values as compare to selected different days of sampling period, Food, plastic and paper waste are the examples of components which contribute positively towards the calorific value. Plastic as an individual component accounted for about 14.3% of the total daily disposal MSW and contribute the most of the heating value (40,809.7KJ/kg) followed by paper (16,192.62 KJ/kg) and yard waste (16,411.88 KJ/kg). Increasing the amount of plastic in waste stream on Thursday compare to Wednesday was a reason on obtained the higher volatile matter and higher value of HHV in that day. As figure 5 & 6 showed that there were small difference between the results from model II (R^2 = 0.667), model III (R^2 = 0.768), model IV (R^2 = 0.667), model XIV (R^2 = 0.823), model XVI (R^2 = 0.877), model XVII (R^2 = 0.837) and model XX (R^2 = 0.789) gave the almost good prediction of HHV values as compare to others model (Fig. 5-8). Thus, model XIV, model XVI, model XVII and model XX were the best model in this category compared to the actual HHV laboratory result (17.5 M /Kg). The finding of compositional and proximate analysis results strengthens the argument that models are best suited in their own area and this finding precise and accurate in predicting the HHV of MSW in Jimma city.

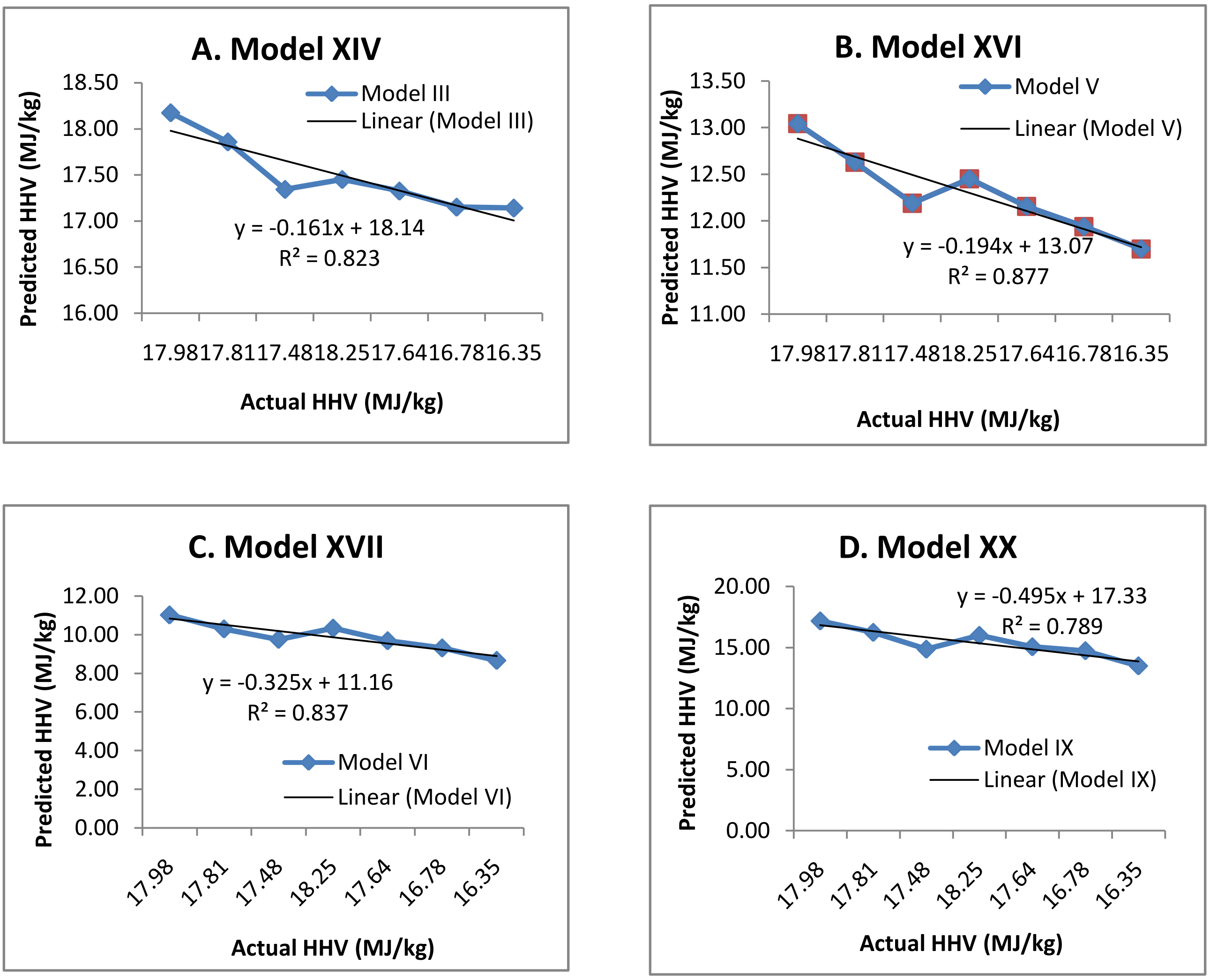

FIGURE 6: R^2 values of selected models from proximate based analysis

The linear analysis confirmed that the assumption of a linear relationship was valid, and as expected, the model indicates that plastics, paper, and organic contribute positively to the energy content, while water is negatively correlated.

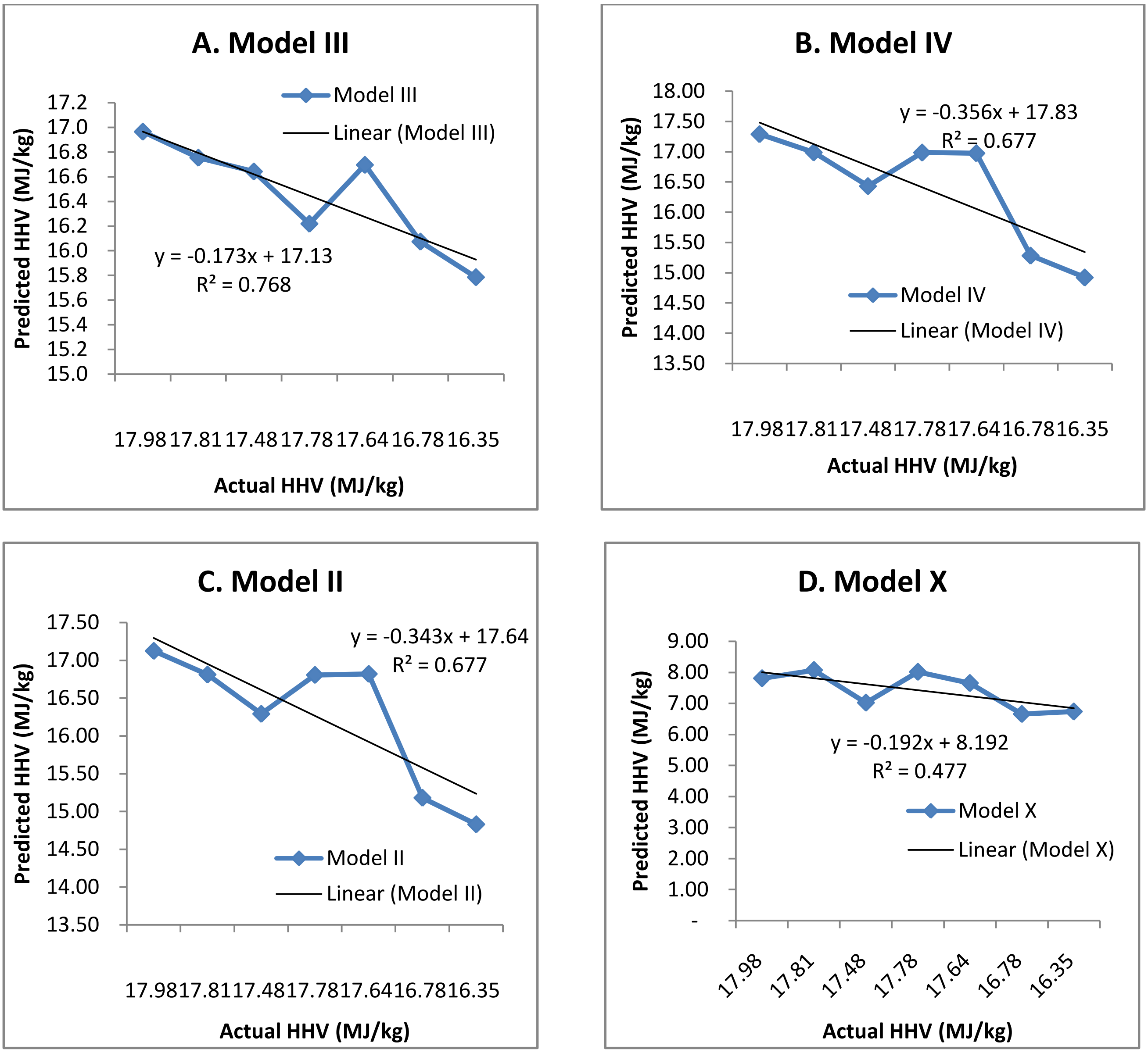

FIGURE 7: R^2 values of selected models from Composition based analysis

IV. CONCLUSION

Physical characterization showed that a high combustible matter and organic waste consisting of food, yard, paper, plastic, wood scrap, and textile waste comprised 91.24% of the total waste of Jimma city household solid waste, suggesting concerting the waste to some economic and environmental characteristics. Estimates of the energy content of Jimma city's household solid waste were made based on Experimental heating and mathematical models developed based on physical composition and proximate analysis. Experimental values led to an estimation of 17.5 MJ/kg for gross heating value, and 9.54 MJ/kg for net heating value which fit the minimum level value required for incineration projects. Generally the heating value of Jimma city household solid waste make it attractive feeds for clean energy production instead of fossil-based solid fuels and can be alternative to the conventional fuels partially due to their high calorific value. The high heating values estimated from selected models were found to be closely matched the value determined experimentally. Therefore, it is concluded that the quantity of energy obtainable from a known amount and composition of solid waste can be estimated without conducting laboratory calorimetric experiments.

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REFERENCES

[1] A. Kalantarifard and G. S. Yang, "Energy Potential from Municipal Solid waste in Tanjung Langsat Landfill, Johor, Malaysia," *Int. J. Eng. Scienece Technol.*, vol. 3, no. 12, pp. 8560–8568, 2011.

[2] E. Akkaya and A. Demir, "Energy Content Estimation of Municipal Solid Waste By Multiple Regression Analysis," in *5th International Advanced Technologies Symposium (IATS'09)*, 2009, pp. 1–4.

[3] Y. Fetene, T. Addis, A. Beyene, and H. Kloos, "Valorisation of solid waste as key opportunity for green city development in the growing urban areas of the developing world," *J. Environ. Chem. Eng.*, vol. 6, no. 6, pp. 7144–7151, 2018.

[4] M. Gunamantha, "Prediction of Higher Heating Value Bioorganic Fraction of Municipal Solid Waste from Proximate Analysis Data," *Int. J. Eng. Res. Technlogy*, vol. 5, no. 02, pp. 442–447, 2016.

[5] A. Ebrahimi, M. M. Amin, B. Bina, M. Mokhtari, and H. R. Alaghebandan, "Prediction of the energy content of the municipal solid waste," *Int. J. Environ. Health Eng.*, vol. 1, no. 6, pp. 45–51, 2012.

[6] A. Demirbas and A. H. Demirbas, "Estimating the Calorific Values of Lignocellulosic Fuels," *Energy Explor. Exploit.*, vol. 22, no. 2, pp. 135–143, 2004.

[7] X. Qian, S. Lee, A. Soto, and G. Chen, "Regression Model to Predict the Higher Heating Value of Poultry Waste from Proximate Analysis," *MDPI, Resour.*, vol. 7, no. 39, 2018.

[8] C. Sheng and J. L. T. Azevedo, "Estimating the higher heating value of biomass fuels from basic analysis data," *Biomass and Bioenergy*, vol. 28, no. 5, p. 7009, 2005.

[9] H. Shu *et al.*, "Prediction for Energy Content of Taiwan Municipal Solid Waste Using Multilayer Perceptron Neural Networks," *J. Air Waste Manage. Assoc.*, vol. 56, no. 6, pp. 852–858, 2012.

[10] E. Gidarakos, G. Havas, and P. Ntzamilis, "Municipal solid waste composition determination supporting the integrated solid waste management system in the island of Crete," *Waste Manag.*, 2005.

[11] T. Getahun *et al.*, "Municipal solid waste generation in growing urban areas in Africa : Current practices and relation to socioeconomic ...," *Environ. Monit. Assess.*, no. July, 2011.

[12] M. Gunamantha, "Prediction of Higher Heating Value Bioorganic Fraction of Municipal Solid Waste from Proximate Analysis Data," *Int. J. Eng. Res. Technol.*, vol. 5, no. 02, pp. 442–447, 2016.

[13] K. Amin and Y. Go Su, "Identification of the Municipal Solid Waste Characteristics and Potential of Plastic Recovery at Bakri Landfill, Muar, Malaysia. Journal of Sustainable Development , 1913-9071.," *J. Sustain. Dev.*, pp. 1913–9071, 2012.

[14] D. D. Gupte and P. G. Saptarshi, "Supply Chain Management as a Tool for Collection and Disposal of Organic Waste in Pune," *Univers. J. Environ. Res. Technol.*, vol. 4, no. 2, pp. 261–268, 2012.

[15] A. Johari, H. Hashim, R. Mat, H. Alias, M. H. Hassim, and M. Rozainee, "Generalizatio, Formulation and Heat Contents of Simulated MSW with High Moisture Content," *J. Eng. Sci. Technol.*, vol. 7, no. 6, pp. 701–710, 2012.

[16] S. Kumar, V. Subbaiah, P. Rao, M. Engineering, and S. C. R. Reddy, "Waste to Energy – A case study of Eluru city , Andhra Pradesh," *Int. J. Environ. Sci.*, vol. 1, no. 2, pp. 151–162, 2010.

[17] J. S. Kumar, R. P. Prasada, and K. V. Subbaiah, "Waste to Energy– A case study of Eluru city, Andhra Pradesh," *Int. J. Environ. Sci.*, vol. 1, no. 2, pp. 151–162, 2010.

[18] R. Charles, J. S. Leander, B. Robert, and G. Mary, *In Waste Management and Resource Recovery*. Florida: CRC Press LLC, 1995.

[19] M. Z. A. Khan and Z. H. Abu-Ghararah, "New approach for estimating energy of municipal solid waste," *J. Environ. Engng*, vol. 3, pp. 376–380, 1991.

[20] S. Kathiravale, M. Yunus, K. Sopian, A. Samsuddin, and R. Rahman, "Modeling the heating value of Municipal Solid Waste," *Fuel*, vol. 82, pp. 1119–1125, 2003.

[21] L. Jiménez and F. González, "Study of the physical and chemical properties of lignocellulosic residues with a view to the production of fuels," *Fuel*, vol. 70, no. 8, pp. 947–950, 1991.

[22] A. Demirbas, "Relationships proximate analysis results and higher heating values of lignites," *Energy Sources, Part A Recover. Util. Environ. Eff.*, vol. 30, no. 20, pp. 1876–1883, 2008.

[23] J. Liu, R. D. Paode, T. M. Holsen, and J. Liu, "Modeling the Energy Content of Municipal Solid Waste Using Multiple Regression Analysis Modeling the Energy Content of Municipal Solid Waste Using Multiple Regression Analysis," *J. Air Waste Manage. Assoc.*, vol. 46, no. 7, pp. 650–656, 2012.

[24] M. Abu-Qudais and H. Abu-Qdais, "Energy content of municipal solid waste in Jordan and its potential utilization," *Energy Convers. Manag.*, vol. 41, pp. 983–991, 2000.

[25] A. Demirbas, "Calculation of higher heating values of biomass fuels," *Fuel*, vol. 76, no. 5, pp. 431–4, 1997.

[26] T. Cordero, F. Marquez, J. Rodriquez-Mirasol, and J. J. Rodriguez, "Predicting heating values of lignocellulosic and carbonaceous materials from proximate analysis," *Fuel*, vol. 80, no. 2, pp. 1567–71, 2001.

[27] D. Dirba, "Household Solid waste generation rate, Composition and content analysis for disposal and resource recovery in two selected kebeles of Hawassa Town.," Addis Ababa University, 2009.

[28] S. Cheru, "Assessment of Municipal solid waste management service in Dessie town.," Addis Ababa, 2011.

[29] K. Sapna, S., N. C., K. N. Arvind, and K. M. K., "Characterization of Municipal Solid Waste in Jalandhar City, Punjab, India," *J. Hazardous, Toxic, Radioact. Waste*, pp. 97–106, 2013.

[30] K. Whiting, "Large scale MSW incineration Technologies. Incineration of municipal Waste Report,. Leeds, UK: University of Leeds, Department of Fuel and Energy.," Leeds, UK, 2002.

[31] M. Onifade, A. I. Lawal, A. E. Aladejare, S. Bada, and M. A. Idris, "Prediction of gross calorific value of solid fuels from their proximate analysis using soft computing and regression analysis," *Int. J. Coal Prep. Util.*, pp. 1–15, 2019.

[32] H. Aslani and H. Taghipour, "Seasonal characterization and quantification of municipal solid waste: energy content and statistical analysis," *J. Adv. Environ. Heal. Res.*, vol. 6, pp. 34–43, 2018.

[33] K. Haro, I. Ouarma, B. Nana, A. Bere, and J. Koulidiati, "Characterization and Potential Recovery of Household Solid Waste in the City of Ouagadougou (Burkina Faso)," *J. Environ. Prot. (Irvine,. Calif).*, vol. 9, pp. 309–324, 2018.

[34] M. Rawat, A. L. Ramanathan, and T. Kuriakose, "Characterisation of Municipal Solid Waste Compost (MSWC) from Selected Indian Cities: A Case Study for Its Sustainable Utilisation," *J. Environ. Prot. (Irvine,. Calif).*, vol. 4, pp. 163–171, 2013.

Effect of Pollination Methods on Fruit Set, Yield, Physical and Chemical Properties of Hayani Date Palm Cultivar

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Abstract— *Field experiment was carried out at Ghour AlSafi in Jordan valley to study the effect of pollination methods on fruit set, yield and some fruit characteristics of Hayani date palm cultivars. Results showed that hand pollination method has better fruit set and yield, but it showed a reduction in fruit weight owing to the obvious increase in yield. The pollination method significantly affected fruit related traits particularly fruit diameter, fruit length to diameter ratio and total soluble solid (TSS).*

Keywords— Fruit set, hand duster pollination, hand pollination, Hayani, pollen grain germination.

I. INTRODUCTION

Date palm trees are classified as a evergreen dioecious fruit tree, where the male and female flowers exist on separated trees. In fruits with seeds, successful fruit set are dependent on the efficacy of pollination. Successful pollination is critical for kernal formation and fruit growth and development, especially in nuts and in drupe fruits with one seed like dates and stone fruits. Pollination in date palm is defined as a transfer of pollen grain from male to female tree either naturally or by hand or mechanical methods. Pollination of 60-80% of the female flowers is considered satisfactory and will usually lead to a good fruit set (Al–Ekidy, 2000).

The date palm naturally is wind pollinated, but this method was inefficient and economically unfeasible (AL-Bakr, 1972). The traditional pollination method in date palm that commonly used in Middle East region is hand pollination. However the mechanical pollination requires mixing the pollen grains with a filler material to minimize the amount needed from pollen grains. Different filler materials were tried such as wheat flour, wheat bran, starch and crushed dry male flowers after the pollen grains extraction. (El-Refaey and El- Dengaw, 2017 and Samouni, et al, 2016)

The pollination methods could affect physical and chemical properties on date fruits. There are many opinions to determine which pollination method is better in date palms. Most of the research results showed that the hand pollination in date palm is very effective to obtain a high fruit set. For example, in 'Samani' date, wind pollination method gave significantly higher in fruit length, diameter, weight, flesh weight, flesh/seed weight ratio and TSS than hand pollination, but gave lower fruit set percentage than in hand pollination (Bakr, et al, 1988).

Previous studies focused on studying the effect of different pollination methods on physical characteristics of the date fruits (Hamood and Mawlood, 1986; Shabana et al, 1986 and Ibrahim, 1988). In general, these studies suggested that mechanical pollination increased labor efficiency, produced comparable yield with lower fruit set, required more pollen and offered greater returns compared to hand pollination. Many previous studies showed that fruit set, yield and fruit quality in mechanical pollination were close to those of hand pollination (Brown et al. 1969; Brown et al, 1970; Hamood and Shalash, 1987 and Shabana et al, 1998). El- Mardi et al, (2002), pointed out that many factors could influence the efficiency of mechanical pollination, including weather, physiological conditions of the palms and their arrangement and spacing in the orchard.

In 'Kustawi' date palm, Al-Khafaji, (1993), did not obtain any significant differences between hand and mechanical pollination with regard to fruit set, bunch weight, water content, TSS and total sugar using different pollen grain dilutions 1:6 or 1:9 or 1:12 (pollen: filler ratio). These results indicated that the economic advantages of using the mechanical pollination compared to the difficult and the cost of hand pollination method.

Othman et al. (1990) explained that the hand pollination on 'Sayer' flower date gave higher fruit weight and mesocarp during Khalal stage, where mechanical pollination gave higher fruit diameter, larger fruit size and higher moisture content, during Khalal and Rutab stage. However, there were no significant differences between both methods in regard to total soluble solid during Khalal and Rutab stages. EL-Makhtoun et al. (1995) found that the dust pollination treatment significantly increased fruit and flesh weight, seed weight, flesh/seed ratio, fruit dimensions, TSS, total sugar and reducing sugar, than those of normal hand pollination in 'Zaghloly' date.

El-Mardi et al, (2002) used different pollination methods (hand pollination, hand duster and motorized duster in various ratios with filler). The motorized duster produced lower fruit set than hand duster, and that was probably due to the large amount of pollen being blown away from the target, and the lowest fruit set was obtained in hand pollination. But they found that, there was no significant effect of pollination method on yield and physical or chemical properties during the same stage of fruit development.

Soilman et al, (2017) examined the impact of water suspension spray at different concentrations on some physical and chemical fruit properties on Segae date palm cultivar, they found the highest bunch weight and yield was produced from spray pollination at 2 gm pollen with 3 gm sugar per liter followed by hand pollination.

The aim of this study is to make a comparison between the hand and dusting pollination methods in relation to fruit set, yield, physical and chemical characteristics of date palm fruits under Ghour Al-safi / Jordan environmental conditions for Hayani dates palm cultivar.

II. MATERIAL AND METHOD:

2.1 Location

The field work of this experiment was carried out at Ghour Al Safi agricultural station, Ministry of Agricultural, Jordan. The laboratory work was done at Faculty of Agriculture at Mutah University, Karak, Jordan.

2.2 Plant material

Hayani cultivar of date palm was selected for this study. The trees for this experiment were chosen according to their uniformity, and they received the same cultural practices during growing season. The pollen grains were obtained from one source and the male spathes were collected after they had been mature. Pollination was done on March, 19.

2.3 Experimental works

2.3.1 Pollen grain germination test

The pollen grains germination was determined according to Albert, (1930) using media contains 15% sucrose and 1% agar. This media was poured in 12 petri dishes, then autoclaved for 2 hours at 120°C at1.5 bars for sterilization.

Half gram of pollen grains was sprayed on this medium; the petri dishes were placed in an incubator at 27^{o}C for four days. Initiation of a pollen tube growth is an evidence of germination. Percent of pollen grains germination was calculated as follow:

$$\%\ \text{of germination} = \frac{\text{Number of germinated pollens}}{\text{Total number of pollens}} \times 100 \quad (1)$$

2.3.2 Pollination methods

Six spadixs were determined for each tree by removing the early and late showing ones. Two pollination methods were used in this experiment. The first one was hand pollination (T1), while the second was hand duster pollination (T2). Each of these two-pollination methods had three spadixs in each tree (replicate). The first treatment was done by separating four strands of male flower from freshly opened male spathe and insert them, length wise and in an inverted position, between the strands of the female inflorescence spadix.

The second pollination method was hand duster pollination; it was developed mostly in the USA (Zaid and De wet, 2002). Pollen grains were extracting from male flowers and mixing with filler agent (White wheat flour, grade zero) in (1:5, pollen grains: filler agent). Then the mixture was put in a hand plastic sprayer and sprayed to female spadix. The pollination process was carried out two days after the opening female spadix. Each treatment was done separately from other treatments, by isolating the bunch with pieces of carton.

2.4 Measurements

2.4.1 Fruit set percent

Ten strands were chosen randomly from each female spadix to calculate fruit set percent. Number of fruit, on each strand was counted, and fruit set was calculated in two different stages during fruit growth. The first count, was done six weeks after pollination (Hababuk stage), the second count, was done 10 weeks after pollination (Kimri stage). Fruit set percentage was calculated by the following equation:

$$\%\ \text{of fruit set} = \frac{\text{Number of setted fruits}}{\text{Total number of flowers}} \times 100 \tag{2}$$

2.4.2 Yield

Fruit were harvested on August, 10 and the yield was recorded in Kg.

2.4.3 Physical and chemical measurements of fruit:

2.4.3.1 Physical properties

Samples of 10 fruits were randomly selected from each replicate for each spadix, to calculate the weight of fruit, seed weight, flesh weights (g) , ratio between flesh and seed weight, length and diameter (cm) by using caliper, and the ratio between length and diameter(L/D), then the means of these traits were calculated.

2.4.3.2 Chemical properties

A. Estimation of moisture percentage

The moisture percent was estimated by cutting five fruits from each replication for each spadix after seed were isolated, and then samples of 5 g from these fruits were taken. Therefore, they were put in vacuum oven at 65-70°C until constant weight was obtained. Finally the percent of moisture was calculated by the following equation:

$$\frac{\text{Fresh weight} - \text{Dry weight}}{\text{Fresh weight}} \times 100 \tag{3}$$

B. Total soluble solids

Four fruits from each spadix were chopped into small pieces and then crashed, place in cloth and squeezed. For juice extracting, Abbe refractometer was used for TSS.

C. Total soluble sugar determination:

Anthron method, used to estimate the total soluble sugar, the absorbance in spectrophotometer at 620 nm was read.

D. Reducing sugar determination

Luff Schorl method was used to estimate the reducing sugar in date fruits

The experimental design was Randomized Complete Block Design (RCBD) with 6 replications. Data were statistically analyzed using Duncan’s Multiple Range Test (DMRT) for means comparison at 0.05 % probability level.

III. RESULT AND DISCUSSION:

3.1 Pollen grain germination test

The pollen grains were cultured in media contains sucrose and agar on April, 13. After 4 days (April, 17), the germination percent was calculated for 12 samples and the mean of these samples was 72.8%.

3.2 Fruit set percent

3.2.1 Hababuk stage

Results showed that the highest fruit set percentage (47.02%) in 'Hayani' at Hababuk stage, was obtained by hand pollination (Table 1).

3.2.2 Kimri stage

Results showed that there were significant differences among the treatments in fruit set percent in Kimri stage for 'Hayani' cultivar (Table 1). The highest fruit set percentage 32.53% was obtained by hand pollination. The lowest fruit set percentage was obtained by hand duster method (27.97 %). In general, the best fruit set percentage obtained through hand pollination, in contrast with hand duster pollination method. There was a 5% decrease in fruit set percent by using hand dust pollination compared to hand pollination. This reduction in fruit set might be due to the lack of pollen grains arrives to female flower in hand duster pollination, or this probably due to keeping the male strands in place in hand pollination by tied the female cluster 5-7 cm from the outer end.

3.3 Yield per bunch:

Results of yield indicate that there were significant differences among different pollination treatments as shown (Table 1). The highest yield per bunch (10.46 kg), was obtained from hand pollination, while the hand duster pollination gave the lower yield (9.36 Kg). In general, the hand pollination gave the highest yield compared with hand duster pollination that decreased the yield to 1% in ‘Hayani’. The hand pollination gave higher yield than the hand dust pollination.

The present results are in disagreement with results obtained by many authors Brown *et al*. 1969; Brown *et al*, 1970; Hamood and Shalash, 1987 and Shabana *et al*, 1998), who found that the mechanical pollination was close to hand pollination in yield characteristics. Also these results were disagreement with Al Khafaji (1993), when he compared the mechanical pollination (pollen filler ratios were 1:6 or 9 or 12) with the hand pollination.

3.4 Physical properties

3.4.1 Average fruit length

Results indicate that pollination method did not affect fruit length (Table 1). The longest fruit was obtained from hand duster pollination and shortest one was by hand pollination.

Similar results were obtained by previous reports (Hamood and Mawlood, 1986; Shabana, *et al*, 1988. AlJuuburi, 1995; El-Mardi, *et al*, 1998), where they found no significant differences between hand and hand duster pollination with regard to fruit length .

3.4.2 Average fruit diameter

Fruit diameter was not significantly affected by pollination method in ‘Hayani’ (Table 1). The widest fruit diameters (2.34 cm) for ‘Hayani’ were obtained from hand duster pollination and the narrowest fruit diameters (2.17 cm) were obtained from hand pollination method.

These results were in disagreement with El-Makhtoun *et al*. (1995), who found that the dust pollination significantly increased the fruit dimension.

3.4.3 Length/Diameter Ratio

The data in table (1) illustrated that there were significant differences among the pollination methods in relation to length/diameter ratio in ‘Hayani’ date. The highest ratio was obtained from hand pollination (2.35), and the lowest (2.18) was from hand duster pollination. So that, the hand pollination resulted fruits were more elongated than fruits from hand duster pollination. These results are in agreement with El Makhtoun *et al*, (1995); they found that dust pollination treatment increased the fruit dimension.

3.4.4 Average fruit weight

It was noticed that the fruit weight was not significantly affected by pollination method (Table 1).

The hand duster pollination has the highest fruit weight in contrast with hand pollination.

These results are in agreement with results obtained by El-Makhtoun *et al* (1995), who reported, that dust pollination treatment increased the fruit weight, and also agreed with Hussein and Hassan, (2001), who found that hand pollination produced the lowest fruit weight. The present results are in disagreement with Othman *et al*, (1990), who worked on 'Sayer' date, and they found that, the higher fruit weight was obtained from hand pollination in contrast with mechanical pollination.

3.4.5 Average flesh weight

Flesh weight was not significantly affected by pollination methods applied (Table1). In general, higher flesh weight was obtained from hand duster pollination. This was possible due to the highest fruit weight in this treatment that cause highest flesh weight.

3.4.6 Average seed weight

Seed weight was not significantly affected by pollination method applied (Table 1)

3.4.7 Flesh/Seed Ratio

Flesh/ seed ratio was not significantly affected by pollination method (Table 1)

These results are disagreement with El-Makhtoun *et al*. (1995), who found that the dust pollination compared to hand pollination could significantly affect seed, flesh weight and seed/ flesh ratio.

3.5 Chemical properties

3.5.1 Moisture percent (Fresh weight)

There were no significant differences among the treatments of the fruits in related to moisture percent (Table 2). Generally, the hand pollination method gave higher moisture percent than in hand duster pollination method.

These results are in agreement with Hussein and Hassan (2001), who found that hand pollination gave highest moisture percent in their fruits.

3.5.2 Total Soluble Solid (TSS)

The TSS percent by hand dust pollination was lower than hand pollination in 'Hayani' date (Table 2).

These results disagree with the results obtained by El-Makhtoun *et al*, (1995) and Othman *et al*, (1990) who found that the hand pollination treatment significantly decreased TSS percent compared with dust pollination.

3.5.3 Total and reducing sugars:

It was noticed that the pollination method did not show any significant effect on total and reducing sugar (Table 2).

These results are in agreement with the results obtained by El-Makhtoun *et al*, (1995), who found that the dust pollination treatment increased total and reducing sugars.

TABLE 1
MEANS FOR PHYSICAL PROPERTIES IN 'HAYANI' DATE.

	T2	T1
Fruit set % at Hababuk stage	41.25 b	47.02 a
Fruit set % at Kimri stage	27.97 b	32.53 a
Yield (Kg)	9.36 b	10.46 a
Fruit length (Cm)	5.11 a	5.10 a
Fruit diameter (Cm)	2.34 bc	2.17 c
Length/diameter	2.18 b	2.35 a
Fruit weight (gm)	19.0 bc	18.73c
Flesh weight (gm)	17.23 a	16.98 a
Seed weight (gm)	1.56 a	1.51a
Flesh/seed	11.04 a	11.25 a
Moisture %	23.65 a	24.91a
TSS %	48.50bc	50 abc
Total sugar %	0.51 a	0.51 a
Reducing sugar %	0.35 a	0.23 a

**** Values within same rows that have different letters are significantly different at 0.05 level of probability according to DMRT.***

TABLE 2
MEANS FOR CHEMICAL PROPERTIES IN 'HAYANI' DATE

	T2	T1
Moisture %	24.91a	23.65 a
TSS %	50 abc	48.50bc
Total sugar %	0.51 a	0.51 a
Reducing sugar %	0.23 a	0.35 a

**** Values within same rows that have different letters are significantly different at 0.05 level of probability according to DMRT***

IV. CONCLUSION

The study aims to identify the effect of pollination method on the fruit set and yield of Hayani date palm cultivars. Pollination methods have significantly affected fruit set, yield and fruit weight; the percentage of fruit set and yield have increased using hand pollination compared to hand duster. Using hand duster has resulted in the highest fruit weight.

There is a significant effect of pollination method on the fruit diameter, length / diameter and TSS with ‘Hayani’ date. But there is no significant effect of pollination method on the fruit length, flesh weight, seed weight, flesh/ seed, moisture percentage and total and reducing sugar. There is a significant effect of pollination method on fruit diameter and length/ diameter in 'Hayani' date.

The hand pollination method was most preferable at Ghour-AL-Safi environmental condition than hand duster pollination. The hand duster pollination method must be repeated more than one time during pollination period, to obtain best fruit set percent.

REFERENCES

[1] AL-Bakr, A. (1972). The date palm pollination and thinning of the fruits. The date palm. AI-Ani Press, Baghdad, Iraq. 340-389.

[2] ALbert, D.W.1930.Viabilityof pollen and receptivity of pistillate flowers. Date growers Inst .rept.9: 5-6.

[3] Al–Ekidy, 2000, Date palm tree, science and technology of agriculture and industrialization. Dar zahran, Amman, Hashemite kingdom of Jordan.

[4] AL-Juburi, H. J. (1995). Effect of mechanical and hand pollination on some fruit characteristics and productivity of date palm trees *(Phoenix dactylifera* L.) ‘Fardh’ cultivar. J. King Saud Univ.7 (1): 97-126.

[5] AL-Khafaji, M.A. (1993).Mechanical pollination effect on fruit set, bunch weight and fruit characteristics of ‘Kustawi’ date palm. The Iraqi Journal of Agricultural Sciences .24(2):51-56.

[6] Bakr, E.I.; Selim, H.H. and Badawi, F.M. (1988). Effect of pollination method and some growth regulators spray on yield and fruit constituents in ‘Samani’ date. Propagation Symposium and palms cultivation in Arab countries, El-Ain, U.A.Emarat, :5-10.

[7] Brown, G.K.; Perkins R.M. and VIS, E.G. (1969). Temperature and heat unit occurrences during date pollination in the Coachella Valley of California. Date Growers' Inst. Report 46: 21 - 24.

[8] Brown, G.K.; Perkins R.M. and VIS, E.G. (1970). Mechanical pollination experiments with the ‘Deglet Noor’ date palm . Date Growers' Inst. Report 47: 19 - 24.

[9] EL-Makhtoun, M.; Abdel-Kader, A.M.M. and Abdel-Ai, A.A. (1995).Effect of different pollination methods on yield and fruit quality of Zaghloul date cultivar. Zagazig J. Agric. 22(1):151-157.

[10] EL-Mardi, M.O.; Esschie, H. and Abdelbasit, K.M. 2002. Effect of pollination method on changes in physical and chemical characteristics of date fruit during development. Agricultural science. 7(1):21-27.

[11] El-Refaey, F. and El-Dengawy, A. (2017). Improvement of the pollination technique in Date Palm. J. Plant Production, Mansoura Univ.8 (2) : 307-314

[12] Estimation of total Carbohydrates in plant tissue (1998). Measurement of total soluble sugar. Experiments in plant physiology: 148-151.

[13] Hamood ,H.H. and Mawlood, E.A. (1986).The effect of mechanical pollination on fruit set , yield and fruit characteristics of date palm ‘Zahidi’ cultivar .Date palm J.4(2):175-184.

[14] Hamood ,H.H. and Shalash, T.S. (1987). Effect of storage periods of pollination mixture on fruit set and fruit quality of date palm ‘Khostawi’ cultivar .Date palm J.5(1):23-37.

[15] Hussein, F.H. and Hassan, A.S. (2001).Effect of hand and mechanical pollination on fruit set, yield and fruit quality of dry dates CV ‘Gondeila’ under conditions of Asswan governorate. Egypt. Zagazig J. Agric. Res. 28(6):1035-1049.

[16] Ibrahim, A.A. (1988). Field performance of different types of mechanical pollination systems of date palm. J.Agric. Water. Reso. Res.7 (1):61-82.

[17] Othman, A.K., Ghalib, H.H., and AlIdany, A.J. 1990. Response of ‘Sayer’ Date fruit to method of pollination. Basrah J.Agric.Sci.3(182): 83- 90.

[18] Reducing sugar content, Luff Schorl method, Food analysis.:144-163.

[19] Samouni, M.T.M., El-Salhy A.M., Ibtesam F.M. Badawy and Ahmed, E.F. (2016). Effect of Pollination and Thinning Methods on Yield and Fruit Quality of Saidy Date Palms. Assiut J. Agric. Sci. 47 (3): 92 – 103.

[20] Shabana, R.H ; Mawlood, E.A. ; Khalil, Th. and Ghalib, H.A. (1986). Mechanical pollen extraction and pollination. Journal of Agricultural water resources 5:227-240.

[21] Shabana, R.H; Khalfan, R.M.; Safadi, W. and Akrout, S.A. (1998). Mechanical pollination of date palm in U.A.E. 2nd Conf. on date palm , Murakish , 16-18:55-64 .

[22] Shabana, R.H; Mawlood, E.A. and Khalil, Th. (1988). Date palm mechanical pollination. Report. Agric. Res. Water Resources Center. Scientific Research Council, Baghdad, Iraq.

[23] Soliman, S.S., AlEbidi, A.I., Al-Saif, A.M. Al-Obeed., R.S. and Al-Bahelly, A.N. (2017). Impact of pollination by pollen grain water suspension spray on yield and fruit quality of Segae date palm cultivar (*Phoenix dactylifera*). Pak. J. Bot., 49 (1) : 119 – 123.

[24] Zaid, A. and De wet, P.F. (2002).Climatic requirements of date palm .Date Production Support Program .United Arab Emirates.

Effect of Various Level of Nutrient Application on Yield and Yield Attributing Characters of Wheat at Dehradun, India

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Abstract— *A field experiment was conducted in the Agronomy research farm, Uttaranchal (PG) College of Bio-medical Sciences and Hospital, Dehradun during Rabi season to study effect of different NPK levels on growth and yield of wheat and work out relative economics of different levels of NPK. This field experiment was conducted to investigate the combined effect of different NPK (Nitrogen, Phosphorus and Potash) levels on the growth, yield and yield attributing characters of wheat cultivars PBW373. The thrice replicated treatments (T_1: Control, T_2:25% N_2+50% P_2O_5+ 25% K_2O, T_3:50% N_2+50% P_2O_5+50% K_2O, T_4:75% N_2+50% P_2O_5+50% K_2O, T_5:100% N_2+50% P_2O_5+50% K_2O, T_6:25% N_2+100% P_2O_5+100% K_2O, $T_{7:}$50% N_2+100% P_2O_5+100% K_2O, T_8:75% N_2+100% P_2O_5+100% K_2O, T_9:100% N_2+150% P_2O_5+150% K_2O RDF) ha^{-1} were tested in Randomized Complete Block Design (RCBD). The results revealed that the highest growth, yield and yield attributing characters replied significantly to NPK fertilizers but access (higher dose than 100%) of Phosphorus and Potash shows negative results. It is resulted that highest growth was recorded with the treatment T_5:100% N_2+50% P_2O_5+50% K_2O or application of (120-30-30) NPK Kg ha^{-1} and lowest conclude treatment combination was T_1 (no fertilizer application). The highest days to maturity was recorded from treatment T_5 while the lowest days to maturity was observed from treatment T_1. Application of different NPK Levels on economics of wheat showed varied trend in benefit: cost ratio (B: C ratio). The maximum B: C ratio was obtained with treatment T_2, while further increase in fertility levels obtained less B: C ratio followed by lowest rate of nutrient. The highest net return was obtained in the treatment T_5 followed by treatment T_2 and T_3 respectively. It was due to the significantly higher grain and straw yield on treatment T_5 crop than the other treatments, which resulted in higher net return and benefit cost: ratio. So it is concluded that the treatment T_5 (100% N_2+50% P_2O_5+50% K_2O) shows best results on wheat crop and proved to the most remunerative dose. This study will enhance the nutrient use efficiency and fetch high and quality production of wheat in less cost of production without causing adverse effect on environment.*

Keywords— Fertilizer, Growth, Nutrients, Soil fertility, wheat, Yield.

I. INTRODUCTION

Wheat (*Triticum aestivum* L.) is the major staple food crop of the world. It is used as a staple food by about 10 million peoples all over the world mainly in the 43 countries and contributes 30% to overall grain demand of the world. It provides around 20% of the aggregate food calories to mankind (Redddy, 2004) having maximum protein as compared to other cereals. In India, wheat is cultivated over an area of 28.17 million hectare with a production and productivity of 73.70 Mt and 26.17 qha^{-1}, respectively (Anonymous, 2007). It contributes 35% of the total food grain production of the country. India alone produces 13% of world's wheat (Anonymous, 2007).

There are many factors responsible for low yield of wheat including improper application of nitrogen fertilizer or no application of nitrogen fertilizer, edaphic properties, biotic properties, availability and distribution of irrigation, prevailing climatic conditions, improper field management and lack of adequate farmer's knowledge and awareness. Firstly nitrogen is one of the major nutrients which play important role for metabolic process of the plant for bumper yield when it applied in appropriate amount. All the biochemical process occurring in the plants are mainly governed by nitrogen and its associated compounds, which make it essential for growth and development of wheat (Kutman et al., 2011). Therefore it is necessary to apply nitrogen fertilizer in the soil to get bumper yield of wheat (Ali et al., 2000). Secondly phosphorus play vital role for plant development starting as wheat is just a seedling and continuing all the way to maturity. Apart from formation of quality seeds, this nutrient ensures uniform heading, faster maturity and strengthens the plant to survive during the winter. The most noticeable symptoms are stunted growth, stems and leaves turn purple, reduced root system and poor tillering are common symptoms when deficiencies are observed, winter wheat is more susceptible to winterkill and vulnerable to disease pressure, among other plant health issues and finally wheat requires potassium for optimum growth and development. Adequate potassium results in superior quality of whole plants due to improved efficiency of photosynthesis, increased resistance and greater water use efficiency and sufficient potassium results in stronger wheat straw and assists in grain filling.

Nitrogen is the most important element to achieve stable high grain yields and growth it is essential for improving grain quality of wheat. In order to get high yield and good and stable quality of wheat N fertilizer rates, split N application and timing of application have been the major strategies recommended to increased protein content and improved oleograph parameters (Shejbaloval et al., 2014). Phosphorus is the second to nitrogen as the nutrient that most commonly limits wheat growth and development. Phosphorus has been the subject of more fertility investigation than any of the other essential elements. Soil phosphorus (P) deficiency is a major constraint to increased crop yields in many areas of the world (Vance et al., 2003). The production of less photosynthetic assimilates and reduced assimilate transport out of the leaves to the developing fruit greatly contributes to the negative consequences that deficiencies of potassium have on yield and quality production (William, 2008). Saini et al (2010) reported that recommended dose of fertilizer may have supplied nutrients to crop in optimum and balanced proportion required for its better growth and development, thereby leading to higher grain yield. The combined application of N, P and K has proved to be more effective in increasing yield of wheat as compared to sole application of either N or P or K (Petkov, 1983).

Application of imbalanced or excessive nutrients led to declining nutrient use efficiency and making fertilizer consumption uneconomical and producing adverse effects on atmosphere and ground water quality causing health hazards and climate change (Aulakh et al., 2009). Keeping this in view the present experiment was conducted with the following objectives:

- To study the effect of different NPK levels on growth and yield of wheat under normal practice and system of wheat intensification.
- To study the effect of different nutrient levels on flowering and maturity of wheat crop.
- To work out relative economics of different levels of NPK.

II. MATERIALS AND METHODS

2.1 Experimental site

The present study entitled “Effect of Various Level of Nutrient Application on Yield and Yield Attributing Characters of Wheat” was carried out at the Agronomy Research Farm of Uttaranchal (PG) College of Bio-medical Sciences and Hospital, Turner Road, Dehradun during rabi season of the year 2019-20. It is situated 30 masl and lies between the evoba retem 674 30 eht neewteb seil hcihw level aes naem^{0}31’40” N latitude and 78^{0}03’05” E longitude and Plots of homogenous fertility were selected from the field and well connected with irrigation channel for timely use. The details of the materials used and method employed are described as under:

2.2 Climatic Condition of the Area

The experimental site had a warm and temperate climate with a hot and dry summer, cold winter and mild to heavy rains. The average annual temperature of the area is 21.8^{0}C with an annual rainfall of 1896 mm. The soil was clay loam in texture, and of medium fertility with slightly alkaline in reaction. It was poor in organic carbon with low to medium in fertility status.

2.3 Land Preparation

Proper field preparation is essential for good germination and growth of the wheat with to have a suitable field for sowing. The experimental field was ploughed, dry weeds and stubbles were removed. The field was again ploughed by cultivator and finally planking was done to obtain a good tilth. The block borders, plot bunds and irrigation channels were made manually as per the layout plan. The experimental plots were leveled before sowing of seeds.

Nutrient application was done as per treatment. In main plots, half of the total quantity of nitrogen along with the full dose of phosphorus, potassium were applied just before sowing and incorporated into the top 15 cm soil manually with the help of spade. The remaining half quantity of N through urea fertilizer was top dressed in two equal installments 25 and 48 DAS. Sowing was accomplished with Row to Row distance of 20 cm.

2.4 Experimental Detail

The present study was design to evaluate the effect of different level of fertilizer on wheat yield and yield attributing characters. The variety used was PBW373. The experiment was laid down as per randomized complete block design (RCBD) with three replications, each replication with nine treatments. Field border and plot border were left to minimize outside effect. The irrigation channels were placed at suitable location for facilitating the irrigation. Five representative plants per treatment per replication were used for data recording. The details of layout were as follows:

TABLE 1
LAYOUT OF THE MAIN PLOT

Details	Value
Plot size	864F2
Border between plots	0.5 m
Border between replications	0.5 m
Gross experimental areas	864F2
Total no of plot	27
Size of mini plot	8*8(feet)

2.4.1 Treatments

T_1= Control

T_2 = 25% N_2+50%P_2O_5+ 25%K_2O

T_3 = 50%N_2+50%P_2O_5+50%K_2O

T_4 = 75%N_2+50%P_2O_5+50%K_2O

T_5 = 100%N_2+50%P_2O_5+50%K_2O

T_6 = 25%N_2+100%P_2O_5+100%K_2O

T_7 = 50%N_2+100%P_2O_5+100%K_2O

T_8 = 75%N_2+100%P_2O_5+100%K_2O

T_9 = 100%N_2+150%P_2O_5+150%K_2O

2.4.2 Fertilizer Material and Observations

Fertilizer materials:

- Urea
- Diammonium phosphate (DAP)
- Single super phosphate(SSP)
- Muriate of potash (MoP)

TABLE 2
DETAILS OF FIELD OPERATION PERFORMED DURING WHEAT CULTIVATION IN THE YEAR 2019-20.

S. No.	Operation performed	Date of Operation
1.	Preparatory tillage	
	Pre irrigation	20/11/2019
	Ploughing	21/11/2019
	Harrowing & planking	22/11/2019
2.	Layout and sowing	23/11/2019
3.	Fertilizer Application	23/11/2019
	Basal Application of NPK	18/12/2019
	Top Dressing of N (1/3)	10/01/2020
4.	Irrigation	15/12/2019
		07/01/2020
		31/01/2020
5.	Weeding	10/03/2020
	Ist	16/12/2019
	IInd	8/01/2020
6.	Harvesting	15/04/2020
7.	Threshing and winnowing	20/04/2020

2.5 Soil and Soil Analysis

Soil as a medium of plant growth is affecting the plant growth and ultimately the final yield through its properties. Therefore, an attempt was made to assess the physical and chemical properties of soil of the experimental field. To evaluate the soil fertility samples were collected from the experimental field before sowing of the crop. Soil samples were taken randomly from the different parts of the field upto a depth of 0-20 cm and a composite sample was prepared which was used for further analysis. Sample was analyzed in the Soil Testing Laboratory of Doon University, Dehradun with following methods. The results thus obtained are presented in the table 3.

TABLE 3
PHYSICAL AND CHEMICAL PROPERTIES OF THE SOIL

Particulars	Value	Rating	Method	Reference
Mechanical Analysis				
Sand (%)	19.81	Silt loam	Hydrometer	Bouyoucos (1962)
Silt(%)	40.20			
Clay(%)	39.99			
Textured class			Soil texture triangle	Black et al. (1965)
Physical constants				
Bulk density (Mg m-3)	1.5		Core sampler	Black et al. (1965)
Chemical Analysis				
Organic carbon (%)	0.25	Low	Wet digestion method	Wankley and Blacks (1934)
Available N (Kg ha^{-1})	202	Low	Alkaline potassium permagnate	Subbiah & Asija (1956)
Available P_2O_5 (Kg ha^{-1})	20	medium	0.5 MNaHCO3 extractable	Olsen et al. (1954)
Available K_2O (Kg ha^{-1})	180	medium	Flame photometer method	Jacksom (1973)
pH (1:2.5 soil: water suspension)	7.6	Alkaline	Glass electrode digital pH meter	Sparks (1996)
Electrical conductivity (1:2.0 soil: water suspension)	0.28	Normal	Systronics electrical conductivity meter	Sparks (1996)

It is evident from soil analysis that the soil of the experimental field was silty loam with moderate fertility status having low in available organic carbon, nitrogen and medium in phosphorus and potassium.

2.6 Observation recorded

All the yield and yield attributing parameters were recorded at regular interval as per the standard procedures and they were analyzed as per the analysis of variance (ANOVA) technique and the critical differences between the treatments were worked at 0.05 probability. The economics were worked out using the prevailing market prices for both inputs and outputs.

2.6.1 Plant height

The height of five plants was measured in cm from ground level up to the height levels reached by the leaves and the average height per plant was calculated. The observations were taken at 30, 60, and 90 and at harvest and then averaged.

2.6.2 Number of tillers per square meter

Tillers were counted in one meter row length at three different places in each sub plot and were converted into tillers m^{-2}.

2.6.3 Number of leaves per plant

Number of leaves was counted in each selected plant per plot and the average value was calculated.

2.6.4 Number of spikes per plant

In field experiment the number of spikes were counted from five plants selected randomly form each treatment and then the average was calculated.

2.6.5 Spike length (cm)

Spike length was measured with a measuring tape from peduncle node to the tip of the spike. Three plants per plot were selected for recording spike length and mean was calculated.

2.6.6 Number of grain per spike

Three spikes were taken from each treatment. Threshed and the number of grains counted, and the mean grain per spike calculated.

2.6.7 1000 Grain weight (g)

Ten random samples of 1000 grains each were weighted using electronic balance to calculate 1000 grain weight.

2.6.8 Biomass yield (Straw yield) per unit area

Harvested crop which included grain+ stem+ leaves were weighed after drying in the sun to record biological yield in each plot.

2.6.9 Grain yield kg/ha

After threshing and cleaning, all grains were harvested to record grain yield per plot. Then converted it into grain yield kg/ha by using the formula.

$$Grain\ yield\ kg/ha\ (Actual) = \frac{Total\ grain\ wt.(kg)}{Size\ of\ the\ area\ (m)^2} X\ 10{,}000\ m^2 \quad (1)$$

$$Grain\ yield\ \frac{kg}{ha}\ (Calculated) = \frac{Spikes\ /m^2\ X\ grain\ /spike\ X\ 1000\ grains\ wt.(g)}{1000\ X1000} X10{,}000\ m^2 \quad (2)$$

2.6.10 Harvest index

Harvest index is the ratio of the economic yield to the biological yield produced. It was calculated by the formula of Singh and Stoskoff (1971).

$$Harvest\ index\ (\%) = \frac{Economic\ yield}{Biological\ yield} X\ 100 \quad (3)$$

2.7 Soil Parameters

Soil sample were collected from 0-20 cm depth at the beginning of experiment to know the available NPK, pH and EC status during the course of investigation. Available nitrogen, phosphorus, potassium, pH and electrical conductivity were determined as per method given in Table 3. Composite soil samples were collected from 0-20 cm depth before starting of the experiment. The soil samples were analyzed chemically for various characters.

2.7.1 Organic carbon

The organic carbon was determined by Walkley and Black's wet oxidation method, as described by Jackson (1973). It was expressed in percentage.

2.7.2 Available nitrogen

It was estimated by alkaline permanganate method as outlined by Subbiah and Asija (1956). It was expressed in kg ha^{-1}.

2.7.3 Available phosphorus

Available phosphorus content of soil was determined by Olsen's method as described by Olsen et al. (1954). It was expressed in kg ha^{-1}.

2.7.4 Available potassium

Available potassium was determined by flame photometer after extracting the soil with neutral normal ammonium acetate as described by Jackson (1973). It was expressed in kg ha^{-1}.

2.8 Economics

The economics of various treatments was calculated by taking into account the existing price of the input and produce. The investment on fertilizers, labour and power for performing different operations such as ploughing, irrigation etc. were worked out. The cost of cultivation was taken for calculating economics of treatments and expressed as net return (Rs. ha^{-1}) and benefit cost ratio.

2.8.1 Gross income (ha^{-1})

The yield of wheat crop was converted into gross income in ha^{-1} on the basis of current price of the produce.

2.8.2 Net return (ha^{-1})

The net return was worked out by using following formula

$$\text{Net return } (ha^{-1}) = \text{Gross income } (ha^{-1}) - \text{cost of cultivation } (ha^{-1}) \quad (4)$$

2.8.3 Benefit: cost ratio

The benefit cost ratio was worked out on the basis of net return per unit cost of cultivation (Rs. ha^{-1})

$$Benefit\ cost\ ratio = \frac{Net\ return\ (ha^{-1})}{Cost\ of cultivation\ (ha^{-1})} \quad (5)$$

III. RESULTS AND DISCUSSIONS

3.1 Growth Parameters and Yield attributes

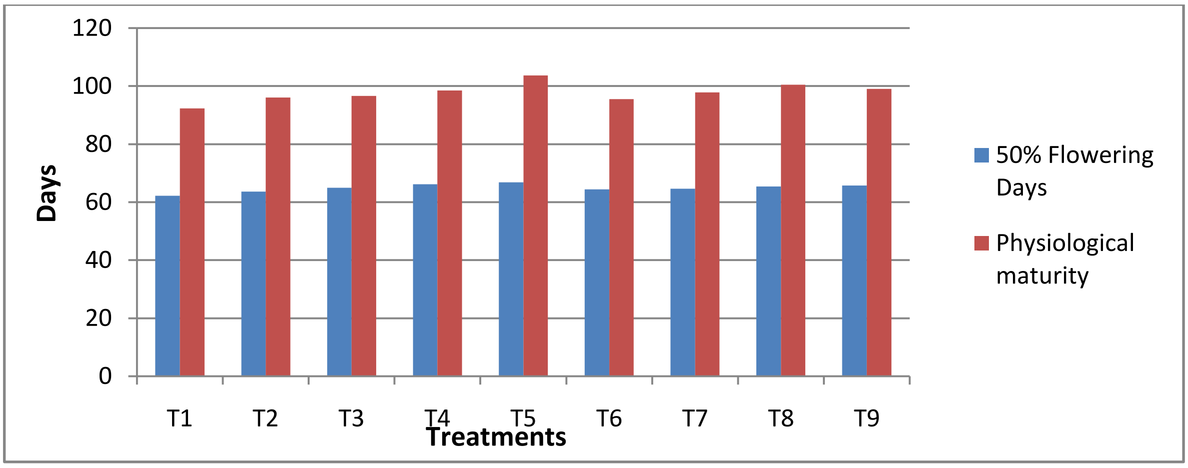

FIGURE 1: Effect of different NPK levels on Phenological characters of wheat.

Days to 50% flowering of wheat showed statistically significant variation due to different levels of NPK. The highest days to flowering (66.81) was recorded from treatment T_5. 53.50 followed by T_4 66.170, T_9 65.73. The lowest days to flowering (62.19) were observed from T_1 (Control). The result of the study revealed that no application of NPK tends to early flowering.

Statistically significant variation was recorded in terms of days to maturity of wheat due to different amount of NPK. The highest days to maturity (103.66) was recorded from T_5 while the lowest days to maturity (92.29) was observed from T_1 (Control). But Atikulla (2013) reported that low level of nutrient hastened the maturity period of wheat.

3.1.1 Effect of NPK level on plant height

Plant height was measured thrice at different days interval (30, 60, 90 and at harvest) and the results revealed that plant height was significantly affected by different treatments. The data present in Table 4 revealed that shoot elongation continued to increase with the advancement in age of the plants and a rapid increase in plant height was noticed up to 90 DAS and thereafter it increased slowly. An examination of data show significant effect of different nutrient (NPK) levels on plant height. Plant height under different treatments varied from 18.02 to 23.67 cm at 30 DAS, 44.56 to 57.57 cm at 60 DAS, 83.09 to 101.61cm at 90 DAS and 84.01 to 102.06 cm at harvest.

Data in table 4 reveals that the observation on plant height at different stages of growth 30, 60, 90 DAS and at harvest that treatment combinations T_5 (N100% P50%, K50%) results is greater increase in height (23.67, 57.57, 101.61 and 102.06) cm respectively in successive stage of growth.

At 30 DAS, the treatment combination T_5 (N100%, P50%, K50% RDF) shows significant increase in height that is 23.67 cm in comparison to other treatments. The minimum plant height was recorded in the treatment T_1 (control) that is 18.02 cm.

At 60 DAS, the treatment combination T_5 (N100%, P50%, K50% RDF) shows a significant increase in height that is 57.57 cm in comparison to other treatments. The minimum plant height was recorded in the treatment T_1 (control) that is 44.56 cm.

At 90 DAS, the treatment combination T_5 (N100%, P50%, K50% RDF) shows significant increase in height that is 101.61 cm in comparison to other treatments. The minimum plant height was recorded in treatment combinations T_1 (control) that is 83.09 cm.

At harvest, the treatment combination T_5 (N100%, P50%, K50% RDF) shows significant increase in height that is 102.06 cm in comparison to other treatments and minimum height was recorded in treatment combination T_1 (control) that is 84.01 cm. It was observed as the level of nitrogen increased plant height was also gradually increased. Similar increase in plant height, number of tillers m^{-2} and dry matter accumulation of wheat by increase in nutrients level were also noted by Hameeda et al. (2010) and Jat et al. (2013).

TABLE 4
EFFECTS OF DIFFERENT LEVELS OF NITROGEN, PHOSPHORUS AND POTASSIUM ON PLANT HEIGHT OF WHEAT (*TRITICUM AESTIVUM L*).

Treatment	Plant Height in Cm (Mean± S.E.)			
	30 DAS	60 DAS	90 DAS	At harvest
T_1	18.02± 0.02	44.56± 1.27	83.09± 0.15	84.01± 0.60
T_2	18.81± 1.11	47.81± 0.18	85.64± 1.51	87.35± 1.01
T_3	19.47± 0.30	49.07± 0.48	87.79± 0.78	89.22± 0.45
T_4	20.68± 0.34	52.44± 0.34	90.52± 0.29	91.59± 0.38
T_5	23.67± 0.35	57.57± 1.22	101.61± 0.88	102.06± 1.11
T_6	19.72± 1.36	45.51± 1.75	84.01± 1.24	85.21± 0.87
T_7	19.47± 0.52	47.09± 1.27	87.24± 1.34	88.12± 1.81
$\mathbf{T_8}$	18.66± 1.06	46.71± 1.35	87.25± 1.67	88.11± 1.45
T_9	18.41± 0.65	48.99± 1.27	84.39± 2.22	85.57± 2.13
C.D.	2.299	3.519	3.881	3.771
SE(m)	0.76	1.164	1.284	1.247
SE(d)	1.075	1.646	1.815	1.764
C.V.	6.698	4.125	2.528	2.427

CD (P=0.05)

3.1.2 Effect of different NPK levels on number of leaves, tillers, spike length, grain per spike and Test Weight of wheat.

The number of leaves per plant was significantly influenced by different levels of nutrient application. Assessment of data indicated that number of leaves per plant firstly increased up to 60 DAS after that it decreased. A reference of data presented in Table 5 shows the number of leaves per plant. A significant increase in number of leaves on account of treatment T_5 was observed. The reduction of leaves was found maximum in control. It is evident from the statistical analysis that it was maximum in treatment T_5 (40.39) and minimum in control (32.22) at the time of harvest. There was a significant difference in number of leaf per plant under different treatments. The data revealed that significant effect of NPK levels on effective tillers m^{-2}. It is clearly evident from the data that increasing levels of NPK increased the effective tillers m^{-2}. The maximum effective tillers m^{-2} were recorded with the treatment T_5 (336.33), whereas minimum value was recorded with treatment T_1 (Control) which was 324.33. Data has given in the Table 5 reveals that the average number of tillers per plant at successive stage of growth under various treatment combinations. Data on number of tillers m^{-2} revealed that the treatment combination T_5 i.e. 336.33 m^{-2} resulted in maximum number of tillers m^{-2} and the minimum number of tillers m^{-2} observed in treatment combinations T_1 (control) i.e.324.33 m^{-2}. Similar results have been reported by Ramakrishna et al., (2007).

Data on spike length are presented in Table 5 Scanning of the data revealed that the variation in spike length due to different NPK levels was not significant. The result of the analysis shows different level of NPK has no effect on spike length. The higher length of spike was recorded with treatment T_5i.e. 11.13 cm. The data pertaining to grains spike^{-1} as affected by different treatments are presented in Table 5. Analysis of the data clearly revealed that significant variation on grains spike^{-1} due to different NPK levels. An examination of the data revealed that a significant increase in grains spike^{-1} was observed with graded level of NPK. The highest grains spike^{-1} were observed with the treatment T_5 and followed by treatment T_4 which was 36.07 and 33.80, respectively. The minimum grains spike^{-1} was observed with the treatment T_1 (control) i.e. 25.47. Data pertaining to 1000-grain weight (test weight) as influenced by different treatments are summarized in Table 5. The analysis of data shows significant effect of NPK levels on 1000-grain weight. It was clearly found from the data that increase in NPK levels increased the 1000-grain weight. The maximum 1000-grain weight was found with treatment T_5 i.e. 36.03 g whereas the minimum value was recorded with T_1 (Control) i.e. 29.15 g. The percent increase in 1000-grain weight under T_5 over T_1 was 23.7. These findings are in close agreement with those of Jat et al., (2013) and Patel et al., (1995).

TABLE 5
EFFECT OF DIFFERENT NPK LEVELS ON YIELD ATTRIBUTES OF WHEAT.

Treatments	At Harvest				
	Number of leaves per plant	**No of tillers m^{-2}**	**Spike length (Cm)**	**Grains per spike**	**1000 Grain weight(g)**
	(Mean± S.E)	**(Mean ±S.E)**	**Mean± S.E.**	**Mean± S.E.**	**Mean± S.E.**
T_1	32.22± 1.807	324.33± 2.333	10.43± 0.35	25.47± 0.41	29.15± 0.52
T_2	34.61± 0.808	326± 1	9.67± 0.39	31.4± 0.35	30.84± 0.03
T_3	35.97± 0.525	329.67± 1.20	9.22± 0.67	32± 0.42	31.76± 0.24
T_4	37.40± 0.776	333.33± 0.88	10.14± 0.24	33.8± 0.35	32.91± 0.53
T_5	40.39± 0.335	336.33± 0.88	11.13± 0.24	36.07± 0.47	36.03± 0.48
T_6	36.12± 0.239	326.67± 0.88	9.64± 0.54	27.13± 2.56	30.81± 0.41
T_7	36.41± 0.599	327.67± 1.45	9.68± 0.24	30.67± 0.37	31.65± 0.33
$\mathbf{T_8}$	37.24± 0.828	331.33± 0.33	9.56± 0.36	31.89± 0.52	32.76± 0.24
T_9	39.07± 0.636	325.67± 2.33	10.27± 0.40	30.82± 0.52	30.8± 0
C.D.	2.506	3.849	N/A	2.671	1.244
SE(m)	0.829	1.273	0.398	0.883	0.411
SE(d)	1.172	1.8	0.564	1.249	0.582
C.V.	3.922	0.67	6.921	4.93	2.237

CD (P=0.05)

3.1.3 Effect of different NPK levels on grain and straw yield and harvest index of wheat.

The data pertaining to grain yield of wheat as influenced by NPK levels have been presented in Table 6, Data shows that the highest grain yield was recorded with treatment T_5 (3,176kg ha^{-1}) and it's gave 20.7 per cent higher grain yield over treatment T_1 control (2,630 kg ha^{-1}). Reduction and excessive dose of NPK application decreased the grain yield significantly. It is supported by (Kachroo and Razdan, 2006; Jat et al., 2013).

The data pertaining to straw yield of wheat as influenced by NPK levels has been presented in Table 6. The data revealed that biological yield was significantly increased with the increasing NPK levels and also decreased with the excess of the NPK level. The maximum biological yield was recorded with treatment T_5 (5,248.67 kg ha^{-1}) which was significantly superior over the lowest fertility recorded minimum biological yield of 4,291.33 kg ha^{-1}. The magnitude of increase in biological yield under treatment T_5 over treatment T_1 (control) was 18.24.

The data on harvest index pertaining to various treatments are presented in Table 6. A perusal of data clearly indicated that the NPK levels were influenced significantly on harvest index of wheat. It revealed from the data that harvest index significantly increased with increase in fertility levels. Maximum harvest index was recorded under treatment T_5 (42.03%) and minimum harvest index was recorded with treatment T_1 i.e. control (36.03 %).

TABLE 6
EFFECT OF DIFFERENT NPK LEVELS ON GRAIN AND STRAW YIELD AND HARVEST INDEX OF WHEAT.

Treatment	Grain yield (kg ha^{-1})	Biological yield (kg ha^{-1})	Harvest Index
	Mean± S.E.	Mean	Mean
T_1	2,630± 83.35	4,291.33± 35.17	36.03± 0.35
T_2	2,795± 6.56	4,559.67± 73.64	37.03± 0.89
T_3	2,798.67± 1.79	4,709.33± 60.12	37.47± 0.58
T_4	2,818± 68.72	4,805.33± 12.42	38.33± 0.38
T_5	3,176± 23.54	5,248.67± 76.17	42.03± 0.87
T_6	2,569.33± 88	4,492.67± 48.53	38.60± 0.79
T_7	2,559.67± 30.82	4,656.33± 77.55	36.43± 0.35
T_8	2,623.33± 63.62	4,711.67± 157.76	37.93± 0.66
T_9	2,633.67± 33.66	4,427.67± 29.19	38± 1.258
C.D.	121.360	236.590	2.000
SE(m)	40.135	78.242	0.661
SE(d)	56.759	110.651	0.935
C.V.	2.543	2.911	3.009

CD (P=0.05)

3.1.4 Effect of different NPK levels on Economics of wheat

Treatment wise cost of cultivation, gross income, net return and benefit : cost ratio have been analyzed and presented in Table 7 which reveals that highest net return (Rs. 79074ha^{-1}) was obtained with treatment T_5 followed by T_3 and T_4 respectively. The maximum but being at par with treatment T_5 (2.41) benefit: cost ratio was recorded when NPK level was treatment T_3 (2.46). The lowest value of benefit: cost ratio was obtained with treatment T_9 (1.89). Similar results have been reported earlier by Singh et al. (2010); Eslami et al. (2014), and Hussain et al. (2015).

TABLE 7
EFFECT OF DIFFERENT NPK LEVELS ON ECONOMICS OF WHEAT

Treatment	Economics (ha^{-1})			B:C ratio
	Gross income	Cost of	Net return	
T_1	92188	27204	64984	2.39
T_2	97962	28298	69664	2.46
T_3	99228	29945	69283	2.31
T_4	100436	31348	69088	2.20
T_5	111856	32782	79074	2.41
T_6	92454	29945	62509	2.09
T_7	93546	30456	63090	2.07
T_8	95394	31873	63521	1.99
T_9	93342	32345	60997	1.89
C.D.	939.546	4.517	4.227	0.111
SE(m)	310.716	1.494	1.398	0.037
SE(d)	439.418	2.113	1.977	0.052
C.V.	0.553	0.008	0.004	2.876

CD (P=0.05)

IV. CONCLUSION

On the basis of growth and yield parameters and economic analysis of different levels of NPK it is concluded that the treatment T_5 ($100\%N_2+50\%P_2O_5+50\%K_2O$) shows best results on wheat crop and proved to the most remunerative dose. This research suggested that the appropriate dose of fertilizer enhances the nutrient use efficiency and get high and quality yield in minimum cost of production without causing adverse effect on environment.

Further study is also required to investigate the effect of micro- nutrient on growth and yield attributing character of wheat. Additional advanced research is needed to explore the effect of macro and micro nutrients in physiological and biochemical attribute of wheat.

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REFERENCES

[1] Ali.A, Choudhry. M.A, Malik. M.A. Ahmad, R. and Saifullah. (2000). Effect of various doses of nitrogen on the growth and yield of two wheat cultivar. Pak. J. Biol. Sci. 3(6): 1004-1005.

[2] Anonymous. (2007). Agriculture Research Data Book, Ministry of Agric, Govt. of India.

[3] Atikulla, MN. (2013). Effect of single irrigation and sowing date on growth and yield of wheat. MS thesis, SAU, Dhaka Bangladesh.

[4] Aulakh, MS. Khurana, MPS. Singh, D. (2009). Water pollution related to agricultural, industrial and urban activities, and its effects on food chain: Case studies from Punjab. J New Seeds 10: 112-137.

[5] Black, CA. Evans, DD. White, JL. Ensminger, LE and Clark, FE. (1965). "Method of Soil Analysis" Part 1-Physical and Mineralogical Properties, Including Statistics of Measurement and Sampling.

[6] Bouyoucos, GT. (1962). Hydrometer method for measuring particle size analysis of soil, Agronomy Journal, 5, (4), 464-465.

[7] Eslami, H. Hadi, SMJM and Arabi, MK. (2014). Effect of Planting Date on Protein content of Wheat varieties, International Journal of Farming and Allied Sciences, 3 (4), 362-364.

[8] Hameeda, B. Harini, G. Rupela, OP. Reddy, G. (2010). Effect of composts or vermicomposts on sorghum growth and mycorrhizal colonization, African Journal of Biotechnology, 6(1), 1009–12.

[9] Hussain, I. Ahmad, HB. Rauf, S. Aslam, M and Aulakh, AM. (2015). Effect of sowing time on quality attributes of wheat grain, International Journal of Biosciences, 6(12), 6-8.

[10] Jackson, ML. (1973). Soil Chemistry Analysis, Prentice Hall of India Private Limited, New Delhi.

[11] Jat, Kumar, Lokesh, Singh, SK, Latare, AM, Singh, RS and Patel, CB. (2013). Effect of dates of sowing and fertilizer on growth and yield of wheat (Triticum aestivum) in an Inceptisol of Varanasi, Indian Journal of Agronomy, 58(4), 611-614.

[12] Kachroo, Dileep and Razdan, Ravinder. (2006). Growth, nutrient uptake and yield of wheat (Triticum aestivum) as influenced by biofertilizers and nitrogen, Indian Journal of Agronomy, 51 (1), 37-39.

[13] Kutman, U. B. Yildiz, B. Cakmak, I. (2011). Effect of nitrogen on uptake, remobilization and partitioning of zinc and iron throughout the development of durum wheat. Plant and Soil. v. 342, n. 1-2, p. $149^{-1}64$.

[14] Olsen, SRCV. Watanabe, FS and Dean, LA. (1954). Estimation of available phosphorus in soil by extraction with sodium bicarbonate USDA Circular 939, pp. 19-23, Fine Method of Soil Analysis, Agronomy No. 9; Black, C.A. (ed.), American Society of Agronomy, Inc., Madison, Wisconsin.

[15] Patel, RM and Upadhyay, P N. (1992). Response of wheat to irrigation under varying levels of nitrogen and phosphorus. Indian J. Agron. 36 (1): $113^{-1}15$.

[16] Petkov, M. (1983). Effect of increasing fertilization rates on grain yield quality of winter soft wheat cultivars. Soils and Fert., 45: 7222.

[17] Ramakrishna, Y. Subedar, Singh and Parihar, SS. (2007). Influence of irrigation regime and nitrogen management on productivity, nitrogen uptake and water use by rice (Oryza sativa), Indian Journal of Agronomy, 52, (3), 102-106.

[18] Reddy, S.R. (2004). Agronomy of Field Crops. Kalyani Publishers.

[19] Saini, Kaur, Mandeep and Walia, US. (2010). Effect of planting patterns and weed control treatments on Phalaris minor growth and productivity of wheat (Triticum aestivum), Indian Journal of Agronomy, 55 (2), 110-113.

[20] Singh, S, Gupta, AK, Gupta, S and Kaur, N. (2010). Effect of sowing time on protein quality and starch pasting characteristics in wheat (Triticum aestivum L.) genotypes grown under irrigated and rain-fed conditions, Food Chemistry, 122, 559-565.

[21] Shejbalova S, Cerny J, Mitura K, Lipinska K, Kovarik J, Balik J.(2014). The influence of nitrogen fertilization on quality of winter wheat grain, Mendel net.105.

[22] Stoskopf, NC. (1971). Cereal grain crops. Reston Publishing Co., Inc. Reston, Virginia, 1971; 187-200: 388-400.

[23] Subbiah, BW and Asija, GL. (1956). A rapid procedure for estimation of available nitrogen in soil, Current Science, 25, (8), 259-260.

[24] Vance, C. Ehde–Stone, C. Allan, D. (2003). Phosphorus acquisition and use: critical adaptations by plants for securing a nonrenewable resource., New Phytol. 157:423-447.

[25] Walkley, AJ. and Black, CA. (1934). Estimation of soil organic carbon by the chromic acid titration method, Soil Science, 37 29-38.

[26] William, TP. (2008). Potassium influences on yield and quality production for maize, wheat, soybean and cotton. J. ISSN. Physiologia Plantarum. 133:670-681.

Potential effect assessment of agricultural activities on water quality of rivers in Rwanda: "Case of Muvumba River in Nyagatare District"

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***Abstract*— *The problem caused by agricultural sector to Water Quality pollution remains a big challenge for Rwanda Government. The general objective of the study was to assess the potential effect of agricultural activities on water quality in Nyagatare District. Specifically, the study assessed agricultural activities in around Muvumba River, examine the level of water quality pollution in Muvumba River, and reveal the relationship between agricultural activities and water quality from Muvumba River. Data collected through interview, and laboratory tests of water samples applied once per month in three points sampling of Muvumba River. The action starting from 19th March 2019 up to 20th March 2020. To determine the correlation between agricultural input and Water Quality data at all selected physic-chemicals parameters, by Linear Regression Model using SPSS statistics with 95% confidence interval. The results indicated that agricultural activities on surrounding of Muvumba River, are presented by the existence of different type of crops, non-protection of anti-erosions, non-wetland margins, the farmers using chemical fertilizers and pesticides, the results revealed also that all selected parameters have not addressed positive relationship or pollution, but many of them did, as per to Rwanda Standards Board guidelines. For sampling point one has taken as baseline because it is upstream of Muvumba river at Nyagatare District, in sampling point 2, the parameters that presented pollution were; turbidity (r=0.193), nitrites (r=0.393), iron(r=0.122), manganese (r=0.008); for the sampling point3: were pH (r=0.319); turbidity (r=0.212); nitrites (r=0.143); nitrates (r=0.618); nitrogen ammonia (r=0.441); Iron(r=0.889); manganese (r=0.269); agricultural activities in surrounding of Muvumba River have significantly contributed to the water quality pollution of Muvumba River, through substances of chemical fertilizers, crop residues, and soil sediments that are transported into the River by erosion. Conclusion of the study that creation of anti-erosions in a surrounding Muvumba River areas, protection of buffer zones, performing vegetation covers, inducing water management bodies at cells level, introducing awareness of farmers how ecosystem functions.*

***Keywords*— Agricultural activities, Water quality, Water pollution, Muvumba River.**

I. INTRODUCTION

The Water its function in ecosystem is to provide the life blood of the community, in the ecosystem makes water a key element for sustaining life as it is fundamental building block that supports biochemistry of all life in the planet (Laurie Brenner, November 15 2019).

In ecosystem Water is very important in lifeblood of the all live in the planet (UNESCO, 2006). It is a basic element for all forms of life for various uses such as drinking, cleaning, as a reproductive medium and as habitat for aquatic organisms and for irrigation purposes (Ninhoskinson, 2011). Water has 70% of the Earth's surface, and 40% of the population in the world, has shortage of Water.

The causes of this water shortage is the absence of freshwater, 95.7% water in the Earth is saltwater, and 2.5 % of water is fresh, while 70% of the freshwater is in the form of ice(Sandi, 2012). The World Health Organization (WHO), quoted by Mmbando J. et al (2007), under 1 % of Water which is able to be used by the different activities of the human. The main sources of the freshwater which is easy to access fund it in Lakes and river, but 25% of the users in the Earth relying on groundwater or deep aquifers for water supplies (Mmbando J. et al 2007). In the world there is no regular to supply freshwater to the users. The areas with the least available Water include most Africa, the Middle East, Asia and Europe.

There is augmentation of famine, hunger and poverty. Population growth is greatest in Low Economic Developed Countries (LEDCs), and this accelerates environmental degradation and poverty. In LEDCs Half of all the populations, do not have safe water to drink. Waterborne diseases kill 25000 people's daily, and about 14 million children under five-year old die each year from illness and hunger (Mmbando J. et al (2007). However, the benefit of safe water for human is highly; generally are main source of water pollution, through outdated farm management activities

The activities of Agriculture, is cited as one of biggest source of water systems deterioration and pollution, (MOSS, 2008). The Agricultural nutrients from farmlands are one of the top running contributors to the poor quality of water. An intensification of agricultural production generally produces an increase of externalities and potential for these by-products to, negatively, affect water quality (Ninhoskinson, 2011). The degradation of water quality by agricultural activities creates hazard life in downstream and requires tuff investments in water analysis and treatment infrastructures (Batchelor, 2000).

The limited areas for agriculture activities is the barrier of adequate distance between farmland and water sources; the result from agricultural product through using varies fertilizers; manure and pesticides and mobile soil particles; each of these groups has serious negative impacts on degradation of both ground and surface water on the site and downstream(Libby, 1990)

II. MATERIALS AND METHODS

2.1 Description of study area

The Muvumba Catchment finds its source in Rwanda on the Mulindi River that is located in the Mountainous and high rainfall central northern part of the country at an altitude of 2030 m.

The Mulindi River flows North over a length of 22.5 km to Uganda onto a flat wetland zone near Kabale from where a complex flow pattern originates that ultimately joins the Muvumba River before it eventually flows back into Rwanda at an altitude of 1 460 m above sea level. The length of the Muvumba River in Rwanda is about 56.3 km. Just south of Nyagatare, the Ngoma River with a number of tributaries contribute their flow to the Muvumba River which flows in a north easterly direction to follow the border between Rwanda and Uganda before finally joining the Akagera River in the North East where the borders of Uganda, Rwanda and Tanzania meet. The final altitude of the Muvumba River is about 1280 meter.

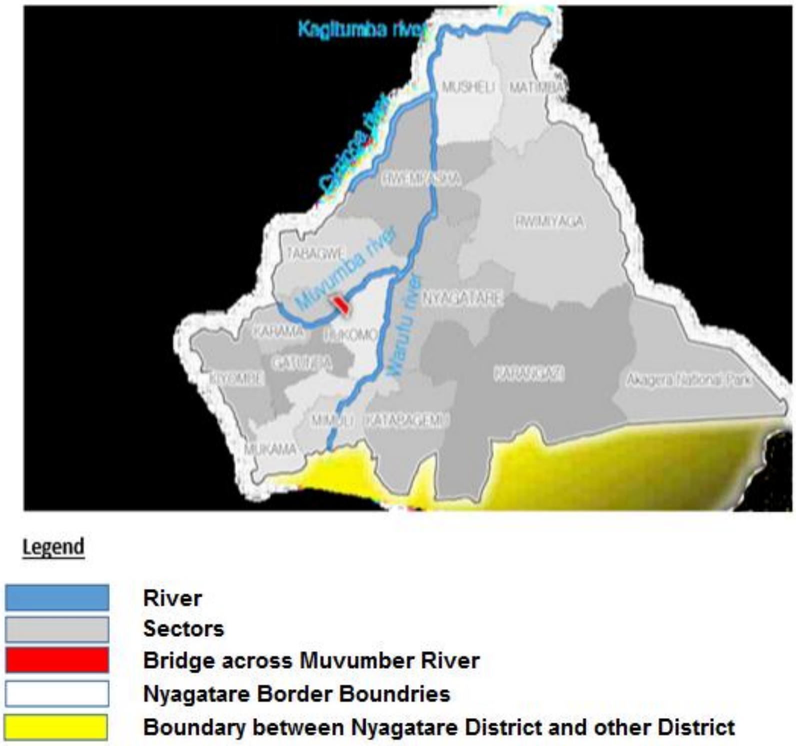

FIGURE 1: Description of study area

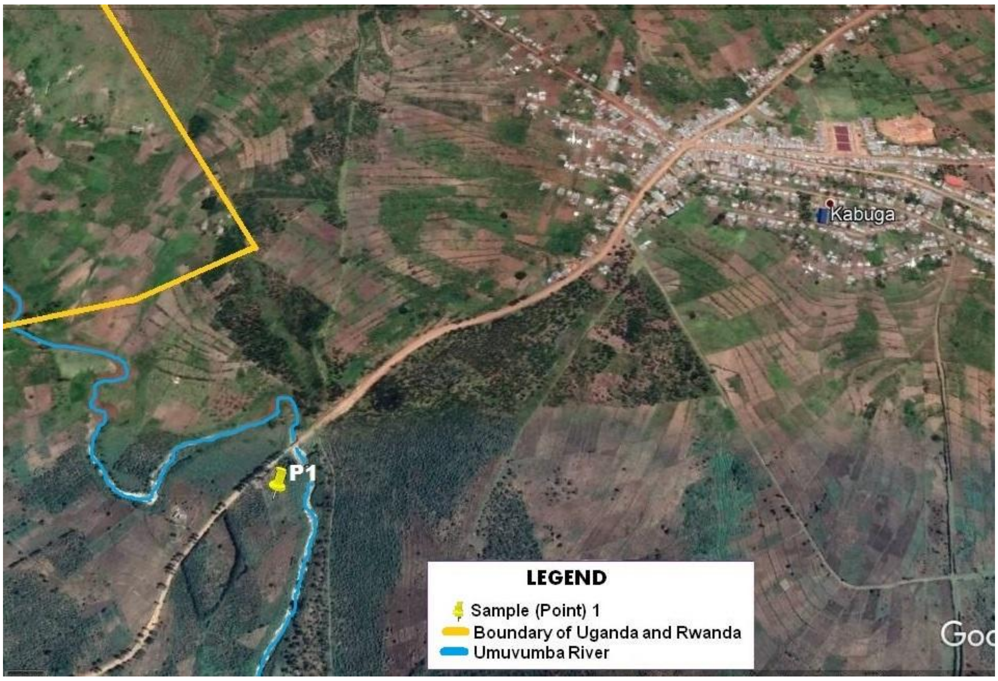

FIGURE 2: Location of sampling point 1in Muvumba River
Ref.: Google Map

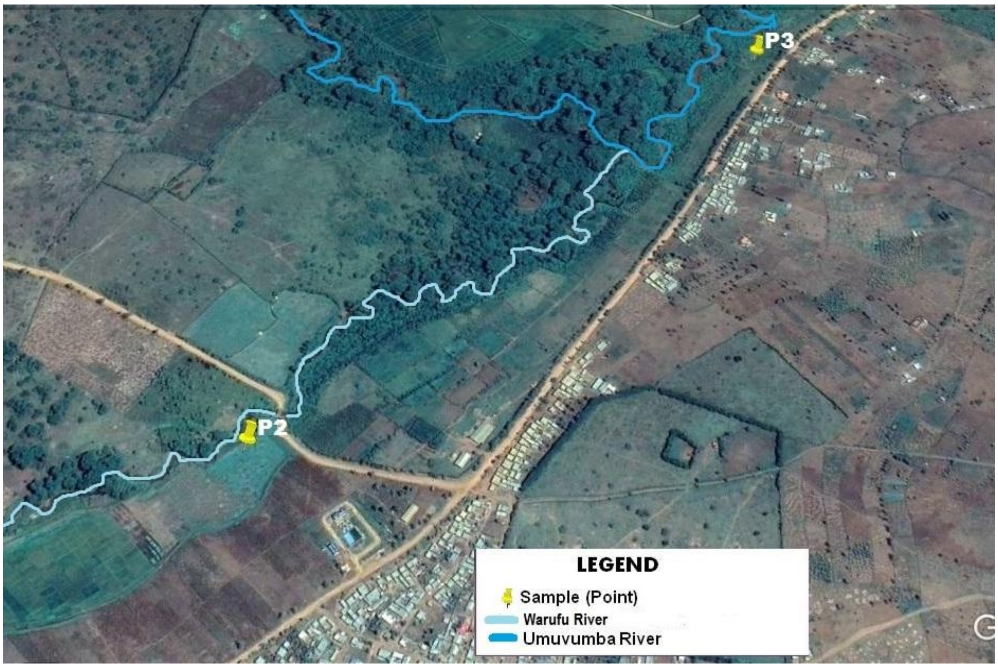

FIGURE 3: Location of sampling point 2 and 3 in Muvumba River

2.2 Research design

Research design is considered as a master plan specifying the accurate methods and procedures for collecting and analysing the required data. Hence, this study used qualitative and quantitative methods. In regard to qualitative method, the researcher conduct face to face interview to the farmers' cooperatives operating at MUVUMBA Marshland and surrounding areas and also use telephone interview to the different farmers 'around tributaries of the Muvumba River. Furthermore, an interview was conducted to the Officer in charge of agriculture in Nyagatare District; and the researcher's own observation was needed for supplementary information. In terms of quantitative method, the researcher has selected three sampling points basing on upstream; main tributary and downstream of Muvumba River and one of tributaries flow to Muvumba in Nyagatare District characterized by agricultural plantations. Furthermore, Linear Regression Model using SPSS statistics with 95% confidence interval was used to demonstrate the correlation between agricultural activities and the degradation of water quality level from Muvumba River.

2.3 Study population

The population, under this study, was composed of all cooperatives performing agricultural activities in Muvumba marshland and surrounding areas, whom the total number are 13 cooperatives; namely CODERVAM; MP8 Rice Growers COPERATIVE; COPRORIKA; COPRIMU; CORVNY; AGROVENTURE Ltd; these cooperatives are firming rice, and Cooperatives maize farming are KABOKU; KOHIIKA; COTEBARU; CODEPCUM; COPAMA; TWUNGUBUMWE; and AMIZERO IWACU; and there are also 1 big individuals farmer which are firming tomatoes around MUVUMBA River; using fertilizers; the total population are 14 farmers.

2.4 Source of data

The study involved the use of primary data and secondary data. Primary data were collected through interview, observation, and laboratory tests of raw water from Muvumba River. Secondary data from literature review such as books and official reports, and websites.

2.4.1 Interview

A formal interview was conducted to the farmer's leaders and Agronomist of Nyagatare District, in order to get information from the respondents, and to ensure of other agricultural features in the area of the study; in order to have accuracy data also the researcher did his own observation on field for different times, in dry and rainy seasons of 2019 and 2020, in order to ensure himself the agricultural features in Muvumba marshlands and surrounding areas.

2.4.2 Laboratory tests of water from Muvumba River

2.4.2.1 Water sampling

The water samples were collected one time per month from Muvumba River in every sampling point, for a period of 12 months starting from 19th March 2019 up to 20th March 2020. Subsequently, twelve sampling campaigns were conducted during that period for the three sampling points in the Muvumba River. Samples were collected and stored in appropriate equipment, which are cleaned, and rinsed with distilled water before use. Samples were put in good condition in order to preserve it during transportation to the laboratory for analysis; and keep it in favorable temperature of 3^0c to 4^oc, to avoid any external contamination, when preparing the laboratory for analyze, the different selected physico-chemical parameters.

2.4.2.2 Laboratory analysis

Water samples from the Muvumba River, were collected and analyzed in Laboratory of WASAC Ltd at Nyagatare Water Treatment Plants; Samples were analyzed using standards manual for testing water and wastewater (APHA, 2005). The physico-chemical parameters analyzed and laboratory method used were pH, turbidity, nitrites, nitrates, ammonia nitrogen, phosphates, iron, and manganese.

2.5 Data analysis procedure

Bailey (1982), data analysis consists of running various statistical tests on the data often by hand computation or by desk calculator. For this study, the collected data was processed, analyzed and managed using editing, tabulation, and graphics in order to provide clear and understandable data. The Linear Regression Model using SPSS statistics with 95% confidence interval was used to find out the correlation coefficient (r) between agricultural activities inputs and the data from laboratory tests of physico-chemical parameters for water samples taken in Muvumba River. Hence the results from laboratory and had positive correlation with agrochemicals data were compared to the Rwanda Standards Board (RSB) guidelines in order to analyse the level of water pollution from agricultural practices in Muvumba.

III. RESULTS AND DISCUSSIONS

3.1 Assessment of agricultural practices in Bishya wetland and surrounding areas

3.1.1 Opinion of interviewees

Basing to the information from all interviewees (100%) has agriculture activities of Maize, Tomatoes and rice as agriculture production performed in Muvumba Marshland, and surrounding areas. This situation shows that agricultural productions are different crops with various fertilizers and pesticides to increase their production capacity and reduce poverty.

The totality of interviewees; (100%) have regularly use fertilizers; 71.42% of interviewed frequently use NPK17*17*17; and 7.14 interviewed used NPK 10-8-10; and 100% used UREA as fertilizer and DAP; also pesticide like Benlate; Beam; cypermethrin 40% ; Tricyclazodale 75%; Bifurthrin; 40%), and fungicide; 60. This situation confirms that agricultural activities in Muvumba Marshland and surrounding areas characterized by the use of different chemical fertilizers and pesticides as agricultural inputs.

3.1.2 The author's own observation

The Author observation, on field for different times, in dry and rainy seasons 2019 and 2020, realized that agricultural features around Muvumba River are composed of non-protection anti-erosions, existence of different types of rocks and soils, the use of chemical fertilizers, absence of wetland margins. This improper management of Muvumba River remains a major challenge, despite the efforts made by the Government of Rwanda at improving wetlands management over the years.

3.2 Laboratory tests of water samples

3.2.1 The sampling points

They are three water-sampling points selected focusing on upstream of Muvumba River; entrances Warufu River as tributary flow to the river, and downstream where agriculture activities concentrated than other areas around Muvumba River; mainly the plantation characterized to these areas are Rice; Maize and tomatoes. Therefore, the upstream of Muvumba River, is the first sampling point where is backing to Rwanda in Nyagatare District from Uganda country, and was considered as water quality parameters baseline, and second is Warufu River which is small River flow into Muvumba river; and the third one is downstream of Muvumba River; all around the long of River characterized agriculture activities of different crops with different Farmers; the plastic bottles well cleaned used to collect water sampled, transported in cooler-box to laboratory for analysis; except the parameters like pH, which are measured on the field.

According to (.FAO, 2014) Agricultural pressures on water quality come from cropping and livestock systems and aquaculture, which have all expanded and intensified to meet increasing food demand related to population growth and changes in dietary patterns; therefore, researcher was chosen those sampling points in order to analyse the level of water quality pollution due to the agricultural activities of Muvumba River in Nyagatare District.

3.2.2 Presentation of the results of physico-chemical parameters from laboratory tests.

This section presents findings from laboratory analysis and then presents the graphical analysis of data. In order to interpret and be able to draw understandable conclusions on the research, the linear regression model has conducted. From the 19th March 2019 up to 20 March 2020, water samples from Muvumba River, have been taken and brought to laboratory for the analysis. Below we present the average results of different physico-chemical parameters for each sampling point.

TABLE 1
AVERAGE RESULTS OF DIFFERENT PHYSICO-CHEMICAL PARAMETERS FOR EACH SAMPLING POINT

Sampling points	P1	P2	P3	RSB standards
	N=12	N=12	N=12	
pH	7.5 ± 0.25	6.5 ± 0.50	5.8 ± 0.25	**5.5-9.5**
Turbidity(NTU)	424.56± 150	731.43 ± 120	970.32 ±100	**-**
Nitrites (mg\L)	0.45 ± 0.07	0.52 ± 0.12	0.82±0.11	**0.9**
Nitrates (mg\L)	34.13 ± 0.60	38.22 ± 0.07	39.13 ± 2.02	**45**
Ammonia Nitrogen (mg\L)	0.32± 0.12	0.35 ± 0.08	0.45± 0.14	**0.5**
Phosphate (mg\L)	3.09 ± 0.06	3.22± 0.10	3.95± 0.13	**2.2**
Iron (mg\L)	2.53 ± 0.32	3.50± 0.43	4.82 ± 0.40	**0.3**
Manganese (mg\L)	0.373 ± 0.05	0.405 ±0.25	0.635 ± 0.43	**0.1**

Water quality parameters described in the table 1, have been selected on regarding of the types of fertilizers applied by farmers in their agricultural activities around Muvumbe River. Moreover, the table indicates the average results and standard deviation of the physico-chemical parameters for each sampling point in Muvumba River. It also indicates the RSB standards and different others to compare with these average results and then to demonstrate the level of pollution.

3.2.2.1 Results from PH laboratory test

The pH is an important parameter in water, as it can indicate whether organisms or substances can exist in water for any value of the pH and thus Ph in water measures to indicate the amount of hydrogen (acid ion) in the Water.

Figure 4 illustrates the average values of pH in three sampling points.

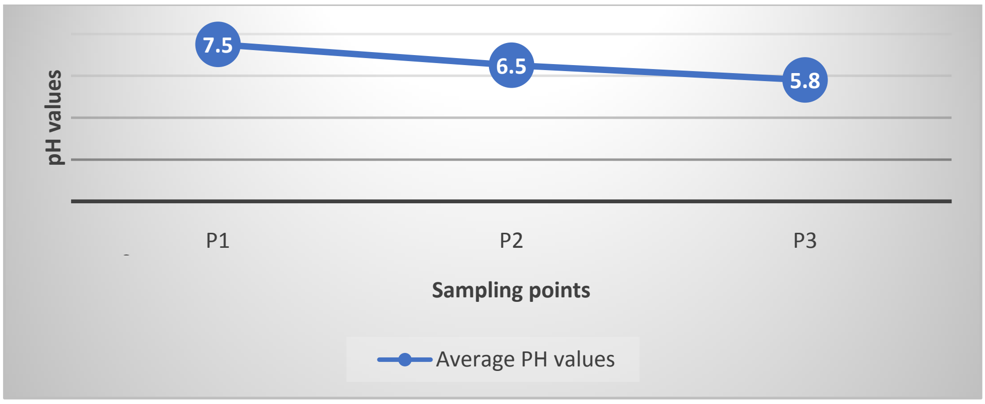

FIGURE 4: Average pH values according to sampling points in Muvumba River.

The figure 4 indicates that the pH in sampling point 3 was changed and tend to be acidic than other sampling points with average pH value of 5.80, this indicate that along of Muvumba River there is a change of pH, according of (Talling, 2010); Naturally occurring fresh waters have a pH range between 6.5 and 8.5; for that reason, sampling point 3, it was indicated lower pH which is under 6.5; and considering the minimum limit of 5.5 fixed by RSB; there is change of pH in water from Muvumba River.

3.2.2.2 Results from Turbidity laboratory test

The average values of water parameters from laboratory results as presented in table 1 showed that turbidity is high in all sampling points ranging from 424.56NTU and 970.31 NTU. These average turbidity values overtake accepted limits of RSB that is fixed at 25NTU.

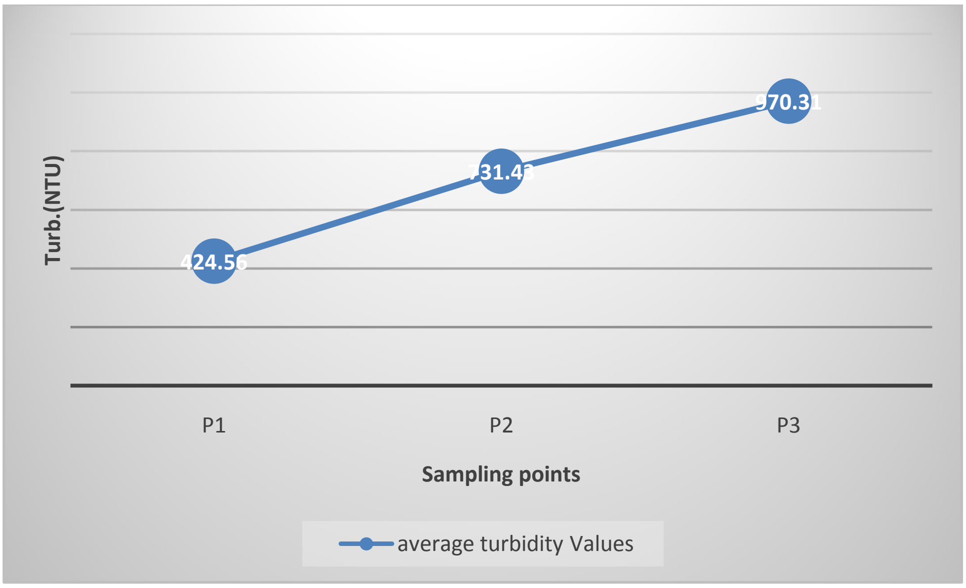

FIGURE 5: Average turbidity values according to sampling points in Muvumba River

From the figure 5, it is observable that in sampling point P3 located in downstream area, level was very high comparing point1 and point2; this situation means that in all sampling points, suspended particles, the presence of organic and colloidal materials from agricultural runoff and soil sediments contribute towards high turbidity values, especially in rainy season; according to Thirupathaiah, 2012. Turbidity can provide shelter for opportunistic microorganisms and pathogens in water and also Turbidity of water has an influence on other parameters such as color and even chemical parameters which affect water quality.

3.2.2.3 Results from Nitrites laboratory test

Nitrites is the one among parameters that have been analysed; the laboratory tests for Nitrites have shown that average concentration of nitrites varies from 0.45 mg/l to 0.87mg/l. These all-mean values are increase along the Muvumba River where agricultural activities are characterized even if the concentration of nitrites is under limit of the RSB guideline, which is 0.05mg/l.

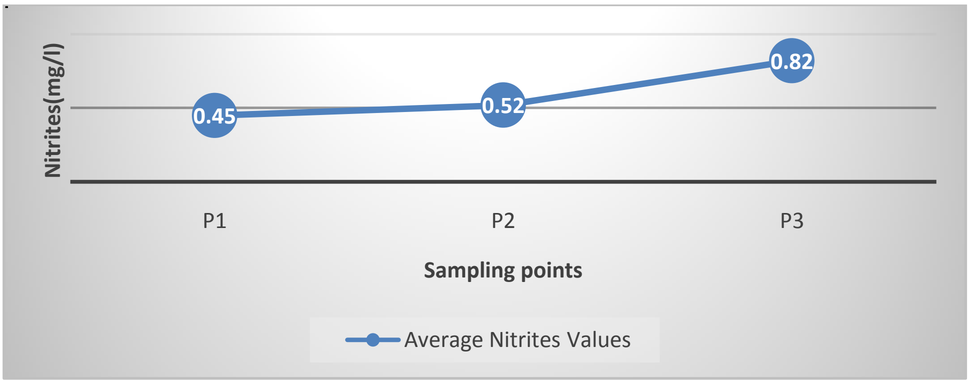

FIGURE 6: Average of nitrites concentration according to sampling points in chosen

The figure 6 shows that the average nitrites levels was high in all sampling points and more increased in sampling point3 (P3); comparatively to other points. According to the limit accepted RSB which is 0.05mg/L; and according to the Canadian guidelines for aquatic water quality has an upper limit for nitrite of 0.06 mg/L; while nitrite in much more toxic to aquatic life than nitrates, nitrite tend to convert quickly to nitrate.

This situation showed that agricultural activities performed in surroundings of Muvumba River; produce substances containing high quantity of nitrites; therefore the water from Muvumba river has been accumulated high quantity of nitrites from agricultural input, according to the required of nitrite level in water.

3.2.2.4 Results from Nitrates laboratory test

Nitrates have been selected among parameters to be analysed as they can contribute in water pollution of the River since they are much more abundant in intensive agricultural runoff. From the laboratory tests, nitrates have shown that the average concentration of nitrates varies from 34, 13 mg/l to 39,13 mg/l in all sampling points. However, all mean concentration levels were within the RSB standards of 45 mg/l.

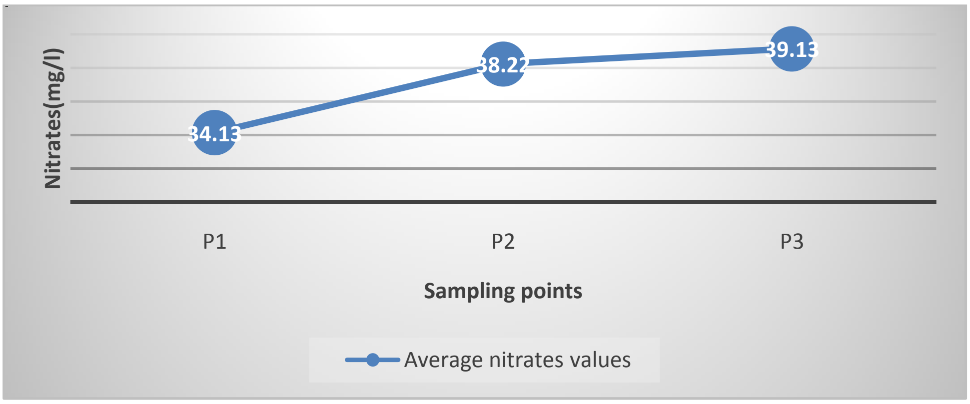

FIGURE 7: Average of nitrate concentration according to sampling points.

From the figure 7, it is noticed that concentration of Nitrates vary at high level, since the difference in average values is high. The sampling point P3 presents a high concentration level of 39, 13 mg/l; this point is in downstream of Muvumba River, where performed more agricultural activities.

3.2.2.5 Results from Ammonia nitrogen laboratory test

The ammonia nitrogen in water body comes from different sources but in our research, we focused the ammonia nitrogen that comes from fertilizers that are used in surrounding of Muvumba River.

According to the Keven Mc Kague, "environmental impacts of nitrogen use in agricultural'' stated that the concentration of ammonium in the soil is generally quite low (1mg/kg), because it is quickly converted to nitrate under condition that are favourable for mineralization, and the high rates of an ammonium fertilizer or high rate of manure are applied; Occasionally, heavy rainfall washes this concentrated ammonium from the field into surface water.

This contains high level of ammonia nitrogen that has a negative impact on water quality.

Laboratory results have shown an average concentration level of ammonia nitrogen ranging between 0.32mg/l and 0.45mg/l for all sampling points. These all-average values were an upper limits accepted by RSB of 0.05 mg/l.

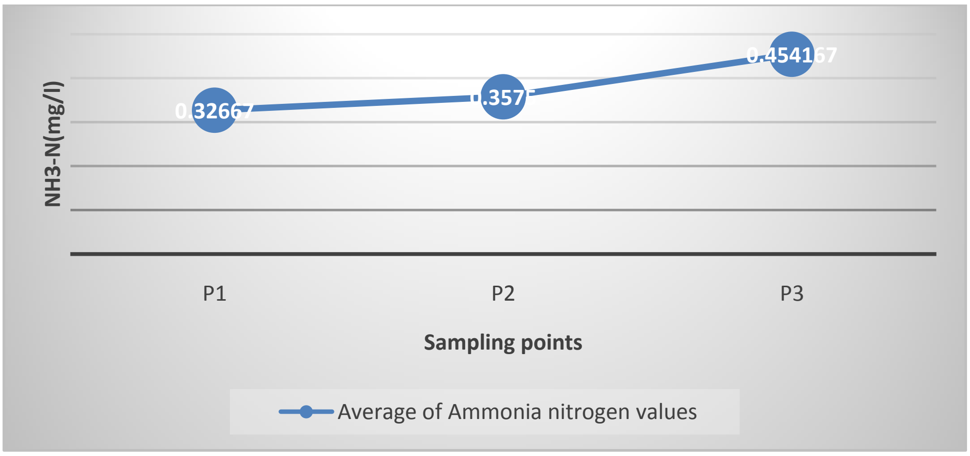

FIGURE 8: Average of ammonia nitrogen values according to sampling points selected.

The figure 8, indicates that the concentration of ammonia nitrogen was on high in all sampling points but more increased in sampling point 3, which located in downstream of Muvumba River, where the agricultural activities is performed much therefore laboratory tests for ammonia nitrogen (NH_3-N) shown that the mean values did overtake RSB guideline which is 0.05mg/l, the trend situation was indicated that there is high concentration of ammonia nitrogen in water from Muvumba river through agricultural activities done in surrounding of River.

3.2.2.6 Results from Phosphates laboratory test

The phosphates were other parameters chosen to be analysed in this research, phosphates from agricultural runoff contribute to the deterioration of water quality in Muvumba River. Laboratory tests for phosphates have shown phosphates concentration level varying between 3.09 mg/l and 3.95 mg/l in all sampling points. These average values present pollution cases of water quality of Muvumba River, since they are all above accepted limit of RSB, which is 3mg/l.

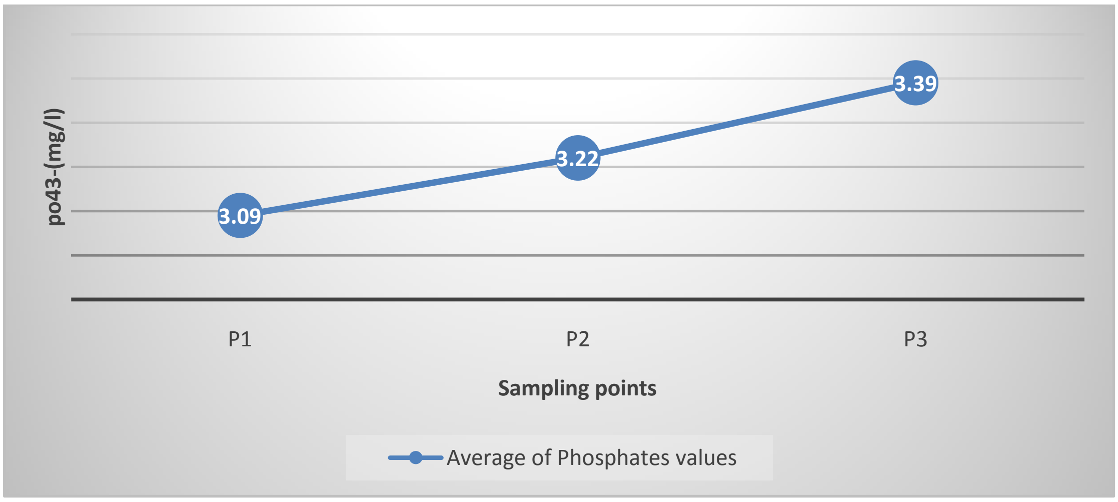

FIGURE 9: Average of phosphate concentration according to sampling points selected

The analysis from the figure 9 shows that there is high concentration levels in P2 and P3 corresponding to 3,09mg/l and 3,39mg/l respectively, comparatively to poin1 which is upstream of Muvumba River at Nyagatare District.

3.2.2.7 Results from Iron laboratory test

Laboratory tests for iron have shown that the concentration level of iron in River varies between 2.53mg/l and 4,82mg/l in all sampling points. These average values are highly surpassed the limits accepted by RSB that stands at 0.3 mg/l.

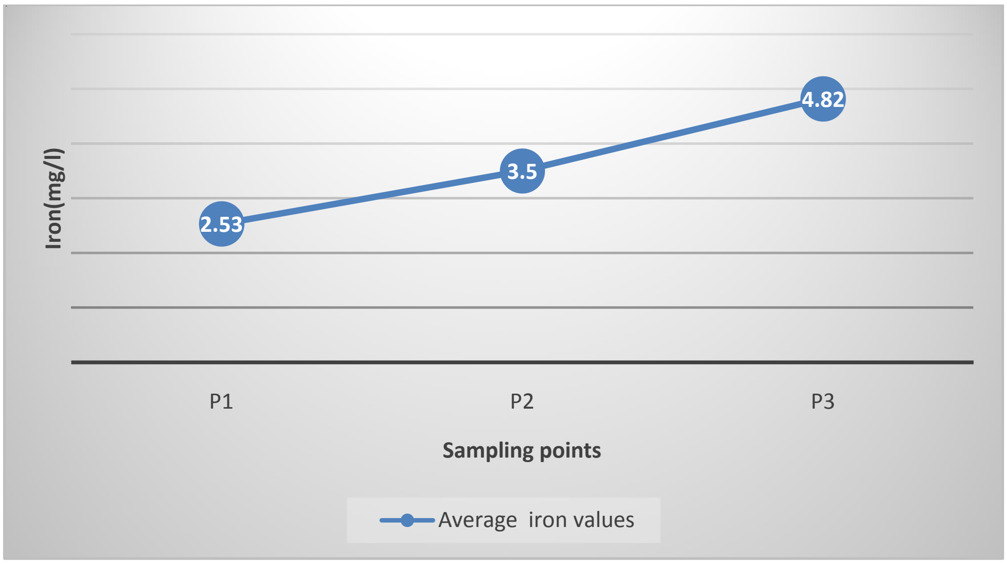

FIGURE 10: Average of iron concentration according to sampling selected sampling points in Muvumba River.

From the figure 10, the concentration of iron is higher in all sampling points but in sampling points P2 and P3 situated near the crops plantation tomatoes, maize, rice, and located in downstream of tributary (Warufu River) and Muvumba River.

Therefore the concentration of Iron in water from Muvumba River is high than guidelines from WHO and RSB limit; and confirming deterioration of water quality from Muvumba River.

3.2.2.8 Results from Manganese laboratory test

Laboratory tests for manganese have shown that the concentration level of manganese in Muvumba River; varies from 0.37 mg/l to 0.63 mg/l in all sampling points. These average values exceeded the limit of RSB standing at 0.1 mg/l.

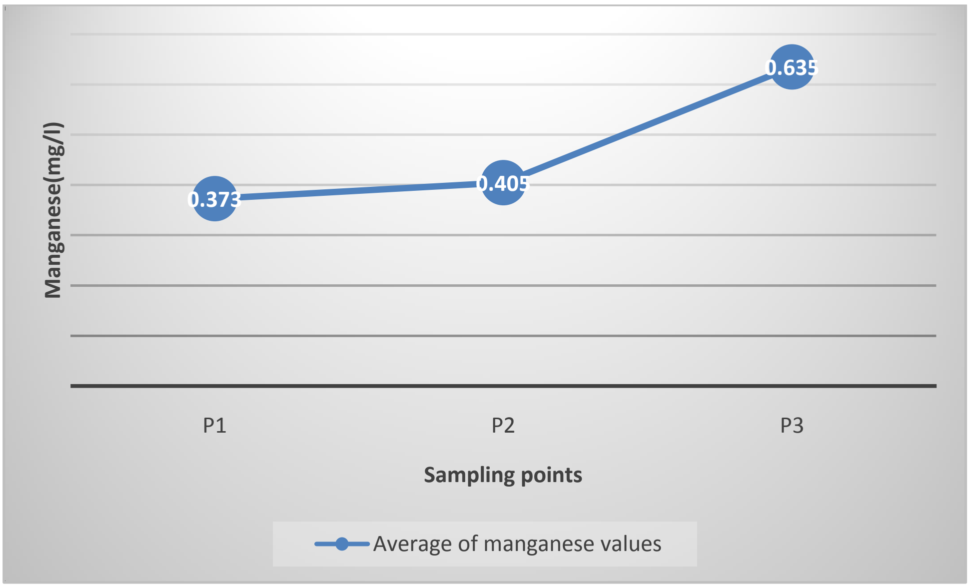

FIGURE 11: Average of manganese concentration according to sampling points selected.

The figure 11 indicates that the concentration of manganese is highly increasing in along of Muvumba River. This situation means that Muvumba River accommodates the sediments of manganese that are highly soluble in water and their concentration manifest itself during the dry season than rainy season.

3.3 Correlation between agricultural practices and water quality from Muvumba River

3.3.1 Demonstration of coefficient of correlation using Linear Regression Model

In order to demonstrate the correlation between agricultural inputs and water quality from Muvumba River, a Linear Regression Model using SPSS confidence interval of 95% was adopted. The following table shows results of coefficient of correlation between these two variables.

TABLE 2
COEFFICIENT OF CORRELATION BETWEEN AGRICULTURAL INPUTS AND WATER QUALITY FROM MUVUMBA RIVER

Parameters	P3 r	P2 r
	N=12	N=12
PH	0.319	-0.058
Turbidity(NTU)	0.212	0.193
Nitrites (mg\L)	0.143	0.393
Nitrates (mg\L)	0.618	-0.356
Ammonia Nitrogen (mg\L)	0.441	-0.430
Phosphate (mg\L)	-0.785	-0.139
Iron (mg\L)	0.859	0.122
Manganese (mg\L)	0.269	0.008

3.3.2 Correlation between agricultural inputs and water pollution from Muvumba River

The relationship between agricultural inputs and water quality parameters demonstrated trough Linear Regression Model using SPSS with confidence interval of 95% considering both data from agricultural inputs used by farmers in their respective farm crops as summarized in Table 3, and laboratory results of water samples as indicated in Table 1.

TABLE 3
SUMMARY OF AGRICULTURAL ACTIVITIES IN SURROUNDING OF MUVUMBA RIVER

Sampling point Selected	Location	Types of Crops	Agricultural inputs	The total Quantity (kg) for each type of fertilizers and pesticides	Total quantity of fertilizers and pesticides for sampling points
P1	Upstream of	N/A	N/A	N/A	N/A
P2	Tributary	Maize Tomatoes Rice	NPK 17*17*17	310800	**553,152**
			NPK 10*8*10	5250	
			urea	149400	
			Beam	86481	
			Benlate	279	
			Fungicide	21	
			insecticide	21	
			Chloropyriphos-ethyl	900	
P3	Downstream of River Of River	Rice	NPK 17*17*17	439,875	**625,949**
			Urea	183000	
			Chloropyriphos-ethyl	294	
			Beam	1050	
		Maize	Benlate	1430	
			Tricyclozole 75%	300	

In subsection 3.3: we have demonstrated the coefficient of correlation between agricultural inputs and water quality; however all parameters that showed positive relationship were not indicating pollution basing on Rwanda Standard Board limit. Therefore, in this section, we highlight the relationship between agricultural inputs and water quality with emphasis on water parameters presenting pollution levels comparing to limits set up by Rwanda Standard Board and compared to the sampling P1 which is water quality baseline.

The Linear Regression Model results indicated that agricultural inputs had positive relationship with turbidity (r=0.193), nitrites (r=0.393), Iron (r=0.122), Manganese (r=0.008, in sampling point P2. This situation highlights pollution of water in sampling point P2, which is cause by use of different fertilizers and pesticides falling into the River from stream passing through maize, rice and tomatoes farms crops.

Results showed also that agricultural activities had positive relationship with pH (r=0.319), turbidity (r=0.212), nitrites (r =0.143), nitrates (r=0.618, ammonia nitrogen (r=0.441, Iron (r=0.859), manganese (r=0.269, in sampling point P3. This situation highlights pollution of water in sampling point P3, which attributed to the use of different fertilizers and pesticides falling into the River from stream passing through maize and rice farm crops.

Considering the farms activities characterized around Muvumba River and different types of fertilizers and pesticide applied to increase production; accommodates the most abundant sediments from agricultural activities containing iron and manganese that are highly soluble in water and contribute to the river pollution. It also highlights that absence of anti-erosion and ineffective drainage of Muvumba River; contribute to degradation of Water Quality

IV. CONCLUSION

The agricultural activities around Muvumba River and quality of water, used SPSS to determine the correlation between them; the result have indicated that there was positive relationship between these variables in sampling points, P2 and P3 compared to P1which is considering as water quality baseline in Muvumba river, and Rwanda Standard Board limit,. Talks about this relationship, all parameters have not presented pollution, but some of them did according to the positive correlation and Rwanda Standard Board guidelines. The parameters which had positive relationship for the sampling point two (P2) are turbidity (r=0.193), Nitrites (r=0.393), Iron (r=0.122), Manganese (r=0.008, and sampling point P3, the parameters that indicated positive relationship between agricultural input and result from water quality. parameters, were pH (r =0.319), turbidity (r=0.212), nitrites (r=143), nitrates (r=0.618; nitrogen ammonia (r=0.441; iron (0.859); manganese (r=269.

Briefly, agricultural activities in surroundings of Muvumba River, where characterized different crops, unprotected of anti-erosion structures, inefficient management of Muvumba marshland margins (buffer zones), utilized of chemical fertilizers and pesticides, and appearance of different types of rocks and soils. All these have contributed to pollution of water in Muvumba River.

The result demonstrated by the coefficient of correlation between agricultural inputs and water quality parameters such as pH; turbidity, nitrites, nitrates, Iron, manganese; nitrogen ammonia presented positive relationship between them; therefore, the research hypothesis confirmed that the agricultural activities have affected the pollution of water quality of Muvumba river. For sustainable wetland management the researcher suggested the following:

- Creation the protection anti-erosions in surrounding Muvumba river areas.
- To make a buffer zone land use in marshland of Muvumba river, through sensitizing local community and educating people using croplands surrounding Muvumba river in a way respecting Marshland margins (buffer zone) and have minimum knowledge the causes of water pollution. referring to the law on wetland protection applicable in Rwanda,
- To sensitize population the way to manage the agricultural wastes for protecting water to be polluted.
- To advise the district planers to consider long-term development matters, in order to sustain economic development of district; agricultural policy should not only be focused on the increase food production but also considering water quality stability.
- To consider environmental protection during the activities of agriculture and avoid the activities which can contribute to the pollution of water quality from the resource.
- To create the activities anti-erosion in order to maintain rainwater.

- Collaborate with district agronomist in order to take action of farming in order to be conformity of laws governing the use of land.
- To prepare agricultural activities which is not degrading the soil and the water quality.
- To mix organic manure with industries fertilizers in order to reduce induced by chemicals fertilizer and increase crop productivity.
- Create clubs for environmental protection in order to educate mass population about it.

REFERENCES

[1] Akbulut, M., Kaya,H., Odabasi,D.A. (2010). Assessment of Surface Water Quality in the Atikhisar Reservoir and Saricay Creek. Ekoloji, 19, 139–149.

[2] APHA.(2005). Standard Methods for the Examination of Water and Wastewater.

[3] EPA. (2009). National Water Quality Inventory: Report to Congress; 2004 Reporting Cycle. Washington, DC: United States Environmental Protection Agency. Washington, DC: EPA.

[4] FAO. (1996). Control of water pollution from agriculture, Rome: Food and Agriculture Organization.

[5] Harrafi, H. K. (2012). Determination of Chemical Oxygen Demand in Spent Caustic by Potentiometric Determination. World Academy of Science, Engineering and Technology, 6(7), 190–192.

[6] IDA. (2008).): L'agriculture un moteur de croissance et de lute contre la pauvrette.Washington,D.C, United States: International Development Association.

[7] IPAR. (2009). Rwanda Agriculture Sector situational analysis, Kigali:Institute of Policy Analysis and Research-Rwanda.

[8] Kibena, J. N. (2014). Assessing the relationship between water quality parameters and changes in landuse patterns in the Upper Manyame River. Zimbabwe.physics and chemistry of the Earth,partsA/B/C 67, 153-163.

[9] Koffi Annan. (2000). United Nations Millennium Summit, New York, USA.

[10] Larsen, H. a. (1997). Water Pollution Control - A Guide to the Use of Water Quality Management Principles. United Nations Environment Programme, the Water Supply & Sanitation Collaborative Council and the World Health Organization.

[11] Mmbando Joseph, Beatrice Admola, Charles Gahima, Micheal Kivuva. (2007), Atlas for East.

[12] Africa, Ministry of Education and Vocational Training, Dar Es Salaam, United republic of Tanzania

[13] Nahayo L, Lanhai,L, Kayiranga,A., Karamage,F., Mupenzi,C. Ndayisaba,F. and Nyesheja,E.M., (2016). Agricultural impact on environment and counter measures in Rwanda.

[14] Ninhoskinson. (2011). Water Pollution: Humans Contributing to their downfall. Ninhoskinson.

[15] Ombaka.O.Gichumbi. J &Kibara.D. (2013).Evaluation of ground water and tap water quality in the villages surrounding Chuka town, Kenya. Journal of chemical, Biological and physical sciences.Vol (3) 1551-1563 [16] RAB. (2012). Annual report. KIGALI: Rwanda Agriculture Board.

[16] REMA. (2009). Rwanda State of Environment and Outlook: Our Environment for Economic Development, p. 137. Kigali.

[17] Schreinemachers, P. (2012). Agricultural pesticides and land use intensification in high, middle and low income countries Food Policy, 37: 616–626. International Journal of Environmental & Agriculture Research (IJOEAR) ISSN:[2454-1850] [Vol-5, Issue-12, December- 2019] Page | 24

[18] Thirupathaiah. (2012). Analysis of water quality using physico-chemical parameters. International Journal of Environmental Sciences volume3, No1,2012, 3-6.

[19] UNESCO. (2006). Global Hydrology and Water Resources. Water: a shared responsibility.UNESCO 2006. [21]

[20] US-EPA. (1994). Introduction to agricultural water pollution. The natural Resources Management and Environment Department.

[21] WASAC. (2019). wasac annual report/department of urban water and sewerage services.

[22] WHO, (2006). Guidelines for Drinking –Water Quality. seconded, Health Criteria and Other Supporting Information Switzerland.

Lettuce Growth and Production under Plastic Shading as a Response to different Microclimate Condition: A Preliminary Study of Climate Change Factors Impact on Crops

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Abstract— *Crop production is vulnerable to climate variability, especially when it associated with increasing temperature. Results from global and local scale research with different methods consistently showed negative temperature impacts on crop yield especially vegetables. One reason of lacking research in quantifying the impacts of climate change on crops is difficult to modify the air temperature and climate change marked by global temperature increase happened on regional and sub-regional scales. Therefore, this primary research tried to overcome this problem with planting highland crops on lowland area which has higher temperature area and study what changes experienced in crops growth and production. Lettuce is chosen in this experiment since lettuce is a wild plant native to temperate regions then vulnerable to climate change and as leafy crops, lettuce is representative in examining temperature effects on crop, leaf area is the main determining factor affecting light interception by crop and lead to biomass production. The experiments were conducted under UV polyethylene sheet to reduce the incoming solar radiation, and measured microclimate factors along with lettuce growth and production. Numbers of leaves for both lettuce plants inside the shading were significantly lower and as the consequences the fresh weight was still lower. Direct full sunshine with lower intensity combined with low temperature is the characteristic of highland area, the habitat of lettuce in Tropical area. In open and under shading condition of the experiment, the incoming radiation was still in the range of recommended light intensity for lettuce production. However, the air temperature seemed too high for lettuce cultivation in lowland area. In the nature it is possible that if the earth temperature keeps rising more crops will inhibit higher altitude.*

***Keywords*— Microclimate, lettuce, radiation, climate changes, shading.**

I. INTRODUCTION

Crop production is vulnerable to climate variability, especially when it associated with increasing temperature. Results from global and local scale research with different methods consistently showed negative temperature impacts on crop yield especially vegetables. All of studies find that crops are sensitive to changes in temperature (IPCC, 2007; Mendelsohn, 2014). The consistency of these findings suggested that crops are potentially vulnerable to climate change.

Environmental extremes that recently magnified by climate change affected several physiological and biochemical process such as photosynthetic activity, metabolism and enzymatic activity (Ayyogari, Sidhya and Pandit, 2014). Even moderate increase of average day or night temperatures could affect the yield and quality of vegetables like spinach, potato, broccoli, and lettuce (Turner and Meyer, 2011). Initially, high temperature reduced leaf area, which reduced radiation intercepted and eventually reduced the biomass. On the other hand, high temperature speeded up phonological development and shortened the period from emergence to flowering and from flowering to maturity; this often turned out to have undesirable traits. Smaller Tomato fruits in size with higher dry matter content and uneven heads with over-sized flower buds in broccoli occurred even at temperatures of only 25^{o}C (Bisbis, Gruda and Blanke, 2019)

Indonesia is a tropical country in the region of Southeast Asia. By the end of the century IPCC scenarios projected that both temperature and precipitations will change; the temperature may rise from 0.72 to 3.92°C while precipitation may decrease by two percent or increase by up to twelve percent (Cruz et al., 2007). Downscaled modeling specific for Indonesia projected that the temperature will rise relatively uniform across all of Indonesia from about 0.1 to 0.3°C per decade for the next 100 years; and other study suggested that the rate of temperature rising for Indonesia will be slightly greater from 0.2 to 0.3°C per decade (Boer and Faqih, 2004).

Indonesia depends much on agriculture productions; both food crops like rice as the staple food and horticulture products are important. While food crops are sensitive to water availability, horticulture products are sensitive to air temperature and humidity. One of the consequences of climate change in a tropical country will be a shift in the areas of cropping; and as crops could invade mountainous area in searching for cooler air it eventually lead to soil erosion and landslides. New crops could be invaded particular area that are currently marginal for cropping because the temperatures were so low, while some previous productive area could become bare soil (Iizumi and Ramankutty, 2015). In long term it will change the land use and endanger the environment. One reason of lacking research in quantifying the impacts of climate change on crops is it needs detailed information on physiological responses of the crops, climate factors effect on crops growth, development, quality and productivity and it is difficult to modify the air temperature (Malhotra, 2017). Moreover, climate change marked by global temperature increase happened on regional and sub-regional scales. For that reason, it is difficult to generalize the impact on vegetable and fruits crop, for growth and development of these crops are influenced by different environmental factors and numerous type with wide diversity makes it even difficult to summarize the potential effects of climate change on growth and yield. For that reason, few studies on the impact of climate change on vegetables have been carried out (Nelson et al., 2010). Therefore, this primary research tried to overcome this problem with planting highland crops on lowland area which has higher temperature area and study what changes experienced in crops growth and production.

Lettuce is chosen in this experiment since lettuce is a wild plant native to temperate regions then vulnerable to climate change. Some problems that might happen if the temperatures higher than 30^{o}C are: seedling malformation, low germination potential, decline in plant size, latex accumulation making leaves bitter and rigid, also loss of apical meristem and browned edges. Higher temperatures can also be associated with stem cleft resulting from deficiency of calcium and boron (Mattos et al., 2014). Lettuce seems to be a model crop well studied for light quality and temperature response, since beside temperature lettuce production also depends on light quality and light intensity. In high latitude area, lettuce production may be limited during late spring and summer months because of unfavorable temperatures which exceeding 30/16 °C day/night that increase the risk of bolting (forming of non-desirable flower stalks), tip burn, rib discoloration and leaf bitterness (Ilić et al., 2017). Lettuce was also chosen because as leafy crops, lettuce is representative in examining temperature effects on crop. Leaf area is the main determining factor affecting light interception by crop and lead to biomass production. Therefore, any reduction of leaf expansion rate is usually associated with reduction of photosynthesis and consequent decrease in above-ground biomass, grain yield and quality. We proposed a hypothesis that changing in crops microclimate would affect crop growth and production.

II. METHODOLOGY

2.1 Experimental and Shading Set-Up

The experiments were conducted under UV polyethylene sheet in form of tunnel shelter with floor area of 1.5 × 2 m2 and 2 m height, oriented in a north–south direction at private land in TelukBetung, Bandar Lampung, Indonesia (5^{0} 26'07" S and 105^{0} 15' 32" E, 10 m asl). Red lettuce (Lactuca sativa L. var. lollorosa), Romaine lettuce (Lactuca sativa L. var. longifolia) were planted inside the tunnel and in open space (without shading) as the control on dry hot season from May to June 2019.

2.2 Measuring the Required Parameters

The microclimate parameters: incoming radiation intensity (watt/m^{2}) measured with Skye instrument pyranometer, above ground temperature (^{0}C) and humidity (%) inside and outside the shading tunnel were measured using Flush USB humidity and temperature data logger E3845 type at noon time. Plants parameters were measured at harvest time including number of leaves, leaves maximum length and width, stem length, root dry weight and crops fresh weight. Means differences were analyzed statistically using T test.

III. RESULTS AND DISCUSSIONS

3.1 Microclimate Condition of Experiment

Average of incoming solar radiation intensity, above ground temperature and humidity inside and outside the polyethylene tunnel shading were presented in Table 1 and daily difference of those measurements between outside and inside the shading were presented in Fig. 1-3.

TABLE 1
AVERAGE OF INCOMING SOLAR RADIATION INTENSITY

Micro Climate measurements	Outside the shading	Inside the shading
Incoming solar radiation (watt/m^2)	673.95 (58.23 MJ/m2/day)	473.11 (40.88 MJ/m2/day) s
Above ground temperature (^oC)	35.61	34.66 ns
Above ground humidity (%)	53.26	56.18 ns

T test with 95% confidence interval

The incoming solar radiation flux is the sum of the diffused (the incoming shortwave in the shade) and direct radiations incident on the earth's surface in the form of shortwave radiation. This is the energy that drives the hydrological cycle and determines the total amount of energy that is available at the earth's surface for life-giving processes including photosynthesis. The diurnal range of the incoming solar radiation at a Tropical station, Ile-Ife (7.53^{0}N; 4.54^{0}E), Nigeria during the dry months was 700.7±105.2 Wm-2 (Soneye, et al., 2019). Photosynthesis use part of the incoming solar radiation called PAR (Photosynthetic Active radiation). The use of simple PA R irradiance ratio values is an average of 0.44 (±0.01) in January to an average of 0.48 (±0.01) in July (Biyun and Cho, 2006).

The polyethylene shield consistently reduced the radiation intensity in average to about 200.51 watt/ m2 (statistically significant 14% reduced), it also could be said that the transmittance was about 70%. White shading had highest in direct and diffuse PAR transmittance 0.5-0.6 all day at all angles, reflectance 0.3-0.5 and lowest in absorbance 0-0.1 (Al-Helal and Abdel-Ghany, 2019). Transmitted solar radiation is the main source of energy in shading and released as sensible and latent heat while contribution of thermal radiation to the total energy in the greenhouse is low. More than 70% of the transmitted solar radiation is transformed to sensible heat used to increase the air temperature (Abdel-Ghany et al., 2019). At a plant density corresponding to a leaf area index (LAI) of 3, about 54% of the integrated solar radiation that was utilized by the greenhouse was converted to sensible heat and about 46% converted to latent heat via evapotranspiration (Abdel-Ghany, 2011).

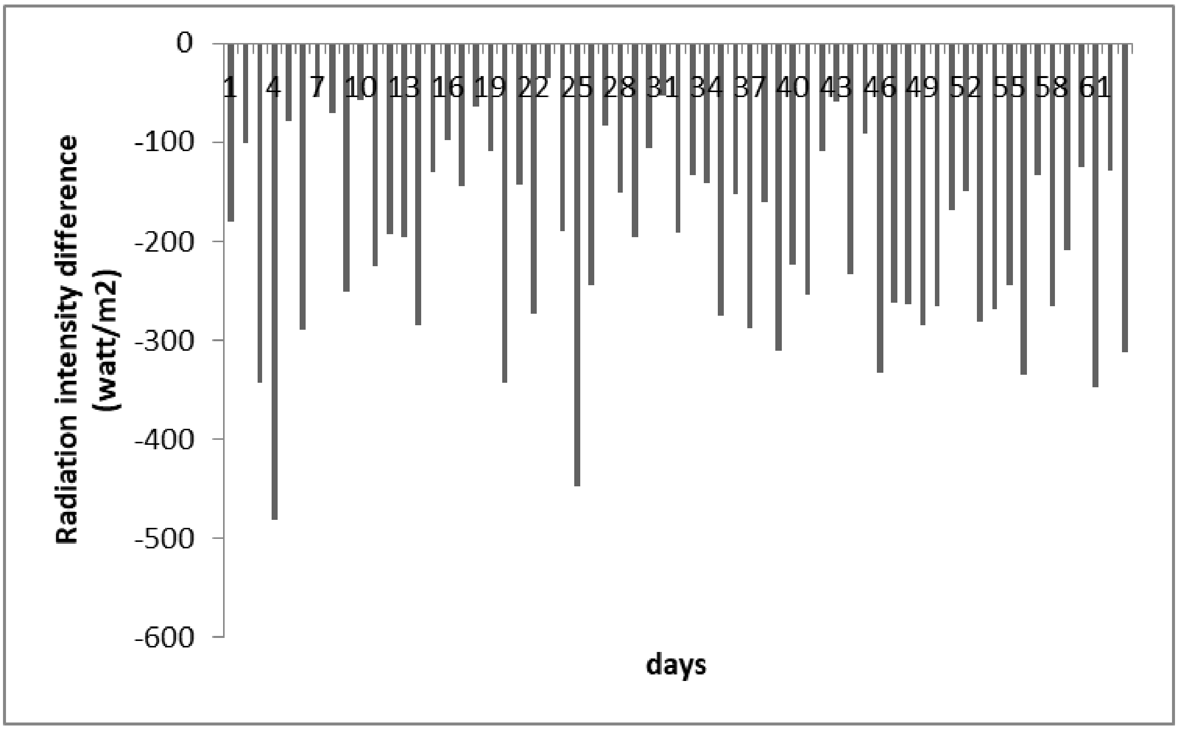

FIGURE 1: Incoming radiation intensity difference inside and outside the plastic shading

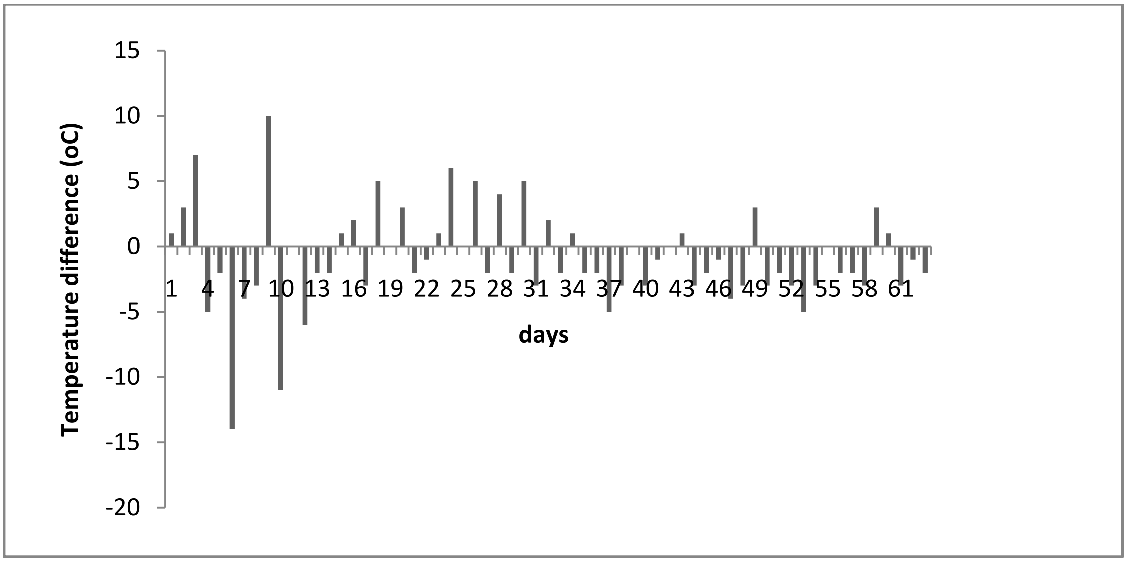

FIGURE 2: Above ground temperature difference inside and outside the plastic shading

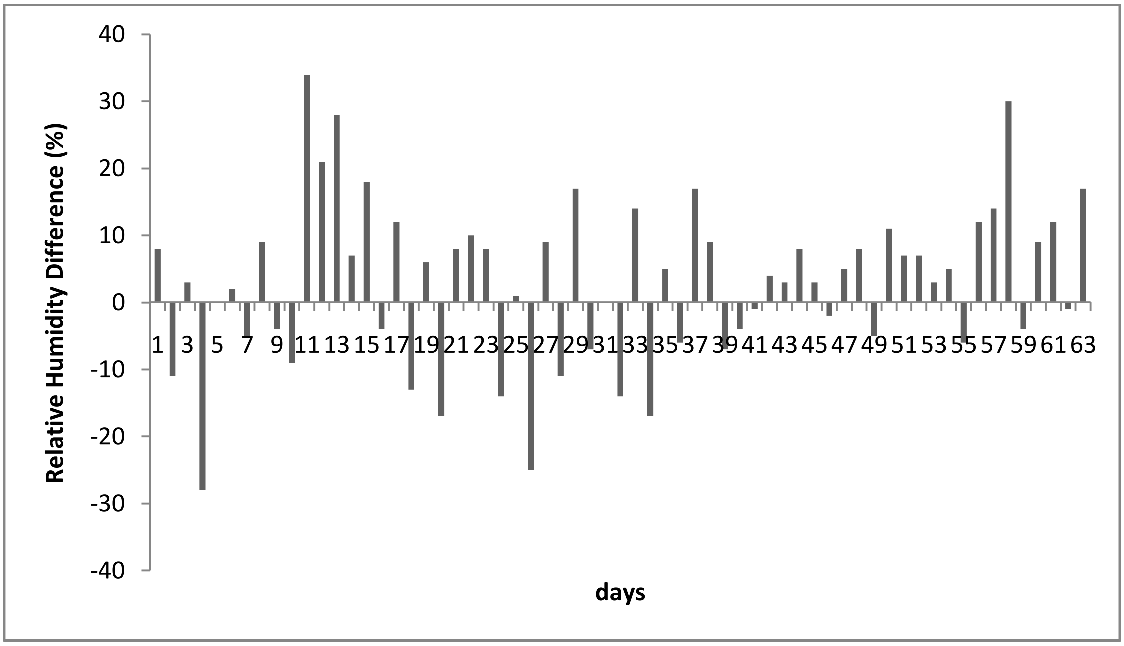

FIGURE 3: Relative humidity difference inside and outside the plastic shading

The above ground temperature inside the shading was not constantly lower compare to the open space even though in average, it was still reduced in about 0,92 ^{0}C. As explained above source for air temperature inside shading is sensible heat converted from the transmitted radiation, so that with little advection the temperature would not reduce much it even might be increased. Some research results noted that shading color had a predominant effect on the transmittance, reflectance and absorbance values. Plastic shading in hot and sunny regions slightly reduce average daily temperature 28.90 °C to 27.81 °C, white plastic shading was significantly lower temperature at night compare of the control. (Chen et al, 2019), 28.4°C to 29.1°C (Rigakis et al, 2012).

Air humidity was mostly higher inside the shade even though with just small differences (3%). While change of air temperature inside greenhouses is a function of the transmitted solar radiation, the ventilation, and the size of the greenhouse; the variation of RH inside greenhouses depends on temperature and air circulation. The higher the temperature, the lower relative humidity and the more intense the air circulation the lower the relative humidity (Holcman and Sentelhas, 2012). The humidity also showed that the transpiration rate was slightly higher under shading and open field conditions. It could be attributed to a possible increase in crop stomata conductance since temperature and air humidity is the variables with the greatest effect on stomatal conductance and transpiration rate (Shaban et al., 2016).

3.2 Lettuce Growth and Production

In general, growth and yield of crops are related to the amount of solar radiation received during the growing period. However, solar radiation could not be used as a single factor to estimate the performance of crops. Other interactions with other climatic variables, especially air temperature, must also be considered. Although air temperatures are related to solar radiation, this relationship is not constant, and may show variations in different seasons and/or locations (Sandri et al., 2003)

Since the temperature and humidity in this experiment could considered similar inside and outside the shield, it can be assumed that radiation difference was the main microclimate factor that effect the plant growth and yield difference of these types of the lettuce as shown in Table 2.

TABLE 2
LETTUCES GROWTH AND YIELD ON SHADING TREATMENTS

Variable	Treatments	Red lettuce	Romaine
Number of leaves	Open space	14.03	34.14
	Under shading	10.52 s	24.90 s
Leaves length (cm)	Open space	12.24	19.81
	Under shading	12.63 ns	19.86 ns
Leaves width (cm)	Open space	10.02	12.02
	Under shading	10.05 ns	11.13 s
Leaves area (cm^2)	Open space	41.41	89.94
	Under shading	40.55 ns	85.36 s
Stem Length (cm)	Open space	11.69	18.59
	Under shading	11.53 ns	23.56 s
Fresh Weight (gram)	Open space	46.50	228.00
	Under shading	35.39 s	123.97 s
Root Dry weight (gram)	Open space	0.54	3.91
	Under shading	0.47 ns	1.26 s

T test with 95% confidence interval

Numbers of leaves for both lettuce plants inside the shading were significantly lower. Leaves length and width and as consequences leaves area as well as stem length in Red lettuce were just similar in open and shading condition. Therefore, lower fresh weight was the results of fewer leaves. For Romaine lettuce even though leaves length was not significantly difference but the leaves width was lower and as consequences the leaves area was lower, and even though stem was longer but the fresh weight was still lower. Similar with the red lettuce lower number of leaves result in lower lettuce fresh weight. One research in Indonesia also showed that planted lettuce in open direct sunshine resulted in much better crops growth and development showed in all variables (Nurdianna, Putri and Harjoko, 2018). Full and direct sun radiation is important in lettuce cultivation and in general photosynthetic performance in greenhouse intensive production can be limited due to reduced distribution of the intercepted solar light along the canopy profile, which can reach levels of about 35%. If all factors to improve the efficiency of radiation use and the efficiency of crop light interception were optimized simultaneously, crop productivity could be improved by 36%–64% (Sandri et al., 2003).

Direct full sunshine with lower intensity combined with low temperature is the characteristic of highland area, the habitat of lettuce in Tropical area. The range of PAR 400 µmol/m^2/s to 600 µmol/m^2/s is a recommendable light intensity for lettuce production (Fu et al, 2012). With the conversion of solar radiation (Rs) Wm^{-2} to photosynthetically active radiation (PAR) is about ~ 2.02 (dos Reis and Ribero, 2020), then PAR in this experiment site was 673.95x0.48x2.02 =653.46 to 473.11x0.48x 2.02= 458.73 µmol/m^2/s which was still in the range of recommended light intensity for lettuce production. However, the air temperature seemed too high for lettuce cultivation in lowland area.

IV. CONCLUSION

As this study aimed to understand whether highland crops could adapt to the lowland environment condition as a premiere study of the impact of climate change on crops, it can be concluded that radiation intensity might not be the problem as long as the temperature would not rise. Shading especially with polyethylene sheet may not be the solving method since it could raise the temperature inside the shading. In the nature it is possible that if the earth temperature keeps rising more crops will inhibit higher altitude.

REFERENCES

[1] A.M. Abdel-Ghany, "Solar energy conversions in the greenhouses", *Sustainable Cities and Society*vol 1 no 4 pp 219-226.ISSN 2210-6707. https://doi.org/10.1016/j.scs.2011.08.002. 2011.

[2] A. M. Abdel-Ghany, I. Al-Helal, F. Alkoaik, A. Alsadon, M. Shady, A. Ibrahim, "Predicting the Cooling Potential of Different Shading Methods for Greenhouses in Arid Regions", *Energies,* vol*12 no 24 pp4716-4729*. https://doi.org/10.3390/en12244716, 2019**.**

[3] D.S. Byun, and Y.K Cho, "Estimation of the PAR irradiance ratio and its variability under clear-sky conditions at Ieodo in The East China Sea", *Ocean Sci. J.*vol41pp235–244 https://doi.org/10.1007/BF030206272006.

[4] D. Nurdianna, R.B. AniPutri and D. Harjoko, "Penggunaan Beberapa Komposisi Spektrum Led Pada Potensi Dan Hasil Hidroponik Indoor Selada Keriting Hijau" *Agrosains* vol 20 no 1pp 1-6. ISSN: 1411-5786, 2018.

[5] H. Chen, Q. P. Li, Y. L.Zeng, "Effect of different shading materials on grain yield and quality of rice", *Sci Rep* 9 pp 9992 . https://doi.org/10.1038/s41598-019-46437-9C, 2019.

[6] I.M. Al-Helal and A.M. Abdel-Ghany, "Responses of plastic shading nets to global and diffuse PAR transfer: Optical properties and evaluation", *NJAS - Wageningen Journal of Life Sciences*vol 57 pp 125–132. https://doi.org/10.1016/j.njas.2010.02.002, 2010.

[7] IPCC (Intergovernmental Panel on Climate Change), "Climate Change: Impacts, Adaptation, and Vulnerability", *Cambridge University Press*, Cambridge, 2007.

[8] K. Ayyogari, P. Shidiya, and M. K. Pandit , "Impact of Climate Change on Vegetable Cultivation - A Review", *International Journal of Agriculture, Environment and Biotechnology*, vol. 7, no. 1, pp. 145–155, 2014. DOI 10.5958/j.2230-732X.7.1.020.

[9] L.M. Mattos, C. L. Moretti, S. Jan, S. A. Sargent, C. E. P. Lima, M.R. Fontenelle, "Chapter 19 - Climate Changes and Potential Impacts on Quality of Fruit and Vegetable Crops", Editor(s): Parvaiz Ahmad, Saiema Rasool. *Emerging Technologies and Management of Crop Stress Tolerance*. Academic Press, Pages 467-486, ISBN 9780128008768. https://doi.org/10.1016/B978-0-12-800876-8.00019-9, 2014.

[10] M.A. Sandri, J.L. Andriolo, M. Witter, T. D. Ross, "Effect of shading on tomato plants grow under greenhouse", *Horticultura Brasileira, Brasília* vol 21 no 4 pp 642-645, 2003.

[11] M.B. Bisbis, N.S Gruda, M.M Blanke, "Securing Horticulture in a Changing Climate—A Mini Review," *Horticulturae*, vol*5*, no 56, 2019. https://doi.org/10.3390/horticulturae5030056.

[12] N.C. Turner.and R. Meyer, "Synthesis of Regional Impacts and Global Agricultural Adjustments". In: *Crop Adaptation to Climate Change, First Edition,* Edited by Shyam S. Yadav, Robert J. Redden, Jerry L. Hatfield, Hermann Lotze-Campen and Anthony E. Hall.

[13] John Wiley & Sons, Ltd, 2011. DOI: https://doi.org/10.1002/9780470960929.ch12.

[14] N.T. Shaban, N. Tzvetkova, R. Cherkez, P. Parvanova. "Evaluation of response of lettuce (Lactuca sativa L.) to temperature and light stress", *Acta Agrobot* vol 69 no 2 pp 1664. http://dx.doi.org/10.5586/aa.16642016.

[15] O.O. Soneye, M. A. Ayoola, I. A. Ajao, O.O. Jegede, "Diurnal and seasonal variations of the incoming solar radiation flux at a tropical station, Ile-Ife, Nigeria", Heliyonvol 5, issue 5, https://doi.org/10.1016/j.heliyon.2019.e01673, 2019.

[16] R. Boer and A. Faqih. "Current and Future Rainfall Variability in Indonesia. An Integrated Assessment of Climate Change Impacts, Adaptation and Vulnerability in Watershed Areas and Communities in Southeast Asia", *Report from AIACC Project No. AS21 (Annex C, 95-126). International START Secretariat, Washington, District of Columbia*, http://sedac.ciesin.org/aiaac/ progress/ FinalRept_AIACC_AS21.pdf, 2004.

[17] R. Mendelsohn, "The Impact of Climate Change on Agriculture in Asia", *Journal of Integrative Agriculture* vol 13 no 4 pp 660-665. https://doi.org/10.1016/S2095-3119(13)60701-7. 2014.

[18] R.V.Cruz, H. Harasawa, M. Lal, S. Wu, Y. Anokhin, B. Punsalmaa, Y. Honda, M. Jafari, C. Li and N. HuuNinh, "Asia. Climate Change: Impacts, Adaptation and Vulnerability". *Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change*, M.L. Parry, O.F. Canziani, J.P. Palutik of, P.J. van der Linden and C.E. Hanson, Eds., Cambridge University Press, Cambridge, UK, 469-506, 2007.

[19] S. K. Malhotra, "Horticultural crops and climate change: A review". *Indian Journal of Agricultural Sciences* vol 87 no 1 pp 12–22, 2017.

[20] S. Z. Ilića, L. Milenkovića , A. Dimitrijevićb , L. Stanojevićc , D. Cvetkovićc , Ž. Kevrešand , E. Fallike , J. Mastilović, "Light modification by color nets improve quality of lettuce from summer production", *Scientia Horticulturae* vol 226 pp 389–397 http://dx.doi.org/10.1016/j.scienta.2017.09.009 , 2017.

[21] T. Lizumi and N. Ramankutty. "How do weather and climate influence cropping area and intensity?" *Global Food Security*, vol 4, pp 46-50, ISSN 2211-9124, https://doi.org/10.1016/j.gfs.2014.11.003., 2015.

[22] V. Nelson, J. Morton, T. Chancellor, P. Burt and B. Pound, "Climate Change, Agricultural Adaptation and Fair-trade. Identifying the Challenges and Opportunities", *Natural Resources Institute* I: 1-45, 2010.


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