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Preface

We would like to present, with great pleasure, the inaugural volume-5, Issue-2, February 2019, 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

Environmental Research:

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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Agricultural Chemistry	Basic biology concepts
Sustainable Natural Resource Utilisation	Management of the Environment
Agricultural Management Practices	Agricultural Technology
Natural Resources	Basic Horticulture
Food System	Irrigation and water management
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Cereals or Basic Grains: Oats, Wheat, Barley, Rye, Triticale, Corn, Sorghum, Millet, Quinoa and Amaranth	Oilseeds: Canola, Rapeseed, Flax, Sunflowers, Corn and Hempseed
Pulse Crops: Peas (all types), field beans, faba beans, lentils, soybeans, peanuts and chickpeas.	Hay and Silage (Forage crop) Production
Vegetable crops or Olericulture: Crops utilized fresh or whole (wholefood crop, no or limited processing, i.e., fresh cut salad); (Lettuce, Cabbage, Carrots, Potatoes, Tomatoes, Herbs, etc.)	Tree Fruit crops: apples, oranges, stone fruit (i.e., peaches, plums, cherries)
Tree Nut crops: Hazlenuts. walnuts, almonds, cashews, pecans	Berry crops: strawberries, blueberries, raspberries
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Influence of silicon, nitrogen and molybdenum doses on the production of bean pods

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***Abstract*—** *The snap beans is greatly appreciated and consumed by Brazilians, and the snap beans commercial seeds are divided into indeterminate growth habit and determined. Farmers most often plant indeterminate growth habit bean-pod, so the fertilizer recommendations are for this habit. Due to the availability of determinate growth habit cultivars, it is necessary to study the nutrition area, because they have the shortest cycle, flowering and pod production in concentrated period, smaller spacing and planting densities with greater influence in the population by ha. The study aimed to evaluate the snap bean growth given in the search response with increased productivity positively due to the use of silicon as well as the rational use of Nitrogen and Molybdenum. The experiment was design on track and installed with subplots and two replications, using treatments with and without foliar application of 5% of eucalyptus ash, four nitrogen doses 0, 50, 100 and 150 kg N / ha and four molybdenum doses in foliar application 0, 30, 60 and 90 g Mo / ha. Nitrogen and molybdenum treatments responded with a yield and quality increase, allowing adjusting of quadratic equations regression and to recommend if the farmer does not use molybdenum, the nitrogen dose of 79.2 kg in coverage application. For molybdenum and nitrogen, according to the results obtained, the doses of 35g Mo / ha and 130 kg N / ha in coverage are recommended in coverage application. The silicon, applied through eucalyptus ash, did not respond in production.*

***Keywords*— *Phaseolus vulgaris, mineral nutrition, cv. Novirex, pod, nitrogen fertilizer, sodium molybdate*.**

I. INTRODUCTION

The bean-pod culture has its importance because it is widely appreciated and consumed by the Brazilian, being among the vegetables more commercialized in the central of supply. From the same botanical species of the common bean, the commercial seeds of the bean-pod are divided in relation to the habit of growth in indeterminate and determined. The majority of the farmers planted bean pods with an indeterminate growth habit (climber) in crop rotation with plants that need to be tutored, such as tomatoes and cucumbers, so the fertilization recommendations found in the literature are for this habit of growth. With the availability of cultivars of determined growth habit, it is necessary the study in the area of nutrition, as they present the shorter cycle, flowering and pod production in the concentrated period, smaller spacing and higher planting densities, with influence on the production per hectare. Different from the traditional cultivars of indeterminate habit, we seek the knowledge for the bean-pod of determined habit, in such a way, that the farmer can conduct his crops with rational and economic fertilization. They can thus achieve better environmental preservation and better utilization of nutrients and thus greater productivity.

The induction of resistance, through the possible activation of defense mechanisms existing in plants in response to biotic or abiotic agents, becomes an important strategy in the pursuit of sustainability. Thus, the silicon can act as an illicitor of the resistance process induced in plants according to [1]. Possibly some illiciting agents induce defense responses in plants, such as changes in cellular, physiological and morphological structure. An interesting source of silicon is eucalyptus ash, which has an average of 16.9% of SiO2, among other nutrients, being important in the vegetative development of plants, acting as a promoter of potato growth [2]; [3]. However, it is important to note that the [4] recommends for the indeterminate growth habit bean the use of 700 kg / ha of NPK formulation 4-14-8 or 350 kg / ha of the formulated 8-28-16, twenty days after emergence of the seedlings, it should be fertilized with 200 kg / ha of ammonium sulphate or 100 kg / ha of urea under cover and at the same time spray the plants with 100 g / ha of sodium molybdate to stimulate the fixation of atmospheric N.

Although N is incorporated into numerous plant essential compounds, it is largely present in proteins. N has two general functions: establishments and maintenance of photosynthetic capacity; development and growth of reproductive drains [5]. It is also an important structural component of macromolecules and a constituent of enzymes, besides acting as precursor of plant hormones, chlorophyll and cytochrome [6].

The main functions of molybdenum in plants are related to nitrogen metabolism. These functions are linked to the action or enzymatic activation, more precisely, with respect to the enzymes nitrogenase and nitrate reductase [7].

In the bean-pod was observed by [8] the positive response in the production in the use of nitrogen in coverage. However it is in common bean culture that more studies on nitrogen and molybdenum are presented, [9] reported that the relative index of chlorophyll in the leaves of the bean was increased by the application of N in cover and the Mo via foliar. The application of N in cover provided an increase in grain yield of the bean only when combined with the supply of Mo via foliar. The supply of 80 g ha-1 of Mo via leaf increased the efficiency of N utilization by bean, according to [10], both in the presence and absence of nitrogen in sowing or cover, the increase of the molybdenum dose up to 80 g ha-1 increases the number of pods per plant and grain yield of the bean.

In relation to molybdenum sources [11] observed that sodium molybdate or ammonium molybdate can be used indifferently for leaf application in common bean. With regard to the installment and application time [12] concluded that the foliar application of Mo, starting at 15 and 20 days after emergence in a single or split dose, increases grain yield in summer-fall cultivation. In winter-spring cultivation, productivity increases with Mo applied between 15 and 30 days after emergence, in a single or split dose. Thus, the objective of this work was to evaluate the influence of silicon application and different nitrogen and molybdenum doses on the economic production of the bean-pod of determined growth.

II. METHODOLOGY

The work was carried out at the Lambari Experimental Farm of the Agricultural Research Company of Minas Gerais (EPAMIG) located at the south of Minas Gerais, at an altitude of 895 meters, latitude 21 ° 58 'S and longitude 45 ° 23' W. The design experimental study was in the range with subplots and two replications. The treatments were with and without application of eucalyptus ash, four nitrogen rates in coverage (0, 50, 100 and 150 kg of N / ha) and four doses of molybdenum via leaf (0, 30, 60 and 90 g Mo / there is). Cover fertilization was performed 20 days after emergence (20 DAE), using as urea source (44% of N).

The application of 5% eucalyptus ash was foliar via weekly, starting 7 days after emergence, which was diluted in water and, after being fired, was sprayed on the plants until runoff [2].

The molybdenum foliar application was performed at 14 DAE, using sodium molybdate (39% Mo) as the source. For greater precision in the dosages the application was made with a manual costal spray, working at a height of 0.5 m in relation to the ground level. The volume of the syrup used was between 300 and 400 l / ha, adding 1% (v / v) of adhesive spreader.

The plots had spacing of 0.5 m between rows and sowing density of 12-13 seeds per linear meter. The plots were constituted by four rows of 5.0 m in length, making a total area of 10.0 m2. As a useful area, the two central rows (5.0 m2) were considered. At sowing the doses of 50 kg N / ha + 150 kg P2O5 / ha + 50 kg K2O / ha were used. The other cultural treatments were those normally used in the culture that received the complementary irrigation.

The final stand and weight of commercial and non-commercial pods per plot were evaluated. Pods less than 10 cm in length, those of 10-15 cm less than 7 mm in diameter and all fibrous were considered non-commercial. The remaining pods were considered commercial, with only one harvest.

The yield was evaluated by weighing the pods of the useful plot, and only the commercial pods were evaluated and presenting the result in kg / ha;

The data were initially submitted to analysis of variance based on [13], using the SISVAR program [14]. In cases of significance in the source of cultivar variation, the Scott-Knott test is used to compare the means. In cases of significance for doses, regression analysis and selection of the appropriate mathematical model to express the relationship between the variables [15].

The variable cost was carried out to show the economic feasibility of the production of bean-pod of growth determined as a function of increasing doses of nitrogen and molybdenum, seeking the economic maximum point aiming to orient the producer to the decision-making with respect to the culture aiming at greater profit.

III. RESULTS AND DISCUSSION

The present experiment was a continuation of two other experiments conducted in 2010 and 2011 [16], when it was observed that nitrogen responded in a growing way up to 90 kg.ha-1, in the discussion of the mentioned work the need to apply molybdenum was also observed in the 14 days after emergence (DAE), since the cultivar (Table 1). In the present study, the effect of molybdenum on the formation of molybdenum in the presence of molybdenum in the presence of molybdenum was observed. (2008) where they report that the application of Mo can be performed efficiently between 14 and 28 DAE.

TABLE 1
MEANS OF TOTAL BEAN POD YIELD. DOES. EXP. DE LAMBARI - MG, BRAZIL,2011.

Average Silício	Average Treatments (kg / ha)
With Molibdênio	6.484
Without Molibdênio	6.669
0	6.242
30	7.155
60	6.700
90	6.209

In the obtained results there was no significant response for silicon and molybdenum when applied to the total production (Table 1). The productivity results were not expected due to the fact that the planting carried out in October 2011 faced low temperatures associated with rainfall, which proved to be a meteorological condition unfavorable to the crop, negatively influencing the production. Regarding nitrogen, the response was significant, which we observed in Figure 1, the regression curve for this variation factor, our results resemble those found by [8], where they observed an increase in yield due to nitrogen fertilization on the pods. When we derive the equation at 1 ° and equate to zero we obtain the maximum total production for the dose of 136.31 kg.ha-1 of nitrogen in coverage, the economic dose being 90% of this value which is 122.68 kg.ha- 1 of nitrogen. In this experiment, it was possible to determine the point of contact with the soil, and to determine the amount of nitrogen used in the experiment [16], which indicated the use of 90 kg.ha-1 of nitrogen. of maximum production and maximum economic production.

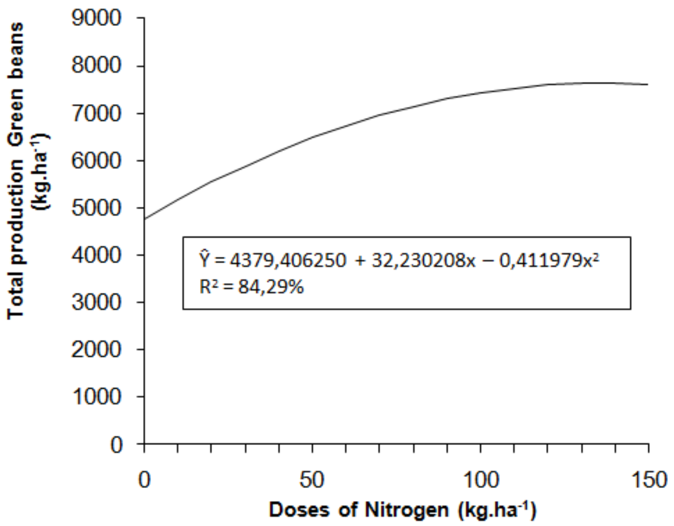

FIGURE 1- Graph of the regression equation as a function of nitrogen rates and total bean production. Lambari – MG, Brazil, 2011.

When we evaluated the commercial production we observed that silicon did not present a significant response according to table 2, and we obtained significant responses for nitrogen, molybdenum and nitrogen interaction with molybdenum.

TABLE 2
RESPONSE OF COMMERCIAL BEAN POD PRODUCTION FOR SILICON APPLICATION.

Average Silício	Average Treatments (kg / ha)
With Molibdênio	4.469
Without Molibdênio	4.594

Regarding the regression equation of nitrogen, figure 2 shows a quadratic response where the maximum and economical dose point is obtained. In figure 3 we observe the regression equation of the molybdenum also adjusted to a 2° Degree equation. In this way we can study the point of maximum production and the economic point that for this equation is 39.11 mg of molybdenum / ha. The point of maximum economic return with 90% of the dose at the maximum production point will be 35.20g Mo.ha-^{1}. The response curves presented in figure 4 represent the responses to nitrogen doses within each dose of molybdenum. It can be observed that the bean pods responded to nitrogen at the dose 0 g Mo.ha-1 reaching the maximum production value at the dose of 88.04 kg of N.ha-1 and the maximum economic point of 79.23 kg of N.ha-^{1}, the dose response of 30 g Mo.ha-^{1} was 135.51 kg of N.ha-1 and the economic maximum point of 121.96 kg of N.ha-^{1}, while the doses of 60 and 90 g Mo.ha-1 the maximum points are outside the range studied. The results corroborate [9], when the authors conclude that molybdenum increases nitrogen efficiency, but in the present experiment, nitrogen increased production even without the use of molybdenum. In the experiment by [16], there was no significant difference in the use of molybdenum due to the fact that the range of nitrogen doses was 0 and 90 kg of N.ha-1. The effect of fertilization with molybdenum when we use higher doses of nitrogen is positive.

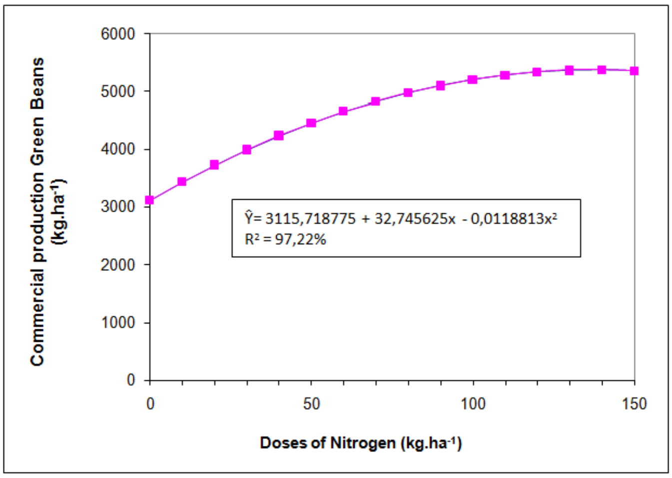

FIGURE 2- Graph of the regression equation as a function of nitrogen rates and commercial production of pod beans. Lambari - MG 2011

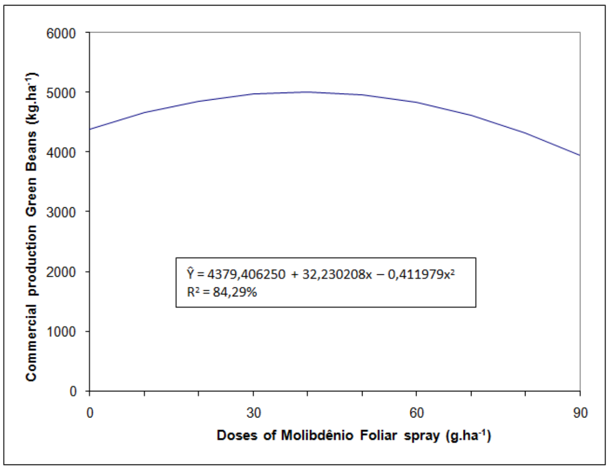

FIGURE 3- Graph of the regression equation as a function of molybdenum doses and commercial bean pod production. Lambari - MG 2011

In the study of economic viability the advantage of studying commercial production is to use the data of how much can be commercialized effectively, the increase in the number of pods does not necessarily come with the desired quality, causing non-standard pods. The maximum point of production occurs with the dose of 138.0 kg of nitrogen per hectare and the economic dose with 130.0 kg of N, obtained through Table 3, where the nitrogen doses were applied and using the equations, if the production that multiplied by the value of US$ 1.92 of the pod data obtained in the Ceasa of Belo Horizonte on July 23, 2012, access day 24 of 2012, we obtained the production value [17].

TABLE 3
STUDY OF THE POINT OF MAXIMUM ECONOMIC RETURN WITH RELATION TO NITROGEN UTILIZATION AND BEAN POD PRODUCTION LAMBARI - MG, BRAZIL, 2012

Doses of N	Production Pod (kg/ha)	Recipe Pod (R$)	Nitrogen Cost (R$)	Economic return (R$)
128	5360,527	10292,21	455,68	9836,53
129	5362,737	10296,46	459,24	9837,21
130	5364,710	10300,24	462,80	9837,44
131	5366,446	10303,58	466,36	9837,21
132	5367,944	10306,45	469,92	9836,53
133	5369,204	10308,87	473,48	9835,39
134	5370,226	10310,83	477,04	9833,79
135	5371,011	10312,34	480,60	9831,74
136	5371,559	10313,39	484,16	9829,23
137	5371,868	10313,99	487,72	9826,26
138	5371,940	10314,13	491,28	9822,84
139	5371,775	10313,81	494,84	9818,96
140	5371,371	10313,03	498,40	9814,63

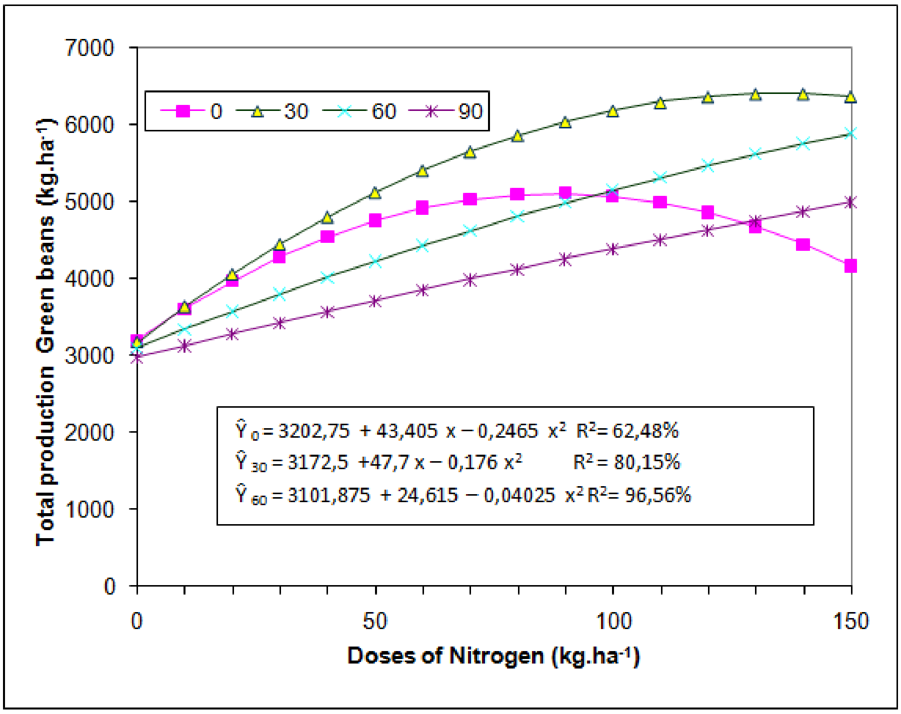

FIGURE 4 - Graphs of the equations as a function of the nitrogen doses inside the molybdenum doses, for commercial production of the bean pod. Lambari - MG 2011.

We discount the costs with the nitrogen whose source was the urea with price of $ 80.00 the bag of 50 kg. Due to the fact that the price of beans is high, the curiosity to verify if the point coincides with the usual 90.00%, showed that in this case the economic maximum point occurred with 94.21% as we can see in table 3. At point of the maximum return to each US$ 0.03 invested in nitrogen, there was a return of R $ 21.29 with the commercialization of the bean pod.

IV. CONCLUSION

If the farmer does not use molybdenum the maximum economic dose of N / ha was 79.2 kg in coverage.

With the use of molybdenum the maximum economic dose was 35 g Mo / ha and 130 kg of N / ha in coverage.

The silicon, applied via eucalyptus ash, did not respond in relation to the production.

The return at the maximum economic point with the sale of commercial beans was US$ 5.60 for each US$ 0.03 invested in nitrogen.

* **Dollar Price 3.84 (13 dec, 2018)**

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REFERENCES

[1] GOMES , F. B.; MORAES, J. C.; SANTOS, C. D., GOUSSAIN, M. M. Resistance induction in wheat plants by silicone and aphids. Scientia Agricola, Piracicaba, v. 62, n. 6, p. 547-551, nov./dez. 2005.

[2] SILVA, V.F. **Indução de resistência a insetos-pragas pela aplicação de silício em plantas de batata inglesa em cultivo orgânico**. 2009. 44 p. Dissertação (Mestrado em Entomologia) – Universidade Federal de Lavras, Lavras, MG.

[3] PINTO, C.M.F. et al., Feijão-vagem (*Phaseolus vulgaris* L.) *In*: PAULA JR, T.J. de & VENZON, M. (Coord.) 101 **Culturas; Manual de tecnologias agrícolas**. EPAMIG, Belo Horizonte, MG. 2007. 800p.

[4] GOMES, F. B. et al. Adubação com silício como fator de resistência a insetos-praga e promotor de produtividade em cultura de batata inglesa em sistema orgânico. Ciênc. agrotec. vol.33 no.1 Lavras jan/fev.. 2009. Acessado em 11 abril. 2013. Available in: http://dx.doi.org/10.1590/S1413-70542009000100002 . Accessed: set 2018.

[5] BELOW, F.E. **Fisiologia, nutrição e adubarão nitrogenada do milho**. Piracicaba: Potafós, p. 7-12, 2002. (Informações Agronômicas, 99).

[6] FAQUIN, V. **Nutrição mineral de plantas**. Lavras: ESAL: FAEPE, 1994. 227 p.

[7] MALAVOLTA, E. **Elementos de nutrição mineral de plantas**. São Paulo: Agronômica Ceres, 1980. 251p.

[8] OLIVEIRA, A.P. et al., Característica e rendimento do feijão-vagem em função de doses e formas de aplicação de nitrogênio; **Ciência e Agrotecnologia**. Lavras, MG. Vol. 27, nº3, p. 714-720. 2003.

[9] BISCARO, G.A. et al. Nitrogênio em cobertura e molibdênio via foliar no feijoeiro irrigado cultivado em solo de cerrado. **Acta Scientiarum. Agronomy**. Maringá, v. 33, n. 4, p. 665-670, 2011. Available in: <http://www.scielo.br/pdf/asagr/v33n4/15.pdf> DOI: 10.4025/actasciagron.v33i4.6387. Accessed: set 2018.

[10] ARAÚJO, P.R.de A. et.al. Combinação de doses de molibdênio e nitrogênio na adubação da cultura do feijoeiro-comum. **Acta Scientiarum Agronomy,** Maringá, v. 31, n.2, p. 227-234, 2009. Available in: <http://www.scielo.br/pdf/asagr/v33n4/15.pdf> DOI: 10.4025/actasciagron.v31i2.7033. Accessed: set 2018.

[11] SILVA, M. V. *da* Fontes e doses de Molibdênio via Foliar em duas cultivares de Feijoeiro. **Ciênc. agrotec.,** Lavras. V.27, n.1, p.126-133, jan./fev., 2003. Available in: www.cloud.editora.ufla.br/revistas/cienagro/pdf/27-1-2003_15.pdf . Accessed: set 2018.

[12] PIRES, A. A. et al. Rendimento de grãos, componentes do rendimento e índice SPAD do feijoeiro (Phaseolus vulgaris L.) em função de época de aplicação e do parcelamento da aplicação foliar de molibdênio Ciênc. agrotec. vol.28 no.5 Lavras set./out. 2004. Acessado em 11 abril. 2013. Online. Available in:http://dx.doi.org/10.1590/S1413-70542004000500017. Accessed: set 2018.

[13] BANZATTO, D. A.; KRONKA, S. N. **Experimentação agrícola.** 3. ed. Jaboticabal: FUNEP, 1995. 247p.

[14] FERREIRA, D. F. Sisvar a computer statistical analysis system. Ciênc. Agrotec. vol. 35 no. 6 Lavras Nov./Dec. 2011. Acessado em 11 abril. 2013. Online. Available in:<http://dx.doi.org/10.1590/S1413-70542011000600001>. Accessed: set 2018.

[15] GOMES, F. P**. Curso de estatística experimental.** 13. ed. Piracicaba: Nobel/USP-ESALQ, 1990. 468 p.

[16] LUZ, I. C. A. et al., Aplicação de silício e adubação com nitrogênio e molibdênio no desenvolvimento e produtividade de feijão-vagem de crescimento determinado. In: Seminário de Iniciação Científica e Tecnológica, 9., 2012, Belo Horizonte. EPAMIG. **Resumos expandidos** Available in:

<http://www.epamig.br/index.php?option=com_docman&task=cat_view&gid=168&dir=DESC&order=date&limit=10&limitstart=50>. Accessed: set 2018.

[17] CEASA MINAS – Centrais de abastecimento. 2013. Acessado em 11 abril. 2013. Available in:

<http://minas.ceasa.mg.gov.br/internet_nova/PrecosInterior/PrecosInterior.php> . Accessed: set 2018.

Physico-chemical Analysis of the MEHDIA Estuary (GHARB –MOROCCO)

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Abstract**—***In Morocco, superficial flows are dependent on rainfall and exhibit high spatial variability. In general, the water resources available to Morocco are limited and subject to extreme cyclical variations. Similarly, the qualitative situation of the waters is far from satisfactory. Indeed, population growth accompanied by rapid urbanization that causes many disturbances to natural environments. Industrialization, the irrational use of fertilizers and pesticides and the lack of awareness of the population towards the protection of the environment, lead as much to an imbalance of the ecosystem and generate polluting elements that can affect the physico-chemical quality biological and aquatic environments, but also alter the uses of water; water collection, swimming ... etc. The sub-basin of OuedSebou drains the Mehdia region and is particularly affected by the problem of continuous development of the agricultural sector. Indeed, the discharges of water-gardens, pesticides and fertilizers drained by rainwater and irrigation and dirt environment, in addition to the domestic discharges generated by the small town Mehdia and the city of Kenitra are dumped directly into the OuedSebou. The present research on the Mehdia region is aimed at the prospection of the hydrobiology of the waters of the Sebouwadi. The study will be based on physicochemical analysis of the mouth of Mehdia and the determination of seasonal fluctuations of these parameters between the low water period and the flood period.*

Keywords**—Morocco, sebou river, hydrochemistry, Mehdia, gharb.**

I. INTRODUCTION

In Morocco, superficial flows are dependent on rainfall and exhibit high spatial variability [1-2]. In general, the water resources available to Morocco are limited and subject to extreme cyclical variations [3]. Similarly, the qualitative situation of the waters is far from satisfactory [4]. Indeed, population growth accompanied by rapid urbanization that causes many disturbances to natural environments [5]. Industrialization, the irrational use of fertilizers and pesticides and the lack of awareness of the population towards the protection of the environment, lead as much to an imbalance of the ecosystem and generate polluting elements that can affect the physico-chemical quality biological and aquatic environments [6], but also alter the uses of water; water collection, swimming ... etc [7]. The sub-basin of OuedSebou drains the Mehdia region and is particularly affected by the problem of continuous development of the agricultural sector [8]. Indeed, the discharges of water-gardens, pesticides and fertilizers drained by rainwater and irrigation and dirt environment, in addition to the domestic discharges generated by the small town Mehdia and the city of Kenitra are dumped directly into the OuedSebou [9]. The present research on the Mehdia region is aimed at the prospection of the hydrobiology of the waters of the Sebouwadi. The study will be based on physicochemical analysis of the mouth of Mehdia and the determination of seasonal fluctuations of these parameters between the low water period and the flood period.

II. STUDY SITE

This is a city in Morocco. It is located in the region of Rabat-Salé-Kenitra. It is a picturesque coastal town located near the town of Kenitra 30 km north-east of the capital Rabat. The fishing port, very picturesque at the mouth of the OuedSebou, the proximity of the SidiBoughaba Lake Biological Reserve with its forests and rare bird colonies, the Spanish, Portuguese and Dutch forts, the Kasbah of Yaqub al-Mansur, and the proximity of the ancient sites of Banasa and Thamusida are undeniable assets to develop tourism of this village, still little known. Its long sandy beaches are also very popular with surfers and bodyboardersMehdia has a population of 16,262.

Coordinates:	34° 15′ 21″ north, 6° 40′ 28″ West
Altitude:	31 m

FIG 1: The Coordinates of Mehdia

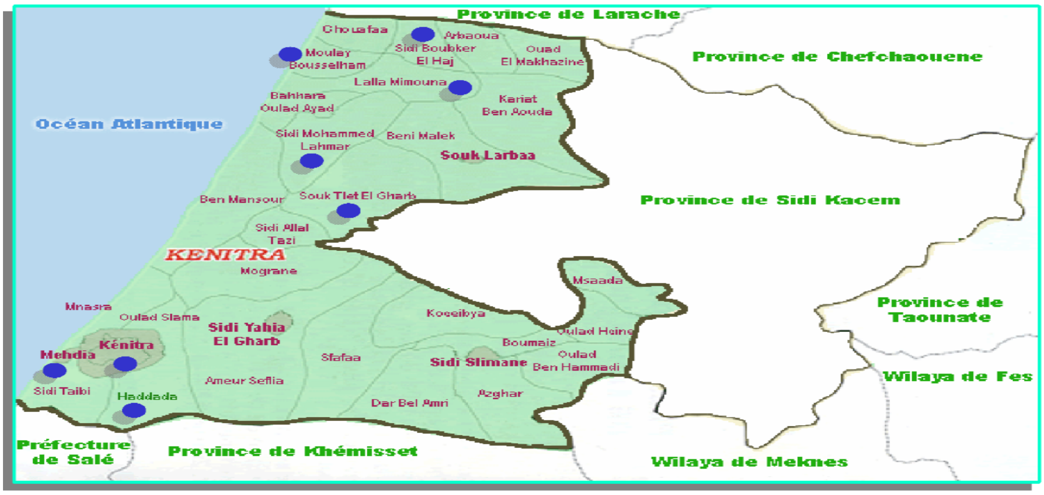

FIG 2: Geographical Limits of the Province of Kenitra

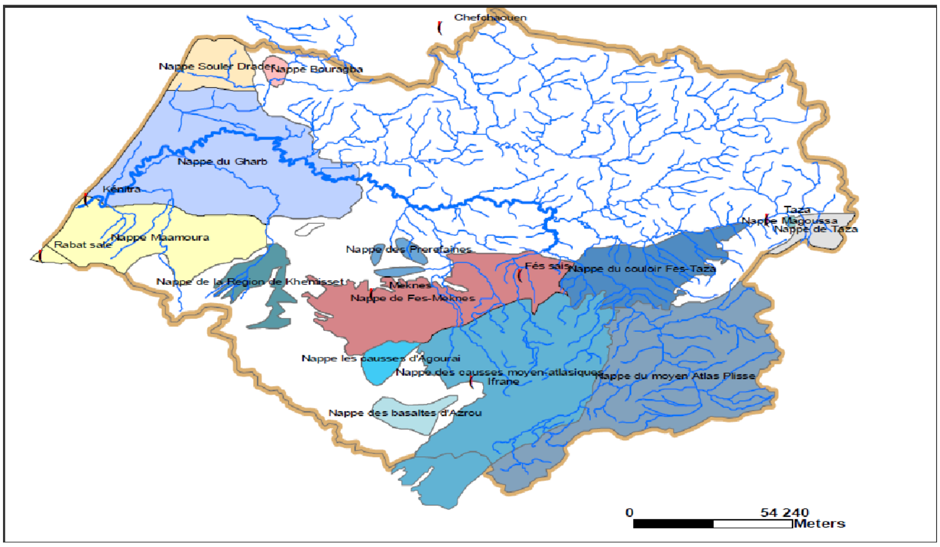

FIG 3: Geographical Localization of the study area (Mâamora Tablecloth) in Yel

III. STUDY METHOD

Four stations S1 to S24, distributed along the Sebouwadi, have been retained in such a way that they are accessible and reflect the real characteristics of the surface water of the Sebouwadi at the level of the Mehdia study area.

IV. SAMPLING AND ANALYSIS

Along the OuedSebou and throughout the study area, water samples were taken in 16 points At each sampling, the samples were kept in plastic bottles, previously rinsed with water from the station. The boteilles were then transported to the laboratory at 4° C. The temperature is measured "in-situ" using a mercury thermometer graduated 1/10 from 0 to 50 ° C. The hydrogen potential (pH), the EC electrical conductivity, the dissolved oxygen (O2) is determined using a CONSORT-Model 835 multi-parameter analyzer, an oximeter and a pH meter. The suspended solids MES are determined by filtration of a volume of water on 0.45 μm cellulose filter according to Rodier [10]. BOD5 is determined by the respiratory method using a WTW DBO-meter model 1020T according to the technique described by DIN [11]. The COD is determined by acid oxidation by the excess of potassium dichromate at the temperature of 148° C of the oxidizable materials under the conditions of the test in the presence of silver sulfate as catalyst and mercury sulphate according to DIN [12]. The chlorides are determined by a volumetric acid determination (HNO3) by a solution of mercuric nitrate in the presence of a pH indicator. Nitrates, ammonium and orthophosphates are analyzed by colorimetric methods using a Visible Type 722 S Beijing UV spectrophotometer.

FIG 4: Method of assays and titrations of mineral elements in the water of the lower sebou

V. RESULT AND DISCUSSIONS

The assessment of raw water pollution of the Lower Sebou was made according to the determination of a certain number of physicochemical parameters characterizing the waters. In the light of this work which contributes to enriching the bases of the data accumulated on the basin of Sebou, and to make it possible to clarify the degree of its pollution thanks to the results obtained during the period of our internship within the Regional Office of Implementation. Agricultural value of GharbKenitra. It can be deduced that the Lower Sebou sub-basin is subject to different types of pollution of natural origin that are mainly mineral (by natural substrate dissolution, Atlantic tides) and anthropogenic (agricultural, industrial and urban). The thermal regime of the Sebou hydrographic network follows that of the Mediterranean climate, cold in November and warmer in summer. The pH does not show any significant variations and the waters are generally alkaline ranging between 8.01 and 8.78 following their travels of limestone and marl-limestone soils characterizing the basin. The mineralization follows suitably the rates of dissolved salts, salinity, chlorides, sodium and potassium. It results mainly from the leaching of the karst limestone-traversed terrain and oceanic spray. Indeed, the electrical conductivity that reflects salinity (Fig 5) varies from 4000 to 25000 µs / cm and far exceeds the Moroccan irrigation standard (> 2700 µs / cm) [12-14]. Concerning the nitrate contents (Fig. 6), the values vary between 0.24 mg / L and 2692 mg / L and clearly reflect the pollution of agricultural origin by the nitrogen fertilizers, the wastewater and leachates of the wild discharges [15-21].

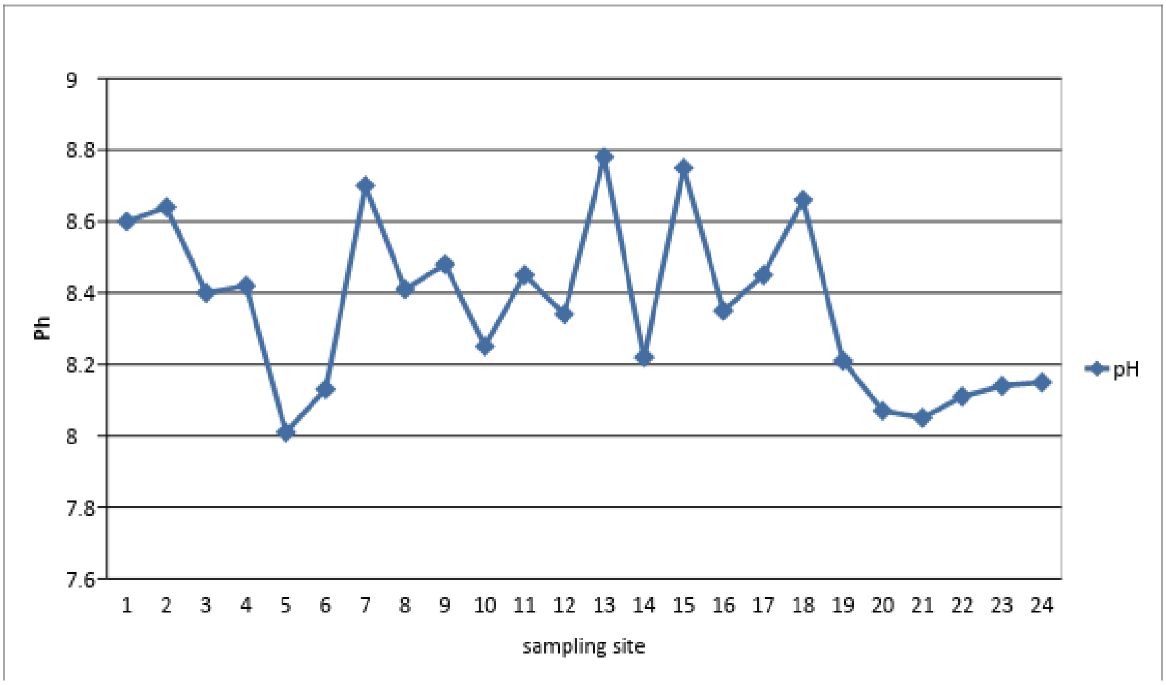

FIG 5: Spatial evolution of the pH of the raw water of the lower sebou-mehdia

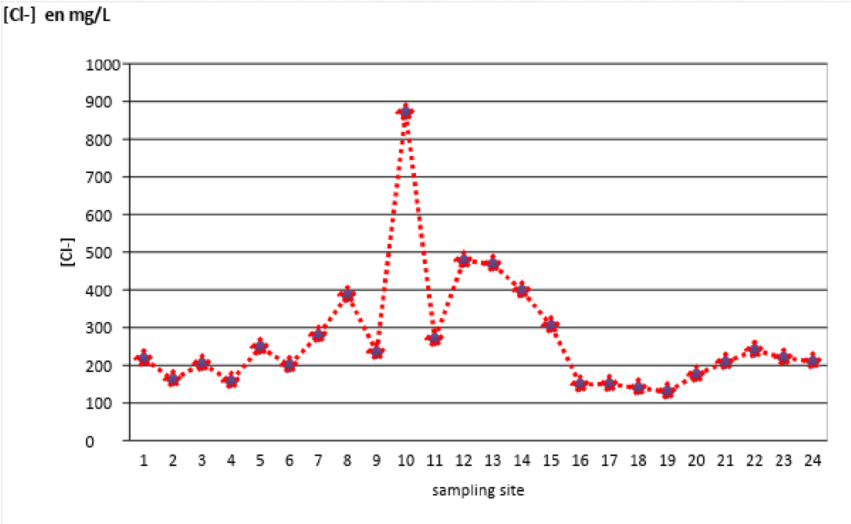

FIG 6: Spatial evolution of [cl-]

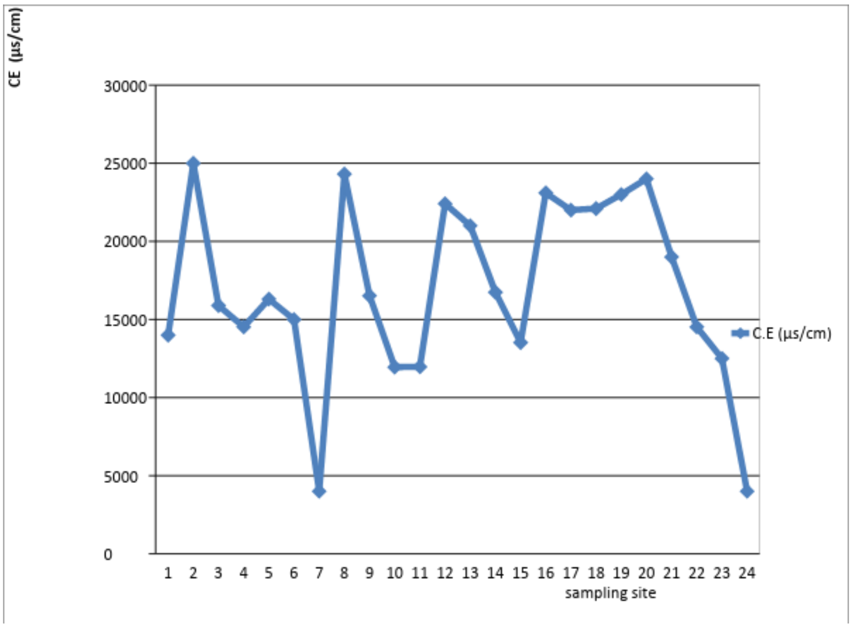

FIG 7: Spatial evolution of the electrical conductivity of the raw waters of the sous-sebou-mehdia

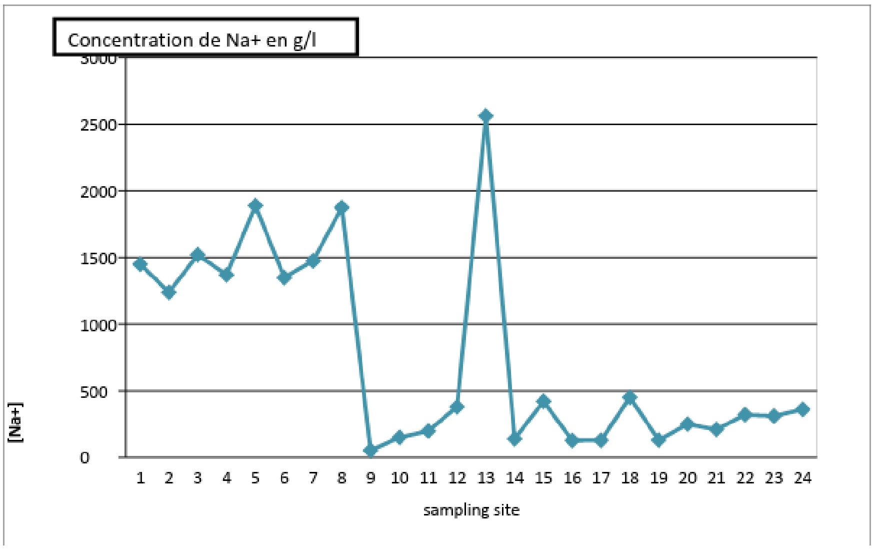

FIG 8: Spatial evolution of [Na+]

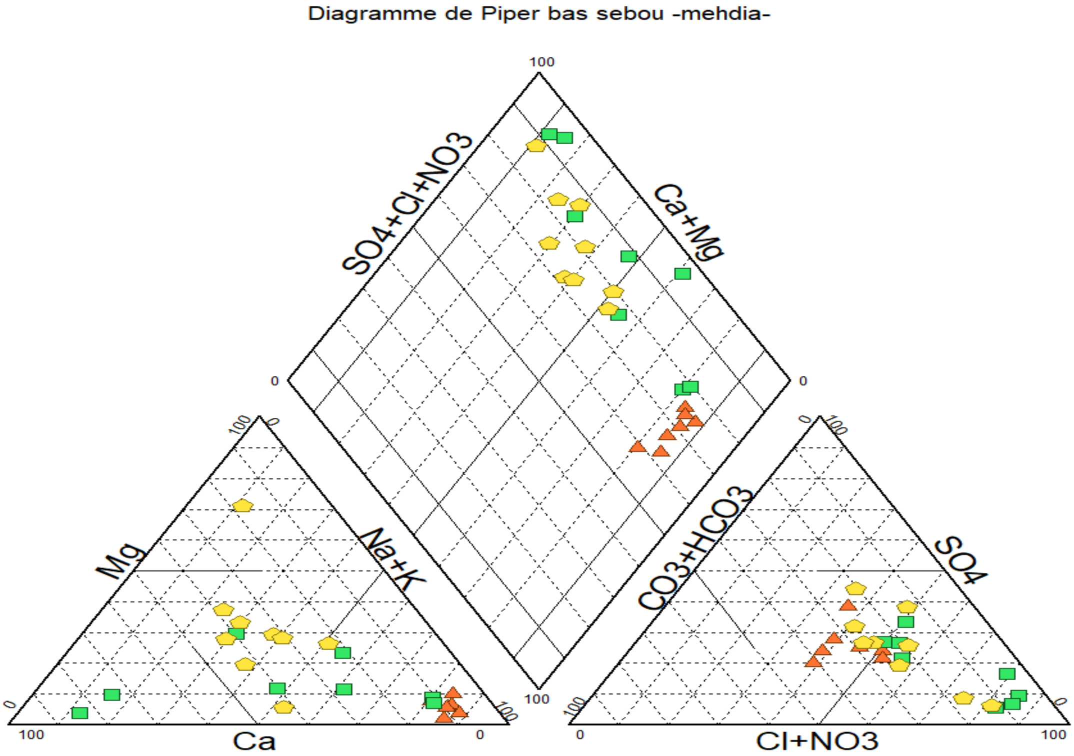

FIG 9: Projection in the piper diagram of hydrochemistry waters of the lower basin of sebou

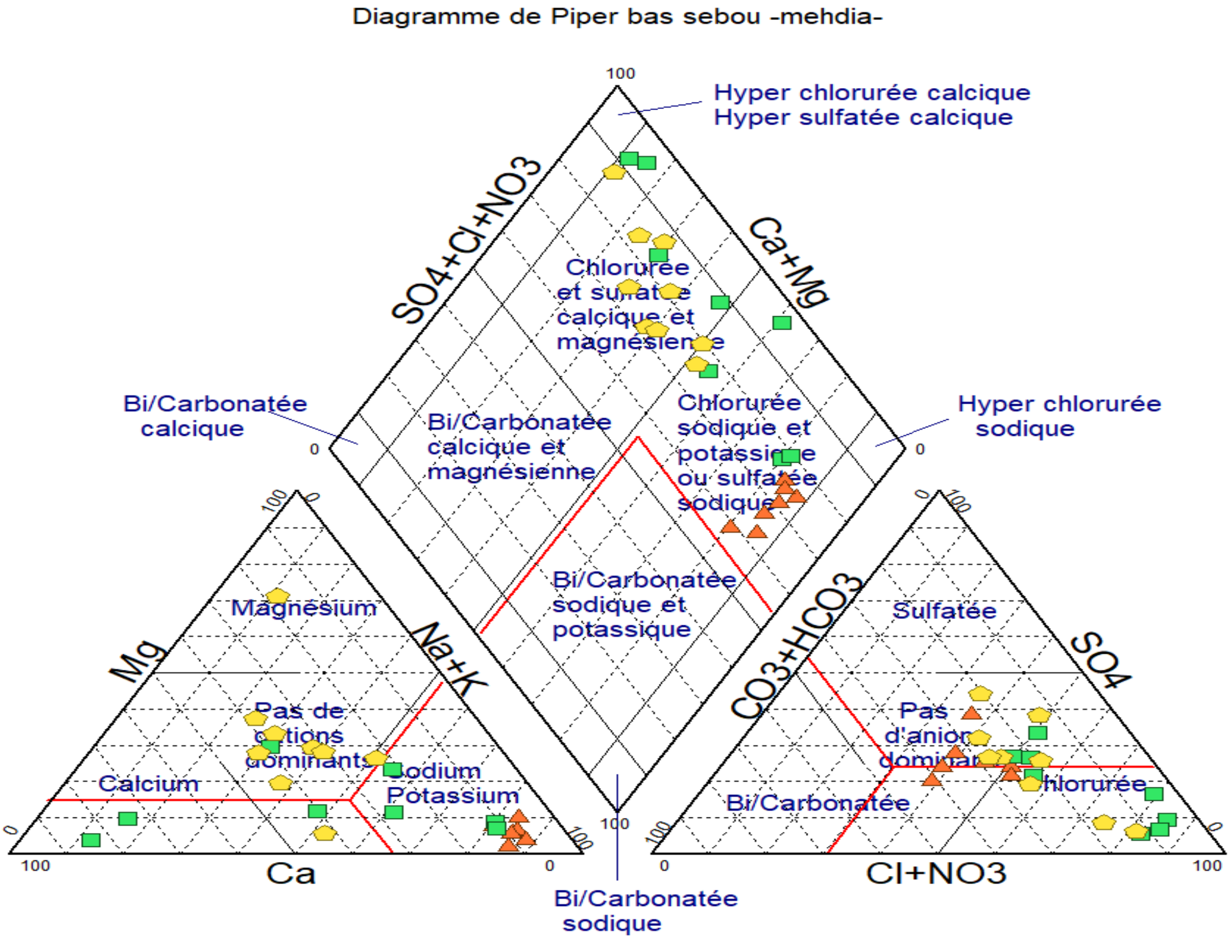

FIG 10: Piper Diagram of low Sebou river

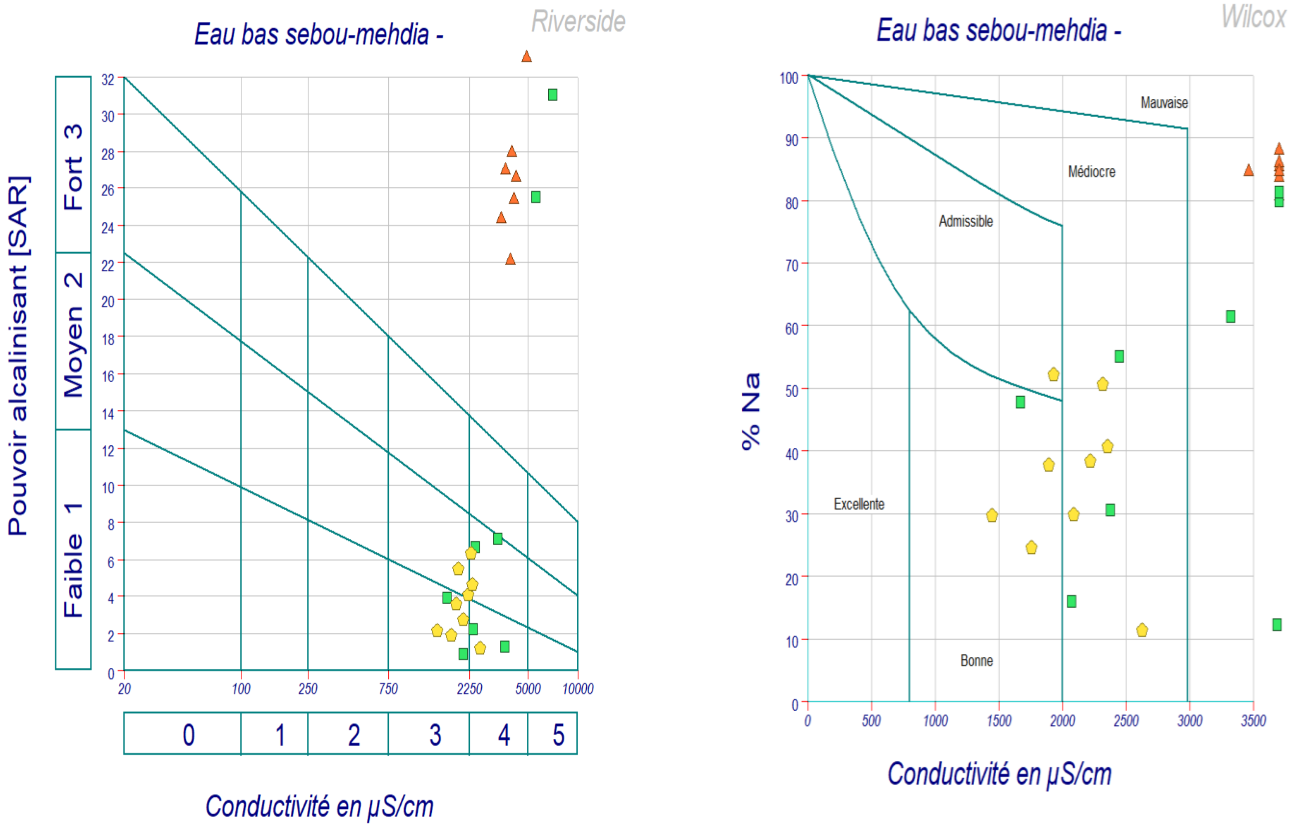

FIGURE 11: Diagram of the raw water quality classes of the sub basin of the lower Sebou and projection of the raw water quality of the subbasin of the lower Sebou in the Wilcox diagram

VI. CONCLUSION

Adjacent agricultural activities occur in the waters of the Lower Sebou sub-basin by significant concentrations of nitrates and sulphates that enter the water stream by runoff and leaching of nitrogenous and phosphorus fertilizer and phytosanitary products [26-27]. The upstream-downstream distribution of physicochemical parameters reflects degraded situations of water quality in salts and chlorides in relationships.

The present work has revealed the poor quality of the waters of the lower Sebou but remains incomplete and needs to be deepened by analyzes of trace heavy metals and pesticides to provide the scientific and technical bases for decision makers [28-30].

REFERENCES

[1] MATUHE.Rapport sur l'Etat de l'Environnement du Maroc (REEM), Ministère de l'Aménagement du Territoire, de l'Eau et de l'Environnement, Département de l'Environnement, Observatoire National de l'Environnement du Maroc (ONEM), Octobre, Ed. 2, 296p. 2001.

[2] LBenaabidat. Caractérisation du bassin versant de Sebou, hydrologie, qualité des eaux et géochimie de sources thermals. Thèseenhydrologie à FST- Saïs, 250p. 2000.

[3] DRPE, Direction de la Recherche et de la Planification de l'Eau. Rapport National sur les ressourcesen eau au Maroc. 2004.

[4] DGH.Direction Générale de l'Hydraulique. Rapport sur Processusd'action et de renforcement des capacités; l'eau et l'environnement. 1996.

[5] A Agoumi, A Debbarh. Ressourcesen eau et bassin versants du Maroc: 50 ans de développement (1955-2005). 2006.

[6] D Belghyti, H Daifi, A Alemad, K Elkharrim, M Elmarkhi, Y Souidi, F Benelharkati, B Joti, Z Elmoukrifi, A Ibeda, Y Azami-Idrissi, S Baroud, F Elkhayyat, O Elrhaouat, S Sadeq, Y Taboz, H Sbai, R Naser, H Chigger, N Derwich. Groundwater management for sustainable production of drinking water quality in Maamora, 2nd International Conference on Water and Society, 4 - 6 September 2013, New Forest, UK, 2013, Vol 178, pp.242 -254, doi:10.2495 / WS130201, 2013.

[7] O.N.E.P. Alimentation en eau potable, Menaces de pollution. Rapport1999.

[8] ORMVAG: Office Régional de MiseenValeurAgricoleGharbMaroc. Etude pédologique au1/20000 de la Troisième Tranche d'Irrigation (TTI) sur unesuperficie de 100000 ha, Zone M'nasra, Z1-Z2, Kénitra, Maroc, Rapport inédit, 180p. 1994.

[9] E Derwich, Z Beziane, L Benaabidate, D Belghyti. Evaluation de la qualité des eaux de surface des ouedsfès et sebouutiliséesen agriculture maraîchère au Maroc. Larhyss Journal, n° 07, 2008, 59-77.

[10] J. Rodier. L'analyse de l'eau, eauxnaturelles, eau résiduaires, eau de mer, 7e edition, Dénod, 1383p. Paris, 1996.

[11] DIN 1992a. Détermination de la DemandeBiologiqueenOxygène (DBO) selon DIN Laboratoire National de l'Environnement, Rabat. 1992.

[12] DIN 1992b. Détermination de la DemandeChimiqueenOxygène (DCO) selon DIN 38409-H52. Laboratoire National de l'Environnement - Rabat. 1992.

[13] CNS. ComitéNormes et Standards. Ministère de l'Environnement du Maroc. Rabat, 1994.

[14] CSE. ConseilSupérieur de l'Eau. Aménagement optimal des eaux de l'ouedOuergha: Réalisation du barrage Mjara. Rabat, Maroc. 1988.

[15] A Krira, B Chakour, & H Fouta. Intensification de l'agriculture et son impact sur l'environnement. Cas des nitrates dans la nappe phréatique de M'nasra du Ghab, Actes 1er Colloq, Sur le Développementagric, Rech, Agron, Au niveau de la région du Ghab. 2001.

[16] M Fekhaoui. Rechercheshydrobiologiques sur le moyen de Sebousoumis aux rejets de la ville de Fès, suivid'une Macro-pollution et élévation de son incidence sur les composantes physiques, chimiques et biologiques de l'écosystème. Thèse d'état, Univ, Med V, Rabat, Maroc, 152p.1990.

[17] T El Hammoumi& D Belghyti. Caractérisationphysicochimique des eaux potables produites par la station de traitement de Mkansa (Maroc). Scienceslib. 2012.

[18] O.N.E.P. Contrôle de la pollution des eaux destinées à l'alimentationen eau potable. Rapport 1998.

[19] O.N.E.P. Alimentation en eau potable, Menaces de pollution. Rapport 1999.

[20] WHO (eds), World Health Organization., Guideline for Drinking Water Quality, Health Criteria and Other Supporting Information. 2nd Edition, Vol.2, Geneva, pp.940-949, 2004.

[21] Amina Ramdani, André Deratani et SafiaTaleb

[22] LéaBazus, Nicolas Cimetiere, Laurent Legentil, Guy Randon et Dominique WolbertRecherche de dérivésconjugués de médicamentsdansl'eau de surface et encours de potabilisation v28 (1) : 19-25. DOI : 10.7202/1030003ar (Volume 28 Numéro 1, 2015).

[23] Nora Bouchahm, Linda Hecini et WahidaKherifiAdoucissement des eauxsouterraines de la régionorientale du Sahara septentrionalalgérien : cas de la région de Biskra v29 (1) : 37-48. DOI : 10.7202/1035715a (Numéro 1, 2016).

[24] Simon Komtchou, Ahmad Dirany, Patrick Drogui et Pierre Lafrance Application des procédésd'oxydationavancée pour le traitement des eauxcontaminées par les pesticides v29 (3) : 231-262. DOI : 10.7202/1038926ar. (Numéro 3, 2016).

[25] Rhouddal MERIEM : Gestion de l'exploitation des eauxsouterraines. Application aux captages de la ville de Kénitra. (2017).

[26] Étude comparative de la rétention des selsmonovalents par nanofiltration : application à une eau naturelle (2017).

[27] ImèneBenstaali et LahouariBenyadaBilan et variabilitétemporelle des matièresen suspension dans le bassin de la Macta : cas du sous bassin versant de Bou-Hanifia (Algérie du nord) v30 (3) : 199-211. DOI : 10.7202/1044247ar (2017)

[28] PhuDuc Nguyen, BabacarToumbou, Sophie Duchesne, NomessiKokutse et Jean-Pierre VilleneuvePhuDuc Nguyen, BabacarToumbou, Sophie Duchesne, Nomessi Koku Évaluation de l'impact de la pollution diffuse sur la qualité de l'eauenrivière avec donnéesrestreintes : casd'application du bassin versant de la rivièreCau v31 (3) : 293-312. DOI : 10.7202/1054308ar (2018).

[29] hydrogeological and hydrochemical study of mellaha village, ouedguir, er-rachidia, morcco (2019).

Impact of Land Fragmentation on Technical Efficiency: The Case of Maize Farmers in the Transitional Zone Of Ghana

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Abstract— *This paper seeks to study the impact of land fragmentation on technical efficiency of 461 maize farmers selected through the multi-stage sampling technique from the transitional zone of Ghana. The study used the stochastic production frontier model to analysis data from 2017/2018 farming season. The findings showed that, most of the farmers were in their youthful age with few of them over the age of 60 therefore, an average age of 44.8. The study revealed that; quantity of labour used , quantity of seed used, and farm size are the factors that determine the technical efficiency of farmers in the study area since it has a significant relationship with technical efficiency. On the other hand, land fragmentation and distance between farms was identified to be the only significant source of technical inefficiency of maize farmers in the study area. It is suggested that resource allocation and land policies should target the improvement of production efficiency of maize farmers in the study area.*

Keywords: ***land fragmentation, technical efficiency, maize farmers, transitional zone.***

I. INTRODUCTION

In African, maize is graded as the first cereal grain of greatest economic importance, at the expense of wheat and rice, which ranking second and third respectively (Thobatsi, 2009). Maize was identified as the solution to Africa food insecurity problem which can reduce poverty. In a summit held in Abuja by Head of States and Government from Africa in December 2006, the African Union Commission (AUC), the New Partnership for Africa's Development (NEPAD) as well as regional economic communities (RECs) were admonished to support the campaign of maize production on the continent so as to achieve self-sufficiency by the year 2015 (Union, 2006). In order to boost maize production in the continent, the summit recognized the significance of accepting the variations in maize production on the continent. Hence, an investigation into the factors affecting the changing patterns in maize production was highly recommended and welcomed so as to improve production and market of maize in the continent.

Although the natural conditions in Ghana are suitable for agricultural production, it's realized that local supply are still lagging behind demand, making the country food insecure (Wolter, 2009). According to the report of the Ministry of Food and Agricultural, Ghana's production in agricultural product supply meets just 50% of domestic meat and cereal needs and 60% of domestic fish intake (MoFA, 2011). Although Ghana is attaining self-sufficiency in starchy staples like plantain, yam and cassava, production of maize is nowhere near demand (Wolter, 2009). With a larger section of maize supply going into food consumption in Ghana, a rise in its productivity is unquestionably vital for achieving food security in the country. As maize also been a key component of livestock and poultry feed, the productivity and development of the poultry and livestock industries depend on the maize value chain. In the medium term, the demand for maize in Ghana was expected to grow at an annual rate of 2.6% (Akramov & Malek, 2012). Unfortunately, Ghana as at now is self-insufficient in the production of this very important commodity. Therefore, there is an urgent need for actions to be taken to improve productivity and aggregate production of maize so as to tackle Ghana's endless demand for maize and food security in general would be improved (MiDA, 2010).

Land fragmentation, also known as pulverization, parcellization or scattering (Bentley, 1987), is defined in the literature as the situation in which a single farm consists of numerous spatially separated parcels (Bentley, 1987; Binns & Binns, 1950; King & Burton, 1982; McPherson, 1982) (McPherson, 1982). According to (Demetriou, 2014), defined Land fragmentation can also be defined as a state where a household owns several non-contiguous land plots, often scattered over a wide area. It is characterized as a fundamental rural spatial problem concerned with farms which are poorly organized at locations across space (King & Burton, 1982). It implies a defective land tenure structure that often leads to major problem at various spatial scales which may hinder effective agricultural production and sustainable rural development. Land fragmentation among others has been identified as the root cause of the low productivity of maize in the transitional zone of Ghana and the nation as a whole.

Four types of land fragmentation are well-known in the literature: they are; fragmentation of land ownership; land use; within a farm (or internal fragmentation); and separation of ownership and use (Van Dijk, 2003). Fragmentation of land ownership refers to the number of landowners who use a given piece of land. Fragmentation of land use refers to the number of users that are also tenants of the land. Internal fragmentation emphasizes the number of parcels exploited by each user and considers parcel size, shape and distance as the main issues. Separation of ownership and use involves the situation where there is a discrepancy between ownership and use.

There exist an argument concerning whether land fragmentation is a problem or not (Nguyen, Cheng, & Findlay, 1996; P. Sklenicka, Janovska, Salek, Vlasak, & Molnarova, 2014; P. J. L. U. P. Sklenicka, 2016; Wu, Liu, & Davis, 2005). Some scholars are of a viewpoint that land fragmentation is a foundation of ineffective agriculture (Apata, 2016; Bentley, 1987; del Corral, Perez, & Roibás, 2011; Di Falco, Penov, Aleksiev, & Van Rensburg, 2010; Latruffe & Piet, 2014; Rahman & Rahman, 2009; P. Sklenicka et al., 2014). These people see land fragmentation as a main hindrance to efficient production system owing to the fact that continuous subdivision of farms would lead to small sized land holdings that may be difficult to economically operate. According to them, land fragmentation is said to impairment to productivity in different ways for example, fragmented land holdings can escalate transport costs. Also if the plots are located far from home, and far from each other, it will result in waste of time for the workers spent on travelling in between the plots and home. Management, supervision and securing of scattered plots can also be more difficult, time consuming, and costly. Land fragmentation have a possibility of increase the tendency of disputes between neighbor farmers (Mwebaza & Gaynor, 2002). Small fragmented land holdings can also result in difficulties to grow certain crops, and stop farmers from moving to high profit crops. More profitable crops, like fruit crops, needs larger plot areas, therefore if the farmers only owns small and fragmented plots they may be pushed to grow only less profitable crops (The World Bank, 2005). Other costs associated cost of land fragmentation include the hindering of economies of scale and farm mechanization. Small and scattered plots hinder the use of machinery and other large scale agricultural practices. In small fields operating machines and moving them from one field to another can cause problems. Small land holdings might also discourage the development of infrastructure like transportation, communication, irrigation, and drainage (Mwebaza & Gaynor, 2002). Also, it is observed that, financial institutions are sometimes reluctant to take small and scattered land holdings as collateral, which prevents farmers from procuring credit to make investments. With these disadvantages, land fragmentation is considered as defective and this has in turn caused several countries to implement land consolidation programs (Shao et al., 2006; Talyzin, Andersson, Sundqvist, Kurnosov, & Dubrovinsky, 2007).

Other scholars on a contrary viewpoint sees land fragmentation as a positive situation where farmers can cultivate many environmental zones, minimize production risk and optimize the schedule for cropping activities (Bentley, 1987). The known advantages of land fragmentation in this viewpoint are mostly related to the demand-side causes of fragmentation. Among the benefits linked with land fragmentation is the variety of soil and growing conditions that decrease the risk of total crop failure by offering the farmer a variety of soil and growing conditions. They are of the view that many different plots allow farmers access to land of different qualities in terms soil, slope, microclimatic variations etc. Another advantage of land fragmentation is the use of multiple eco zones. Holding different plots enable farmers to cultivate a wider mix of crops. Since crops ripe at different times when the plots are in different altitudes, spreading out the agriculture work like harvest and sawing during a longer period of time helps farmers to avoid household labour bottlenecks. Farmers may also desire fragmented land holdings in situations like diseconomies of scale with respect to the size of the parcels.

Previous studies and ample literature have studied the connection between land fragmentation and land productivity, or efficiency at farm level, (Blarel, Hazell, Place, & Quiggin, 1992; Thomas & Economics, 2006; Van Hung, MacAulay, Marsh, & economics, 2007; Wu et al., 2005) (Chen, Huffman, & Rozelle, 2009; Rahman & Rahman, 2009; Thomas & Economics, 2006). The focus of this paper is to examine the impact of land fragmentation on technical efficiency (TE) of maize farmers in the transitional zone of Ghana. As far as we know, no research has empirically estimated the impact of land fragmentation on maize production output in the transitional zone of Ghana, which justifies the need for this study. The specific objectives were to:

i. know the pattern of land holdings in the study area and

ii. Investigate the determinants of technical efficiency of maize farmers in the study area.

1.1 Conceptual framework and literature review

Agricultural land fragmentation is well-known in the world and it is usually attributed to numerous factors such as inheritance laws, political system, historical antecedence and consolidation processes, and transaction costs in land markets, urban development policies, and personal valuation of land ownership (Balogun & Akinyemi, 2017). Land fragmentation is often believed to be one of the main problems prevailing in rural land management, especially in developing countries (Rusu, Florian, Popa, Marin, & Pamfil, 2002; Wan & Cheng, 2001). Numerous studies have contended that the adverse effects of land fragmentation overshadow its possible benefits, mostly because it expands economic costs and decreases agricultural efficiency (Wan & Cheng, 2001). Specifically, it is viewed as a hindrance to adoption of modern agricultural technologies, to construction and maintenance of rural infrastructure and thus as an impediment to agricultural modernization.

There is inadequate proof available in the literature on the output and labour allocation influence of land fragmentation. With the use of the Cobb-Douglas production function, Fleisher and Liu (1992) estimated that land fragmentation leads to inefficiency in agricultural production. This result was reaffirmed by Nguyen, Cheng, and Findlay (1996), who also in their studies established a positive relationship between plot size and output for major grain crops in China. Whereas (Chen et al., 2009) established that fragmented farm structures links to higher labour costs; it is not completely clear why this implies that land consolidation does release rural labour, as the authors do not investigate the actual mechanisms of labour allocation any further.

1.1.1 Concept and measurement of land fragmentation

Land fragmentation is said to exist when a household have controls on a number of owned or rented noncontiguous lands at the same time. Numerous factors are accountable for agricultural land fragmentation, among the main factors that contribute to subdivision and fragmentation are, traditional system of inheritance of land (inheritance laws, which divide a family's land among all the remaining sons, which means as the population increases, not only does the size of holdings fall, but fragmentation also increase into small plots, scattered over a wide area), (Gebeyehu, 1995). Agricultural land fragmentation in the world has become rampant in the world and it is usually credited to numerous factors such as inheritance laws, political system, historical antecedence and consolidation processes, and transaction costs in land markets, urban development policies, and personal valuation of land ownership (Blarel et al., 1992; King & Burton, 1982). It is believed that Land fragmentation is one of the main problems existing in rural land management, most especially when it comes to developing countries (Wan & Cheng, 2001). Numerous studies are in support of the argument that, the adverse effects of land fragmentation dominate its likely benefits, mostly because it expands economic costs and decreases agricultural efficiency (Wan & Cheng, 2001). Land fragmentation is viewed as a hindrance to adoption and implementation of modern agricultural technologies, to construction and maintenance of rural infrastructure and therefore as an impediment to agricultural modernization. There is inadequate evidence presented in the literature on the output and labour allocation impacts on land fragmentation. Fleisher and Liu (1992) estimated that land fragmentation led to inefficiency in agricultural production by the use of Cobb-Douglas production function. Nguyen, Cheng, and Findlay (1996), also confirm the above result by establishing a positive relationship between plot size and output for major grain crops in China.

Land fragmentation can be measured with two different approaches namely: single dimension indicators and integrated indicators. Under the single dimension, one indicator is used to measure the extent of land fragmentation, indicators such as, farm size, total number of plots in the farm, average plot size, distribution of plot sizes, spatial distribution of plots, and the shape of plots are commonly used in the literature (Bentley, 1987). Farm size is used to measure the total holding of a farm but among the remaining parameters, size and spatial distribution (i.e. distance) are often considered to be most significant (Shuhao, 2005). The integrated indicators capture the information from several single indicators into one index. The most commonly used index is the Simpson index (Blarel et al., 1992). The Simpson index (SI) measures the degree of land fragmentation in the following way:

$$SI = 1 - \frac{\sum ap^2}{(\sum ap)^2} \tag{1}$$

where ap is the area of each plot. The Simpson index is positioned between 0 and 1. Differently to the Jawanski Index (JI), a higher SI value matches with a higher degree of land fragmentation. The value of the Simpson index is also determined by the number of plots, average plot size and the plot size distribution. Also, farm size, distance and plot shape are no taken into account.

1.1.2 Factors that influence Agricultural Productivity

Factors influencing the output of farmers can be categorized into three, firstly, the physical inputs engaged (capital, land and labour), secondly, the characteristics of farmers and farm, and lastly, factors that are external to the farmer such as climatic conditions, government and institutional policies (Wiebe et al, 2001). Capital inputs employed comprises of herbicide, fertilizer, seed, pesticide as well as farm tools and implements. The second category which is the characteristics of the farm and farmer covers factors such as topography and size of land cultivated, distance of farm from input and output markets, level of education, age, gender, family size etc. Soil conditions and weather as external factors including temperature, rainfall and humidity (Michele, 2001). Shamsudeen et al (2013), Sienso et al (2013), Oppong (2013) and Bempomaa and Acquah (2014) have testified to significant positive impacts of size of land cultivated on the productivity of maize production in Ghana. Sienso et al (2013), Oppong (2013) and Bempomaa and Acquah (2014) for example discovered 5.3%, 0.201% and 1.29% respectively rises in maize outputs for the respective above-mentioned studies in Ghana. Fan and Chan-Kang (2005), studies into farm size, productivity, and poverty in Asian agriculture in addition to that of Goni et al (2007) analysis of resource-use efficiency in rice production in Nigeria also exposed positive correlations between farm size and agricultural productivity. Nevertheless, Pender et al (2004), Okoye et al (2008), Stifel and Minten (2008), Masterson (2007) as well as Byiringiro and Reardon (1996) reported that, there is a negative relationship between area for crop production and productivity. Farmer's resources are limited and may not be able to meet the requirements of large farm lands that they cultivate. Farmers are consequently incapable to provide for and apply key production inputs such as fertilizers, herbicides, pesticides, improve seeds, etc. thereby resulting in low productivity.

1.1.3 Technical Efficiency among Smallholder Farmers

Technical efficiency as an element of economic efficiency reveals the farmers ability to maximize productivity from a given level of inputs (e.g. output-orientation).Theoretical developments in assessing technical efficiency can be traced back to the works of Debreu (1959). There has been numerous literature on the technical efficiency of smallholder agricultural outstanding among them are the works of, Basnayake and Gunaratne (2002), Barnes (2008), Duvel et al (2003), Shapiro and Muller (1977) and Seyoum et al (1998). Large number of studies have associated farmers` age, farmers` educational level, access to extension, access to credit, land holding size, number of plots owned, farmers` family size, gender, tenancy, market access, and farmers` access to improved technologies such as fertilizer, agro-chemicals, tractor and improved seeds with technical efficiency. The works of the following, Amos, 2007; Ahmad et al, 2002; Tchale and Sauer, 2007; Basnayake and Gunaratne, 2002, reported that, farmers` age and education, access to extension, access to credit, family size and tenancy as well as farmers access to fertilizer, agrochemicals, tractors and improved seeds have positive effect on technical efficiency of maize production. The impact of educational level on the efficiency and productivity of cereals was also scrutinized by Weir (1999). Weir and Knight (2000) also studied the impact of education externalities on the productivity and technical efficiency of crop producers and found that education externalities resulted from use and dissemination of innovations that shifted out the production frontier. Notwithstanding the outcomes there is one identified shortcoming of the Weir (1999) and Weir and Knight (2000a) work that is, it only investigate formal education as the only source of variations in technical efficiency of smallholder farmers. Amos (2007), Raghbendra et al (2005) and Barnes (2008) holds the view that there is a relationship between land holding size and technical efficiency to be positive. However, impact of the number of plots on technical efficiency has been reported by Raghbendra et al (2005) to be negative, that is land fragmentation (as measured by number of plots) has a negative impact on productivity. There has been disagreeing results on the impact of socio-economic variables such as gender on technical efficiency. While some studies by (Kuwornu et al, 2013; Bempomaa and Acquah, 2014) reported that gender of the farmer has no significant influence on technical efficiency, other studies (Sienso et al, 2013; Shamsudeen et al, 2013; Oppong, 2013) are on a contrary view that gender plays an important role on Technical efficiency. Addai (2011) also studied the Technical Efficiency of Maize Producers in three Agro Ecological Zones of Ghana and reported a mean technical efficiency of 64.1 % for maize producers in te chosen agro ecological zones. The study again identifies the determinants of technical efficiency of maize producers across the selected agro ecological zones to be contact with extension agents, mono cropping, gender, age, land ownership and access to credit.

II. MATERIAL AND METHOD

This study used primary data which was collected through a questionnaire from smallholder maize farmers. The multi-stage sampling technique was adopted in the selection process. In the first stage of the sampling process, two (2) districts were purposively selected from the transitional zone; the selected districts were Nkoranza and Ejura Sekyerdumasi. In the next selection process, five and four farming communities/villages were randomly selected from each of the district selected above respectively, Dotobiri, Koforidua, Abountem, Banofour, Donkro Nkwanta (Nkoranza District) and Durobo, Asuogya, Ejura, Sekyeredumase (Ejura Sekyerdumasi District).

The study makes use of the (Bartlett, DeMasi, Quinn, Moxham, & Rousseau, 2001)'s sample size determination formula to determine the sample size. That is

$$n = \frac{t^2(z)(h)}{d^2}$$

$$n = \frac{1.96^2 \times 0.513 \times 0.585}{0.05^2} = 461$$

where

n = sample

t = the value for selected alpha level of 0.025 in each tail = 1.96 (the alpha level of 0.05 represent the level of risk.

z = proportion of population engaged in maize production activities.

h = proportion of population who do not engage in maize production activities.

d = acceptable margin of error for proportion being estimated = 0.05 which the researcher is willing to take.

The study employed analytical techniques like descriptive statistics and stochastic frontier production. Descriptive statistics such as frequency tables, percentages means and standard deviations were used to analyze farmers' socio-economic characteristics, land fragmentation. The original models of stochastic frontier production model by (Aigner, Lovell, & Schmidt, 1977); and proposed by (Battese & Coelli, 1995), was applied to cross-sectional data to determine the efficiency of the maize farmers in the study area. The model was employed because it is capable of capturing measurement error and other statistical noise influencing the shape and position of the production frontier.

2.1 Model Specification

As employed by (Ajibefun, Battese, & Daramola, 2002) this study used the stochastic frontier production function. According to (Battese & Coelli, 1995) this model has advantage over other models because it allows simultaneous estimation of individual technical efficiency of respondents and also determines the technical efficiency. The stochastic frontier approach, contrary to other parametric frontier measures, give room for stochastic errors which may arise from statistical noise or measurement errors. With our objectives in mind we apply a Cobb-Douglas production function and the stochastic frontier which is expressed as:

The model of the stochastic frontier production for the estimation of technical efficiency is therefore specified.

$$\ln(y_i) = f(x_{ij}, \beta) + \varepsilon_j$$

$$\varepsilon_i = v_j - u_j$$

Where y is the level of output of the *j*th plot, *x* is the value of input used on the *j* plot, β is a vector of parameters to be estimated, $\varepsilon_i = v_j - u_j$ that is the error term, where $v_j - N(0, \sigma\ )$ and u_j is the one-sided error term, v_j and u_j is the two- side-sided error term and assumed to be independently distributed. The term v_j is the symmetric component and allows random variation of the production function across farms and also capture factors outside the control of the farmer. The one-sided element (u_j>0) reveals technical efficiency relative to the stochastic frontier. Output is said to lie on the stochastic frontier when u_j = 0 on the other hand there is inefficiency when u_j > 0.

The error term is presumed to follow one of the three likely distributions (Bauer, 1990)

i. Half-normal as U/N $(0, \sigma u^2)$

ii. Exponential as exp $(\mu u, \sigma u^2)$

iii. Truncated normal at zero $N \square \mu u, \sigma u^2$

$$\sigma^2 = \sigma_{v^2} + \sigma_{u^2} \tag{2}$$

Where $\sigma = (\sigma_{v^2} + \sigma_{u^2})1/2$

The technical efficiency (TE) of each an individual farmer is calculated as the projected values of v_j conditional on $\varepsilon_j = v - u$ with reference to (Jondrow, Lovell, Materov, & Schmidt, 1982).

That is

$$\text{E}= (u_j / \varepsilon_j) = \frac{\sigma_x - \sigma_y}{\sigma}[\frac{f(\varepsilon_j^2/\sigma)}{1-F(\varepsilon_j^2/\sigma)} - \frac{\varepsilon_j^2}{\sigma}] \tag{3}$$

Where E is the expectation of the farmer, F* is the values of the standard normal density and f* is the distribution function. Therefore Technical Efficiency (TE) is calculated as

Where 0 ≤TE ≤ 1.

$$\text{TE} = \exp(-Eu_j / \varepsilon_j);\ j = 1 \tag{4}$$

$$\text{Technical Efficiency (TE)} = \exp(-Eu_j / \varepsilon_j); i = 1 \tag{5}$$

The stochastic production frontier model is stated as follows

$$\ln Y_1 = \beta_0 + \beta_1 \ln S_1 + \beta_2 \ln S_2 + \beta_3 \ln S_3 + \beta_4 \ln S_4 + \beta_5 \ln S_5 + \beta_6 \ln S_6 + V_j - U_j \tag{6}$$

where Y is the productivity or output of farmer in kg; β 's is the parameters to be estimated; ln's is natural logarithms; V_j is the symmetric component that considers random errors associated with random factor under the control of maize farmers; U_j is the asymmetric error component that represent deviation from the frontier production (inefficiencies); S_1 represent the quantity of labour employed on a man-day; S_2 represent the quantity of seed (kg) used; S_3 represent the quantity of fertilizer (kg) applied; S_4 represent the quantity of herbicides (litre) applied; S_5 represent farm size (ha) and S_6 represents quantity of pesticides applied.

Empirically, the stochastic frontier translog production function was estimated as

$$\begin{aligned}
\ln OUTPUT_i &= \beta_0 + \beta_1 \ln LAB_i + \beta_2 \ln SED_i + \beta_3 \ln FET_i + \beta_4 \ln HEB_i \\
&+ \beta_5 \ln LAD_i + \beta_6 \ln PET_i + \beta_7 \ln(LAB)_i^2 + \beta_8 \ln(SED)_i^2 + \beta_9 \ln(FET)_i^2 \\
&+ \beta_{10} \ln(HEB)_i^2 + \beta_{11} \ln(LAD)_i^2 + \beta_{12} (PET)_i^2 + \beta_{13} (\ln LAB \times \ln SED)_i \\
&+ \beta_{14} (\ln LAB \times \ln FET)_i + \beta_{15} (\ln LAB \times \ln HEB)_i + \beta_{16} (\ln LAB \times \ln LAD)_i \\
&+ \beta_{17} (\ln LAB \times \ln PET)_i + \beta_{18} (\ln SED \times \ln FET)_i + \beta_{19} (\ln SED \times \ln HEB)_i \\
&+ \beta_{20} (\ln SED \times \ln LAD)_i + \beta_{21} (\ln SED \times \ln PET)_i + \beta_{22} (\ln FET \times \ln HEB)_i \\
&+ \beta_{23} (\ln FET \times \ln LAD)_i + \beta_{24} (\ln FET \times \ln PET)_i + \beta_{25} (\ln HEB \times \ln LAD)_i \\
&+ \beta_{26} (\ln HEB \times \ln PET)_i + \beta_{27} (\ln LAD \times \ln PET)_i + v_i - u_i
\end{aligned}$$

The inefficiency model is specified as;

$$T_1 = \sigma_0 + \sigma_1 B_1 + \sigma_2 B_2 + \sigma_3 B_3 + \sigma_4 B_4 + \sigma_5 B_5 + \sigma_6 B_6 + \sigma_7 B_7 \tag{7}$$

Where T_1 represent the technical efficiency of maize farmers; σ 's represent the parameters estimated; B_1 represent the age of farmers (years); B_2 represent the sex of farmers (Male=1 and Female=2); B_3 represent the marital status of the farmers (Married=1 and Otherwise=0); B_4 represents the Household size; B_5 is the number of the years spent in school (years); B_6 represent the fragmentation index; B_7 represents the distance between plots (kilometer).Also, the empirical inefficiency model was estimated as;

$$u_i = \delta_0 + \delta_1 AGE_i + \delta_2 GENDER_i + \delta_3 MARST_i + \delta_4 HOSIZ_i + \delta_5 EDU_i$$
$$+\delta_6 FRAIND_i + \delta_7 FRADIS_i$$

III. RESULTS AND DISCUSSION

The tables below present the socioeconomic characteristics of maize farmer in the study area. It was realized from the result that, as high as 192 farmers representing 41 % were in the age group of 41-50 years, followed by farmers in the age group of 31-40 with 157 farmers representing 34.1% farmers in the age range of 20-30 and 51-60 recorded percentages of 8.7% and 11.1% respectively. Farmers with age above 60 years recorded the least number with a percentage of 4.6% The average age of the farmers in the study area recorded 42.7 years with a Standard Deviation (SD) of 11.7, which testified that majority of the farmers are still within their youthful active productive age. The result has consequence on availability of labour and productivity because age has a direct bearing on the availability of labour and the adoption of new and improved agricultural practices. This result is in agreement with the work of Rauf (2010) who also identified that age of farmers has direct implication on labour productivity and improved agricultural practices. However some literatures consider age to have an ambiguous effect on productivity (Tan, 2005).

The result revealed that, as many as 320 farmers representing 69.4% in the study area were males, with 141 farmers representing 30.6% been females, this indicates active involvement of males in maize production in the study area than females. The result agrees with the work of Sdiq et al (2013) which revealed 67% of maize farmers were males and 33% were females in their study of Profitability and Production Efficiency of Small-Scale Maize Production in Niger state. It is also in agreement with the study results of (Oladejo & Adetunji, 2012) Economic Analysis of Maize (Zea mays L.) Production in Oyo State of Nigeria, which also found out that majority (70.9%) of the farmers were males with minority (29.1%) been females.

TABLE 1
SOCIOECONOMIC CHARACTERISTICS OF THE FARMERS

Age (Years)	Frequency	Percentage %
20 – 30	40	8.7
31 – 40	157	34.1
41 – 50	192	41.6
51 – 60	51	11.1
More than 60	21	4.6
Total	461	100
Mean = 42.7		
SD = 8.8		
Min. = 20, Max. = 77		
Sex		
Male	320	69.4
Female	141	30.6
Total	461	100
Marital Status		
Married	331	71.8
Otherwise	130	28.2
Total	461	100
Educational Level		
No formal education	58	12.6
Primary education	118	25.6
Middle School Education	93	20.2

Secondary education	132	28.6
Tertiary Education	60	13.0
Total	461	100
Mean = 13.1		
SD. = 1.21		
Min. = 0 Max. = 19		
Household Size		
1 – 4	100	21.7
5– 8	255	55.3
More than 8	106	23.0
Total	461	100
Mean = 7.1		
SD. = 3.2		
Min. = 1 Max. = 19		

Source: Survey 2018.

The results of educational level from the table above revealed that, 58 farmers representing 12.6% of the farmers interviewed were illiterates with no formal education at all. Farmer with secondary school education recorded the highest percentage of 28.6% representing 132 farmers, second to them was farmers with primary education with a percentage of 25.6 representing 118 farmers, whilst 20.2% and 13.0% were the percentages of farmers with middle school education and tertiary education respectively. The results proves majority of the farmers interviewed were literates within various levels of education that is 87.4% of the farmers were literates with formal education. According to the works of Huffman, (1977); Lockheed, Jamison & Lou, (1980) and Osman, Binici,& Zulauf, (2009) education partly determines farmers stock of human capital and positively influenced the level of technical efficiency of farmers and hence, the greater the stock of human capital, the better a farmer's ability to organize the factors of production for maximum efficiency. The result agrees with that of the work of Oladejo and Adetunji (2012) which revealed that 82.3% of maize farmers in Oyo state of Nigeria were literates.

The household size ranges from 1 to 19 with a mean of 7.1 and a Standard Deviation (SD) of 3.2 for maize farmers in the study area. The mean household is large enough to influence land fragmentation in the study area since per the custom of the people in the study area, land holding of the demise farmer must be divided among the children in the family.

TABLE 2
NUMBER OF PLOTS OWNED AND MEAN LAND SIZE BY FARMERS IN THE STUDY AREA.

Number of Plots	Frequency	Percentage %	Average Plot size (hectares)
1	93	20.2	0.58
2	180	39.0	0.90
3	119	25.8	1.29
4	51	11.1	1.81
5	18	3.9	2.41
Total	461	100	Mean= 1.09 $\pm$ 0.3

Source: Survey 2018.

The table above shows the number of land plots owned by maize farmers in the study area, from the table it was realized that farmers with two (2) pieces of land located at different arears recoded the highest percentage of 39.0 representing 180 farmers. Next to them were farmers with three pieces of land also located at different areas separated by distance from each other with a percentage of 25.8 representing 119 farmers? The others recorded 20.2%, 11.1% and 3.9% for farmer owning one, four and five different plots of lands respectively. The mean plot owned by farmers in the study area was 1.09 $\pm$ 0.3. Some researchers are of the view that, the number of plots can has positive effects on technical efficiency among them are, (Shuhao, 2005; Marara and Takeuchi, 2003). The work of (Raghbendra 2005) revealed that, the higher the number of plots the lower the technical efficiency lever of the farmer.

TABLE 3
THE AVERAGE TECHNICAL EFFICIENCY SCORE FOR MAIZE FARMERS.

Technical efficiency range	Frequency	Percentage
0.61-0.70	21	4.6
0.71-0.80	150	32.5
0.81-0.90	282	61.2
0.91-100	8	1.7
Total	461	100
Min	61.1	
Max	91.6	

Source: Survey 2018

The table above presents the minimum, maximum and mean of the technical efficiency of maize farmers in the study area. The table shows that, efficiency of maize farmers in the transitional zone of Ghana ranges between 61.1 % and 91.6% with a mean of 81.0%. This implies farmers in the transitional zone are operating at a high efficient level given all the available production technologies. However, farmer still have room of about 19.9% to improve by adopting and practicing the best farming practices.

TABLE 4
RESULTS OF THE STOCHASTIC FRONTIER SCALE OF EFFICIENCY FUNCTION OF MAIZE FARMERS.

Variable		Coefficient	Standard error	T-Value
Constant	β_0	4.5267***	0.22672	19.95
Quantity of labour (Man-day)	β_1	-0.01317***	0.003949	-2.89
Quantity of Seed (kg)	β_2	-0.783844***	0.010051	-1.83
Land Size (Ha)	β_3	-0.01183928*	0.280894	-2.79
Quantity of fertilizer (kg)	β_4	0.0004087	0.008709	0.05
Quantity Herbicides (litre)	β_5	0.010099	0.008663	1.17
Cost of farm implement	β_6	-0.0662485	0.0428042	1.54
Inefficiency				
Constant	B_0	0.1376273	0.243386	0.56
Age (year)	B_1	-0.0011641	0.001171	-0.68
Sex	B_2	0.0400865	0.040874	1.18
Marital Status	B_3	0.0031164	0.035340	0.89
Household Size	B_4	0.00391	0.0029525	1.34
Education (Years)	B_5	0.0006845	0.001992	0.34
Fragmentation index	B_6	0.1490806***	0.060665	2.46
Farm distance	B_7	0.010808**	0.004872	2.22
Sigma-squared (σ^2)		0.0139141***	0.4174042E+01	3.33
Gamma (γ)		0.99999	0.11558621E-03	
Log-likelihood function	0.54256121E+02			
LR-test of one sided error	0.17580149E+03			
Mean efficiency	0.828			

Source: Survey 2018 Note: * is significant at 10%, ** is significant at 5% *** is significant at 1%

The results of the maximum likelihood estimate of the Cobb-Douglas function revealed that the Lambda and the Gamma were both significant at 1% with values of 0.0139141 and 0.99999 respectively. For the fact that the values are significantly different from zero, it implies there is a good fit of the model and the distribution assumptions are correct. The results revealed that, quantity of labour (man-day) used, farm size and quantity of seed used, are very important inputs factor for the production of maize in the study area, because they all have a significant relationship with technical efficiency. Quantity of labour used in the farm which is measured in man-days has a negative relationship with technical efficiency but significant at 1%. This implies that, as the number of labour used in the farm increases by a unity the technical efficiency of the farmer will also decrease by 0.13%. This results in consistent with work of (Byiringiro & Reardon, 1996) who found out that land and labour had positive significant effects on production. Land size with coefficient of (0.01183928) also has a negative relationship and significant at 10% with technical efficiency. The implication of this result is that, a 10% increase in the area of land allocated of the cultivation of maize will reduce the technical efficiency of the farmer by 0.12%. With an increase in farm size, farmers' resource endowment will be proportionate to their scale of production. The results of the current study confirm existing knowledge about the effect of land holding on the technical efficiency of farmers. Even though Raghbendra et al (2005), Amos (2007) and Barnes (2008) reported a positive correlation between farm size and technical efficiency. This result is in agreement with the work of Msuya et al. (2008) who found out that land, expenditure on materials (including maize seed) and family labour positively affect maize productivity in Tanzania. Moreover, the cost of farm implements has significant relationship with technical efficiency and a negative coefficient value which is inelastic. This means a 10% increase in farm implement will cause a 7.8% decrease in technical efficiency of the farmer. Although, quantity of seed was significant it had a negative relationship with technical efficiency on the other hand quantity of herbicides was not significant and also had a negative relationship. This means as quantity of seed is increased by one kilogram (kg) the technical efficiency of the farmer will decrease by 0.10%, in the same way as the quantity of herbicides is increased by one litre the technical efficiency of the farmer will decrease by 0.36%. Both quantity of herbicides and pesticides were insignificant but herbicides had a negative relationship whiles pesticides had a positive relationship with technical efficiency.

In the case of the inefficiency variables, land fragmentation index and distance between farms were all significant at 10%, and 5% respectively with all the factors having a positive relationship with technical efficiency. The positive coefficient of land fragmentation means a unit increase in the fragmentation index will affect the technical efficiency of maize farmer in the study area. The positive effect of the fragmentation index on technical efficiency of farmers confirms the results of Sherlund, Barrett, and Adesina (2002) and Tan et al. (2010) whose studies revealed that technical efficiency is higher for farmers who cultivate few plots than more plots. The positive relationship of the land fragmentation of this study disagrees with the study of Dao (2013) who claimed that there is a positive relationship between farm size and technical efficiency and a negative relationship between land fragmentation and technical efficiency. In the case distance between farms plots a positive relationship significance was recorded which means a unity increase in distance between farm plots will result in an increase of output of maize farmer in the study area. These results confirm the results of Sherlund et al. (2002) and Tan et al. (2010). Who claims there is a positive effect of the number of plots on technical efficiency? Both age and sex of the farmers were not significant with age having a negative relationship with technical efficiency and sex having positive relationship. The age of the farmer though was not significant but had a positive relation with technical efficiency, however some literature consider age to have ambiguous effect on technical efficiency (shuhao, 2005). The effect of education on technical efficiency was positive and insignificant for maize farmers in the study area. The results show that educated farmers produced maize more efficiently than illiterate farmers. This is true since human capital represented by educational level, enhances the managerial and technical skills of farmers. According to (Battese & Coelli, 1995), education is hypothesized to increase the farmers' ability to utilize existing technologies and attain higher efficiency levels. This result was consistent with the work of by (Bizimana, Nieuwoudt, & Ferrer, 2004) in Rwanda. However Owour and Shem (2009) are of the view that educational level is negatively correlated to technical efficiency of farmers. They explanation that, scientific skills in agriculture, for example in developing economies are more affected by practical training in modern agricultural methods than just formal education. Household size on technical efficiency by maize farmers in the study area was significant and had the expected positive signs. This result is in agreement with Chukwuji et al (2007) work that revealed that large families enable farm activities to be completed on time in Nigeria. This on the other hand contradicts the work of Addai (2011) and Coelli et al (2002) that concluded that larger families are clearly a cause of lower efficiencies in the less labour intensive season, when surplus labour is a problem.

IV. CONCLUSION AND POLICY RECOMMENDATIONS

This study was concentrated on the effects of land fragmentation on technical efficiency of maize farmers in the transitional zone of Ghana. The findings showed that most of the farmers were in their youthful age with few of them over the age of 60 years therefore, an average age of 44.8 years. The age of the farmers has direct bearing on the technical efficiency of the farmers because productivity tends to decrease with increase in age. With the system of land tenure in the study area, the large mean of household size which is about 8 members per household would have a serious impact on land fragmentation since the land must be shared among all children in the family after the demise of the farmer. The revealed quantity of labour used, quantity of seed used, quantity of fertilizer, and farm size as the factors that determines technical efficiency of farmers in the study area. On the other hand, household size, land fragmentation and distance between farms were identified as the source of technical inefficiency of maize farmers in the study area. The results in this study show a positive relation between land fragmentation and productivity. We draw the following key lessons from the study of land fragmentation. (a) Land fragmentation should not be considered as undesirable; (b) it should also not be viewed as purely originating from, and/or made persistent by the influences of only a single type of factor (e.g. population density – a supply side factor) but a result of interaction between both the supply – and demand – driven factors. Which type dominates the other will depend on the farming environment prevailing in a specific area. The study recommends that there should be proper resource allocation and also, attention should be paid to the most efficient resources in order to make farmers more efficient. Technical efficiency determinants should also be taken into consideration to help in forming policies on land use.

REFERENCES

[1] Aigner, D., Lovell, C. K., & Schmidt, P. J. J. o. e. (1977). Formulation and estimation of stochastic frontier production function models. *6*(1), 21-37.

[2] Ajibefun, I. A., Battese, G. E., & Daramola, A. G. J. Q. J. o. I. A. (2002). Determinants of technical efficiency in smallholder food crop farming: application of stochastic frontier production function. *41*(3), 225-240.

[3] Akramov, K., & Malek, M. J. G. S. S. P. W. (2012). Analyzing profitability of maize, rice, and soybean production in Ghana: Results of PAM and DEA analysis. *28*.

[4] Apata, T. J. A. J. o. A. R. (2016). Small farms and agricultural productivity in Nigeria: empirical analysis of the effects of land tenure, fragmentation and property rights. *4*(12), 691-697.

[5] Balogun, O., & Akinyemi, B. J. C. S. S. (2017). Land fragmentation effects on technical efficiency of cassava farmers in South-West geopolitical zone, Nigeria. *3*(1), 1387983.

[6] Bartlett, J. A., DeMasi, R., Quinn, J., Moxham, C., & Rousseau, F. J. A. (2001). Overview of the effectiveness of triple combination therapy in antiretroviral-naive HIV-1 infected adults. *15*(11), 1369-1377.

[7] Battese, G. E., & Coelli, T. J. J. E. e. (1995). A model for technical inefficiency effects in a stochastic frontier production function for panel data. *20*(2), 325-332.

[8] Bauer, P. W. J. J. o. e. (1990). Recent developments in the econometric estimation of frontiers. *46*(1-2), 39-56.

[9] Bentley, J. W. J. A. r. o. a. (1987). Economic and ecological approaches to land fragmentation: in defense of a much-maligned phenomenon. *16*(1), 31-67.

[10] Binns, S. B. O., & Binns, B. O. (1950). *The consolidation of fragmented agricultural holdings*: Food and Agriculture Organization of the United Nations.

[11] Bizimana, C., Nieuwoudt, W. L., & Ferrer, S. R. J. A. (2004). Farm size, land fragmentation and economic efficiency in southern Rwanda. *43*(2), 244-262.

[12] Blarel, B., Hazell, P., Place, F., & Quiggin, J. J. T. W. B. E. R. (1992). The economics of farm fragmentation: evidence from Ghana and Rwanda. *6*(2), 233-254.

[13] Byiringiro, F., & Reardon, T. J. A. e. (1996). Farm productivity in Rwanda: effects of farm size, erosion, and soil conservation investments. *15*(2), 127-136.

[14] Chen, Z., Huffman, W. E., & Rozelle, S. J. C. E. R. (2009). Farm technology and technical efficiency: Evidence from four regions in China. *20*(2), 153-161.

[15] del Corral, J., Perez, J., & Roibás, D. J. J. o. D. S. (2011). The impact of land fragmentation on milk production. *94*(1), 517-525.

[16] Demetriou, D. (2014). Land Fragmentation. In *The Development of an Integrated Planning and Decision Support System (IPDSS) for Land Consolidation* (pp. 11-37): Springer.

[17] Demetriou, D., Stillwell, J., See, L. J. C., Environment, & Systems, U. (2013). A new methodology for measuring land fragmentation. *39*, 71-80.

[18] Di Falco, S., Penov, I., Aleksiev, A., & Van Rensburg, T. M. J. L. u. p. (2010). Agrobiodiversity, farm profits and land fragmentation: Evidence from Bulgaria. *27*(3), 763-771.

[19] Gebeyehu, Y. (1995). *Population pressure, agricultural land fragmentation and land use: A case study of Dale and Shashemene Weredas, Southern Ethiopia.* Paper presented at the Proceedings of the fourth Annual Conference on the Ethiopian Economy.

[20] Januszewski, J. J. G. P. (1968). Index of land consolidation as a criterion of the degree of concentration. *14*, 291-296.

[21] Jondrow, J., Lovell, C. K., Materov, I. S., & Schmidt, P. J. J. o. e. (1982). On the estimation of technical inefficiency in the stochastic frontier production function model. *19*(2-3), 233-238.

[22] King, R., & Burton, S. J. P. i. G. (1982). Land fragmentation: notes on a fundamental rural spatial problem. *6*(4), 475-494.

[23] Latruffe, L., & Piet, L. J. A. s. (2014). Does land fragmentation affect farm performance? A case study from Brittany, France. *129*, 68-80.

[24] McPherson, M. F. (1982). *Land fragmentation: a selected literature review*: Harvard University, Harvard Institute for International Development.

[25] MoFA, G. (2011). Agriculture in Ghana. Facts and figures (2010).

[26] Mwebaza, R., & Gaynor, R. J. R. D. I., The Government of the Republic of Uganda. (2002). Land sector analysis; land market, land consolidation, and land re-adjustment component.

[27] Nguyen, T., Cheng, E., & Findlay, C. J. C. E. R. (1996). Land fragmentation and farm productivity in China in the 1990s. *7*(2), 169-180.

[28] Oladejo, J., & Adetunji, M. J. A. S. R. J. (2012). Economic analysis of maize (zea mays l.) production in Oyo state of Nigeria. *2*(2), 77-83.

[29] Rahman, S., & Rahman, M. J. L. U. P. (2009). Impact of land fragmentation and resource ownership on productivity and efficiency: The case of rice producers in Bangladesh. *26*(1), 95-103.

[30] Rusu, M., Florian, V., Popa, M., Marin, P., & Pamfil, V. J. A. c. s. f. R. M. I. h. w. f. o. r. s. e. m. d. r. p. p. (2002). Land fragmentation and land consolidation in the agricultural sector.

[31] Shao, Y., Molnar, L. F., Jung, Y., Kussmann, J., Ochsenfeld, C., Brown, S. T., . . . O'Neill, D. P. J. P. C. C. P. (2006). Advances in methods and algorithms in a modern quantum chemistry program package. *8*(27), 3172-3191.

[32] Sklenicka, P., Janovska, V., Salek, M., Vlasak, J., & Molnarova, K. J. L. u. p. (2014). The Farmland Rental Paradox: extreme land ownership fragmentation as a new form of land degradation. *38*, 587-593.

[33] Sklenicka, P. J. L. U. P. (2016). Classification of farmland ownership fragmentation as a cause of land degradation: A review on typology, consequences, and remedies. *57*, 694-701.

[34] Smith, P. K., Mahdavi, J., Carvalho, M., & Tippett, N. J. R. B. N. R.-L. D. (2006). An investigation into cyberbullying, its forms, awareness and impact, and the relationship between age and gender in cyberbullying.

[35] Talyzin, A., Andersson, O., Sundqvist, B., Kurnosov, A., & Dubrovinsky, L. J. J. o. S. S. C. (2007). High-pressure phase transition in LiBH4. *180*(2), 510-517.

[36] Tan, S. (2005). *Land fragmentation and rice production: a case study of small farms in Jiangxi Province, PR China*: Wageningen University.

[37] Tan, S., Heerink, N., Kuyvenhoven, A., & Qu, F. J. N.-W. J. o. L. S. (2010). Impact of land fragmentation on rice producers' technical efficiency in South-East China. *57*(2), 117-123.

[38] Thobatsi, J. T. (2009). *Growth and yield responses of maize (Zea mays L.) and cowpea (Vigna unguiculata L.) in an intercropping system.* Citeseer,

[39] Thomas, J. J. J. o. A., & Economics, D. (2006). Property rights, land fragmentation and the emerging structure of agriculture in Central and Eastern European countries. *3*(2), 225-275.

[40] Union, A. J. A. A. (2006). Resolution of the Abuja Food Security Summit.

[41] Van Dijk, T. J. E., Delft. (2003). Dealing with Central European land fragmentation.

[42] Van Hung, P., MacAulay, T. G., Marsh, S. P. J. A. j. o. a., & economics, r. (2007). The economics of land fragmentation in the north of Vietnam. *51*(2), 195-211.

[43] Wan, G. H., & Cheng, E. J. A. E. (2001). Effects of land fragmentation and returns to scale in the Chinese farming sector. *33*(2), 183-194.

[44] Wolter, D. J. O. J. G. P. (2009). Ghana: agriculture is becoming a business. *2009*(2), 9-32.

[45] Wu, Z., Liu, M., & Davis, J. J. C. E. R. (2005). Land consolidation and productivity in Chinese household crop production. *16*(1), 28-49.

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