International Journal of Agriculture and Environmental Research

ISSN: 2455-6939

Volume: 06, Issue: 03 "May-June 2020"

PERFORMANCE OF MAIZE AND SOYBEAN MIXTURE AS INFLUENCED BY ORGANIC MULCH IN THE SOUTHERN GUINEA SAVANNAH ZONE OF NIGERIA

*Nkiruka Celestina Odoh; Effiom Essien Oku; Emem Ebuk Efiok

Department of Soil Science, Faculty of Agriculture,
University of Abuja, Abuja, Nigeria.

*Corresponding author

DOI: 10.46609/IJAER.2020.v06i03.008 URL: https://doi.org/10.46609/IJAER.2020.v06i03.008

ABSTRACT

Influence of different organic mulch materials on soil properties and on the growth and yield response of maize-soybean intercrop was investigated at the Teaching and Research Farm, University of Abuja. The mulch treatments used include; *Centrosema pubescens*, Sawdust, Rice husk and No- mulch. The experiment was laid out in a Randomized Complete Block Design (RCBD) with four replications. Soil pH and Electrical conductivity were observed to have been lower under mulched plots. Soil organic carbon was generally low (1-9 g/kg) for maize while for soybean OC across mulch treatment ranged from 2- 17 g/kg; with the highest OC value (17 g/kg) recorded under sawdust. A significantly (P< 0.05) highest maize grain yield (1.01ton/ha) and stem diameter (10.3 cm) was observed under *Centrosema pubencens* while the least grain yield (0.66 ton/ha) was obtained under sawdust treatment. The highest soybean grain yield of 0.14 ton/ha was recorded under *Centrosema pubescens* treatment while the lowest grain yield of 0.12 ton/ha was recorded under sawdust treatment. The varied effect of organic mulch treatment on some soil characteristics and also on the growth and yield of maize - soybean mixture is a reflection of the effects of organic mulch on the microclimate of the soil.

Keywords: Intercrop, mulching, legume, yield, climate adaptability

INTRODUCTION

Crop mixture and mulch application comes in handy as a climate change adaptation strategy for smallholder farmers in Africa. Crop production in Sub-Saharan Africa (SSA) is majorly rainfed and is highly threatened by climate change variability leading to poor crop yield [1]; [2]; [3]. In

ISSN: 2455-6939

Volume: 06, Issue: 03 "May-June 2020"

other to ameliorate the adverse effects of climate variability on crop production, microclimate management must be integrated into smallholders cropping system in the Guinea Savannah.

Such management practices aim at maximizing crop yield while reducing water loss on cultivated fields. Cereal - legume intercrop is a cropping system that could guarantee nutrition food security and livelihood of smallholder farmers in sub-Saharan Africa. The legume and cereal component crops in the intercrop systems vary with culture, tradition, agroclimatic condition, economic status, and food preferences of communities [4].

Tropical soil is reported to be deficient in Nitrogen (N), a constant N supply through BNF from legume component is assured when incorporated into the cropping system [5]. Beside an increased amount of soil N, other essential nutrients are made available in cereal -legume mixture as compared to monocrops of cereals [6]. The ability of legumes to restore soil fertility have been linked to their characteristic deep rooting, nitrogen fixation, leaf shedding ability and mobilization of insoluble soil nutrients [7]. Intercropping of soybean (*Glycine max* L.) with maize (*Zea mays* L) provides great room for the soil and other crops in the mixture to cope with adverse climatic conditions. This is linked to the varied morphology and architecture of both crops such as diverse rooting and growth pattern, differences in nutrient requirement as well as crop duration [8]. These crop mixture beside their importance as rich food source is a form of assurance against crop failure, some measureable yield could be achieved from at least one component [9]; [10]. Maize and soybean are commonly grown economic crops in the Southern Guinea Savanna region and are highly sensitive to moisture stress particularly at their critical growth stages. Soybean, yield reduction of 40 % can occur due to moisture stress during reproductive stage [11]. Naturally, water is lost from cultivated fields through evapotranspiration and percolation. Some of such losses could be effectively minimized through the spread of mulches over the crop area.

Mulching is one climate change adaptation method of manipulating crop growing environments. It has been helpful in mitigating water losses due to global warming and irregular rainfall pattern [12]; [13]. It helps to increase crop yield and soil productivity through reduction in weed growth, regulation of soil temperature, increased water infiltration, soil and water conservation and water availability to crops. Over time organic mulch decomposes and is incorporate into the soil as organic fertilizer leading to improvement in soil physical condition [14]. The favourable physical condition in the soil promotes soil microbial activities, nutrient release and long-term plant growth. Improvements in soil microbial diversity had been observed to protect soil organisms against different meteorological conditions [15]. Thus, mulching indirectly and positively affect the chemistry, biology, physics and fertility of the soil. Organic mulches are derived from organic sources and includes agricultural wastes such as rice husk, straw, sawdust, leaves and

ISSN: 2455-6939

Volume: 06, Issue: 03 "May-June 2020"

live mulch. Studies have shown that organic mulches decreases soil pH and this decrease could proportional to the depth of these mulches [16]; [17].

A Study has shown a positive performance of Rice husks on soil and onion over sawdust although sawdust had more water retaining ability than rice husk [18]. An enhanced grain yield of soybean from 0.95 to 1.25 t ha^{-1} due to straw mulch has earlier been reported [19]. Rice husk mulch is known to improve water storage, protects the soil surface against raindrop, moderate soil temperature and helps maintain soil organic matter, slowly releasing the nutrient over time [18] [20].

The suitability of organic mulch materials as well as their influence on soil properties and crop yield is variable. This could depend on the crop species, edaphic and climatic condition, management system and type of mulch materials used [21] [13]. Therefore the objectives of the study were to assess the influence of saw dust, rice husk and *Centrosema pubescens* on soil characteristics and on the growth and yield of soybean and maize grown on Alfisols in Abuja.

MATERIALS AND METHODS

Experimental site description

The study was conducted during the raining season of 2019 at the Teaching and Research Farm of the University of Abuja in the Federal Capital Territory (FCT) of Nigeria. The study area falls within the Southern Guinean Savanna zone and lies between latitude 08^0 51' and 09^0 37' N and longitude 007^0 20' and 007^0 51'E. The soil of the study area is classified as Alfisol order, Ustalf with Ustic moisture regime. The area being dominated by plinthite layers or continuous concretionary layers, its great-order group of Plinthustalfs, another sub-group as TypicPlinthustalfs exist [22]. The weather is characterized by a warm, humid, rainy season and a scorching dry season and with a highest annual rainfall of about 1631.7 mm.

Land preparation and experimental setup

The experimental plots were marked out after field clearing and tilled into ridges using a traditional hoe. Each plot area was 4 m x 4 m, with 1m space between plots. There was a total of 16 plots. Seeds of maize (white variety) and soybean (TGX1448-2E) were sourced from Institute of Agricultural Research (IAR) Zaria, Nigeria. Maize and soybean were alternately sown on a ridge at a spacing of 25cm, thus 2 maize or soybean plants were spaced at 50 cm. Two seeds were planted per hole and later thinned to 1 plant per stand at 2 weeks after sowing (WAS). Fertilizer application was done two weeks after sowing (WAS) using NPK 20:10:10 at 200 kg $ha^{-1}$for the maize and Single Super Phosphate (SSP) at 30 kg ha^{-1} for the soybean. Routine weeding was done manually using a native hoe.

ISSN: 2455-6939

Volume: 06, Issue: 03 "May-June 2020"

The organic mulch materials used include sawdust, rice husk and *Centrosema pubescens*. Sawdust was collected from a saw mill while rice husk was collected from rice mill both within the FCT *Centrosema pubescens* was collected from the University farm. The collected mulch materials were air dried to a constant weight prior to their measurement and application. Mulch treatment was applied at four (4) levels namely T_{1-} *Centrosema pubescens* (17 tons/ha), T_{2-} Sawdust (28 tons/ha), T_{3-} Ricehusk (28 tons/ha) and T_{4-} No-mulch (control) all at 3 WAS. The experiment was laid out in a Randomized Complete Block Design (RCBD) and replicated four times. Routine weeding was done manually using a native hoe. The experiment was terminated 16 WAS.

Soil analysis

Representative soil samples (0 – 30cm) were randomly collected at the beginning (Pre-planting) from 5 different spots at the experimental site. The samples were thoroughly mixed and bulked to form a composite sample. Post experiment soil samples were collected from maize and soybean rhizosphere from each mulch treatment. These soil samples were air-dried and sieved through 2 mm mesh and used for laboratory analyzes. Electrical conductivity, EC (1:1 w/v) and Soil pH (1:2.5 w/v) were determined in saturated soil-pastes extract, by EC and pH meter, respectively [23]. Soil organic carbon was determined by the wet oxidation method [24]. Percentage (%) organic matter = % organic carbon × 1.724 [25]. Particle size analysis was done using the hydrometer method [26].

Data collection and statistical analysis

Growth parameters such as number of leaves, plant height and stem diameter were measured for maize while cob weight, pod weight and grain yield were measured for maize and soybean. All the data were subjected to analysis of variance (ANOVA) using the Genstat package version 3 (3^{rd} edition Genstat Discovery).

RESULTS AND DISCUSSION

Effect of organic mulch on some soil characteristics

Table 1 shows some soil characteristics of the experimental site as influenced by organic mulch. The particle size analysis showed that the texture of the soils were predominantly sandy clay loam except for soil collected from no- mulch soybean rhizosphere which was shown to be sandy clay. The clay fraction ranged from 320 g kg^{-1} to 406 g kg^{-1}. The silt fraction ranged from 26 g kg^{-1} to 124 g kg^{-1} while the sand fraction ranged from 500 g kg^{-1} to 600 g kg^{-1}. The slightly different sand, silt and clay fractions of the samples have not changed the textural class of the soil, which confirms the observation of [27] that soil particle size sample does not change easily within short period of time.

Soil pH of the samples was slightly acidic and ranged from 4.68 to 5.08 [28]. Soil pH decreased further with the application of organic mulch compared to no- mulch treatments. The least pH was recorded under sawdust and rice husk mulches. Organic mulching has been reported to indirectly influence soil chemistry and fertility, as a result of its influence on soil moisture and temperature, which in turn affect the microbial activities and organic matter degradation [17]. The observed reduction in soil pH under organic mulch could be linked to nitrification processes and the accumulated organic acids produced from the decomposition of organic materials [29]. Researches have earlier shown decreases soil pH due to organic mulches and this decrease could be proportional to the depth of these mulches [16]; [17].

Table 1: Soil characteristics of the experimental field as affected by mulch application

Treatment	Clay gkg^{-1}	Silt gkg^{-1}	Sand gkg^{-1}	Textural class	pH	EC $dScm^{-1}$	OC g/kg	OM g/kg
Pre-planting characteristics	372	92	536	SCL	5.01	7.05	2	3.42
Post experiment characteristics								
Maize rhizosphere								
No-mulch	388	68	544	SCL	5.08	7.1	2	3.45
Centrosema pubescens	330	124	546	SCL	5.00	2.4	9	15.52
Sawdust	352	68	580	SCL	4.68	3.1	1	1.72
Rice husk	374	26	600	SCL	4.91	5.1	7	12.07
Soybean rhizosphere								
No-mulch	406	58	536	SC	5.00	7.2	2	3.45
Centrosema pubescens	380	120	500	SCL	4.97	3.9	3	5.17
Sawdust	320	80	600	SCL	4.78	2.0	17	29.31
Rice husk	320	100	580	SCL	4.78	5.4	11	18.96

NB: EC = electrical conductivity, OC = organic carbon, OM = organic matter, SC= sandy clay, SCL= Sandy clay loam

ISSN: 2455-6939
Volume: 06, Issue: 03 "May-June 2020"

Electrical conductivity was in the range of 2 to 7.2 $dScm^{-1.}$ As observed, application of mulch caused a decrease in soil EC, with the least value under *Centrosema pubescens* for maize and sawdust for soybean treatment. The finding of this study corroborates previous works of [30] and [31] in which mulching caused reduction in soil EC. Mulching can depress soil EC either through reduction in water evaporation from the soil thereby reducing soil accumulated salt ion or by the absorption of water-soluble salts at the soil layer. Greatest effect of mulches on soil EC was observed in the surface layer of soil [16]. The organic carbon content where low under maize rhizosphere and ranged from 1.00 g/kg to 9 g/kg [28]. For soybean, moderate and high level of OC were recorded under rice husk (11 g/kg) and saw dusk as compared to 2 g/kg found under no- mulch treatment.

Effects of organic mulch on growth parameters of Maize

Table 2 shows the effects of organic mulch on plant height and stem diameter of maize. The plant height was not significantly different in all the treatments. However, at 15 WAS, No-mulch treatment had the least (90.1 cm) plant height while Rice husk had the highest (123.8 cm) plant height. This was followed by treatment with *Centrosema pubescens* which had 118.0 cm. The observed increase in plant height under mulched over no-mulch plots could be attributed to higher moisture retention and regulated soil temperature due to mulching. In addition, rice husk and *Centrosema pubescens* are more readily decomposable and as such may increase soil nutrient content more than sawdust with a higher C:N ratio leading to slower decomposition. This assertion conforms to the reports of [32], who recorded 10 to 37 % and [17] with 27.5% increase in the plant height due to straw mulch over no-mulch treatment. [33] work on tomato also showed an increase in plant height under rice straw mulched as compared to the control. A varied effect of organic mulch material on sorghum plant height was noted by [34].

Stem diameter was not significantly different at 3 and 6 WAS; however, at 9 and 12 WAS, stem diameter of maize was significantly different ($P<0.05$) across the mulch treatments. At 9 WAS, the stem diameter was significantly higher (8.18 cm) under *Centrosema pubescens* as compared to that of no- mulch treatment (7.29 cm). Again at 12 WAS, highest stem diameter was obtained for *Centrosema pubescens* (10.27 cm) while the least was found under rice husk. This result is in line with the findings of [17], which shows that straw mulch validly promoted the crop growth in terms of plant height, number of leaves, leaf area and stem diameter over the control.

ISSN: 2455-6939

Volume: 06, Issue: 03 "May-June 2020"

Table 2: Effect of organic mulch on maize plant height and stem diameter

Types of Mulch	Plant height (cm)				Stem diameter (cm)			
	3WAS	6WAS	9WAS	12WAS	3WAS	6 WAS	9WAS	12 WAS
No- mulch	16.9	44.3	76.20	90.1	2.39	5.68	7.29b	9.71ab
Centrosema pubescens	18.45	43.95	90.55	118.0	2.22	5.43	8.18a	10.27a
Sawdust	17.25	43.85	83.15	113.1	2.30	5.28	7.64ab	9.72ab
Rice husk	18	43.75	80.90	123.8	2.34	5.66	7.67ab	9.03b
LSD	2.56	9.92	15.88	19.74	0.51	0.77	0.57	1.02

Means with the same letter in a column are not significantly different ($P \leq 0.05$), LSD = Least Significant Difference, WAS= weeks after Sowing.

Effects of organic mulch on growth parameters of soybean

Table 3 shows the plant height of soybean as influenced by different mulch materials. Mulch treatment significantly ($P < 0.05$) influenced plant height of soybean at 12 WAS. No-mulch treatment had the least plant height (10.60cm) as compared to all the mulched treatments. This supports the findings of [17] who had earlier recorded 27.5% increase in the plant height of soybean due to straw mulch as compared to no-mulch treatment.

Table 3: Effect of organic mulch on soybean plant height

Types of Mulch	Plant height (cm)			
	3WAS	6WAS	9WAS	12WAS
No-mulch	4.26	9.71ab	10.12	10.60b
Centrosema pubescens	3.97	9.78ab	9.71	14.25a
Sawdust	3.54	10.26a	10.55	13.90a
Rice husk	3.43	9.055b	9.35	14.90a
LSD	0.805	1.088	1.487	1.306

Means with the same letter in a column are not significantly different ($P \leq 0.05$), LSD = Least Significant Difference, WAS= weeks after Sowing.

ISSN: 2455-6939

Volume: 06, Issue: 03 "May-June 2020"

Yield of maize under different organic mulch materials.

Maize grain yield (Table 4.) significantly (P< 0.05) differed across mulch treatments. The highest grain weight of 1.01 ton/ha was recorded under *Centrosema pubescens* while the least grain yield 0.66 ton/ha was obtained under sawdust treatment. A higher grain yield of maize observed under *Centrosema pubescens* may be attributed to its faster decomposition rate. Besides, being a leguminous plant it has relatively higher nitrogen content as compared to sawdust. The observed yield depression of 26.6 % and 21.1 % under sawdust and rice husk mulch respectively could be an indication that these organic materials may not be the best mulch materials for maize in this area. This result agrees with the submission of [21] and also [13], on variable effect of organic mulch materials on yield. This could be influenced by crop type, edaphic and climate and management system.

Table 4: Yield of maize as influenced by organic mulch

Types of Mulch	Cob (ton/ha)	Grain (ton/ha)
No-mulch	0.36	0.90ab
Centrosema pubescens	0.41	1.01a
Saw dust	0.4	0.66c
Rice husk	0.36	0.71bc
LSD	0.19	0.11

Means with the same letter in a column are not significantly different ($P \leq 0.05$),
LSD = Least Significant Difference, WAS= weeks after Sowing.

Yield of soybean as influenced by organic mulch treatments

As shown in Table 5, the grain yield of soybean under different mulch treatments was not significantly different. However, while the yield of soybean under *Centrosema pubescens* increased by 7.7 % over no-mulch treatments there was a yield reduction of 7.7 % under sawdust treatment while no difference was observed for soybean yield with rice husk mulch. This varied grain yield observed is in line which the work of [34] who recorded a varied yield range 3.7 %-12.6 % in sorghum across the varied organic mulch material. Thus, suitability of organic mulch materials to crop yield is variable as stated by [34]. This could depend on the crop species, edaphic and climatic condition, management system and type of mulching materials used [21]; [13].

ISSN: 2455-6939

Volume: 06, Issue: 03 "May-June 2020"

Table 5: Yield of soybean as influenced by organic mulch

Types of Mulch	Pod + Gain	Pod	Grain
		ton/ha	
No-mulch	0.27a	0.13	0.13
Centrosema pubescens	0.28a	0.16	0.14
Sawdust	0.29a	0.16	0.12
Rice husk	0.24b	0.11	0.13
LSD	0.03	0.02	0.04

Means with the same letter in a column are not significantly different ($P \leq 0.05$), LSD = Least Significant Difference, WAS= weeks after Sowing.

CONCLUSION

Mulch treatment varied in their effect on measured soil characteristics and also on the growth and yield of maize and soybean. Maize grain yield was significantly enhanced under *Centrosema pubescens* mulch while yield decline was observed under sawdust. Also, soybean grain yield increased under *Centrosema pubescens* when compared the other mulch types. *Centrosema pubescens* is a common leguminous weed which is available and could easily be incorporated as organic mulch materials to enhance soil microclimate as well as improved maize and soybean production.

REFERENCES

[1] Ferreira, D.B., and Rao, V.B. Recent climate variability and its impacts on soybean yields in Southern Brazil. *Theor Appl Climatol* 2011; 105**:**83–97 https://doi.org/10.1007/s00704-010-0358-8

[2] Ikehi, M.E., Onu, F.M., Ifeanyieze, F.O. and Paradang, P.S. Farming Families and Climate Change Issues in Niger Delta Region of Nigeria: Extent of Impact and Adaptation Strategies. *Agricultural Sciences* 2014; **5**:1140-1151. http://dx.doi.org/10.4236/as.2014.512124

ISSN: 2455-6939

Volume: 06, Issue: 03 "May-June 2020"

[3] Chen B., Liu E., Mei X., Yan C., and Garré S Modelling soil water dynamic in rain-fed spring maize field with plastic mulching. Agric Water Manag 2018; 198:19–27.

[4] Layek J., Das A., Mitran T., Nath C., Meena R. S., Yadav G. S., Shivakumar B. G., Kumar S., and Lal R.. Cereal + Legume Intercropping: An Option for Improving Productivity and Sustaining Soil Health. In Legumes for Soil Health amd sustainable Management. Editors Meena, RS, Das, A., Yadav, GS., L, R. (Eds). Springer 2018; pp 349-386 DOI: 10.1007/978-981-13-0253-4_11

[5] Odoh, N.C., Abraham, G.A., N'cho, O.C. and Oku, E.E., Evaluation of a new rhizobial inoculant for soybean (*Glycine max*) production in semi-arid zone of Nigeria. International Journal of Agriculture and Biosciences 2017; 6(2):120-124 http://www.ijagbio.com/.../120-124.pdf

[6] Mugwe J., Mugendi D.N., Mucheru-Muna M., and Kungu J. Soil inorganic N and N uptake by maize following application of legume biomass, tithonia, manure and mineral fertilizer in Central Kenya. In: Bationo A, et al (eds) Innovations as key to the green revolution in Africa. Springer, Dordrecht, 2011 pp 605–612. https://doi.org/10.1007/978-90-481-2543-2_62

[7] Bedoussac L, E.P. Journet, H. Hauggaard-Nielsen, C. Naudin, G. Corre-Hellou, E.S Jensen, L Prieur and Justes E.. Ecological principles underlying the increase of productivity achieved by cereal-grain legume intercrops in organic farming: a review. Agron Sustain Dev. 2015; 35: 911–935

[8] Layek J, Shivakumar B.G., Rana D.S., Munda S., and Lakshman K. Growth pattern, physiological indices and productivity of different soybean (*Glycine max*) based intercrops as influenced by nitrogen nutrition. Indian J. Agron. 2012; 57:349–356

[9] Sanginga, N., and Woomer, P.L. Integrated soil fertility management in Africa: Principles, practices and developmental process. Tropical Soil Biology and Fertility. Institute of the International Centre for Tropical Agriculture. Nairobi, Kenya, 2009; 263p.

[10] Odendo, M., Bationo, A., and Kimani, S. Socio-economic contribution of legumes to livelihoods in Sub-Saharan Africa. In A. Bationo, B. Waswa, J. M. Okeyo, F. Maina, J. Kihara and U. Mokwunye (Eds.), Fighting poverty in Sub-Saharan Africa: The multiple roles of legumes in integrated soil fertility management 2011; pp. 27–46. Dordrecht: Springer Netherlands.

ISSN: 2455-6939

Volume: 06, Issue: 03 "May-June 2020"

[11] Pathan M.S., Lee J.D., Shannon J.G. and Nguyen H.T. Recent advances in breeding for drought and salt stress tolerance in soybean. M.A. Jenks, P.M. Hasegawa, and S.M. Jain (eds). In: Advances in molecu-lar breeding toward drought and salt tolerant crops. 2007 pp 739-773. Springer Netherlands..

[12] Li C., Wang C., Wen X., Qin X., Liu Y., Han J., Li Y., Liao Y., and Wu W. Ridge – furrow with plastic film mulching practice improves maize productivity and resource use efficiency under the wheat—maize double—cropping system in dry semi—humid areas. F Crop Res 2017; 203:201–211.

[13] Kader, M.A., Singha, A., Begum, M.A. A. Jewel F., Khan H. and N. I. Khan Mulching as water-saving technique in dryland agriculture: review article. Bulletin of the National Research Centre 2019; 43**:**147

[14] Oku, E., Fagbola, O., and Truong, P. Evaluation of vetiver grass buffer strips and organomineral fertilization for the improvement of soil physical properties. Kasetsart J. (Nat. Sci.) 2011; 45: 824-831.

[15] Teame**,** G.**,** Tsegay A. and Abrha, B.. Effect of Organic Mulching on Soil Moisture, Yield, and Yield Contributing Components of Sesame (*Sesamum indicum L.*) International Journal of Agronomy 2017(6):1-6 //doi.org/10.1155/2017/4767509

[16] Hild A.L. and Morgan D.L.. Effects on Crown Growth of Five Southwestern Shrub species. Journal of Environmental Horticulture 1993; 11(1): 41-43 https://doi.org/10.24266/0738-2898-11.1.41

[17] Xue L., Wang, L., Anjum S. A., Saleem, M. F. Bao M., Saeed A. and Bilal M. F. Gas exchange and morpho-physiological response of soybean to straw mulching under drought conditions African Journal of Biotechnology 2013; 12(18):2360-2365, DOI: 10.5897/AJB12.902 ISSN 1684-5315

[18] Salahudeen, A. B. and Sadeeq J. A. Use of rice husk and sawdust as composite mulching material for onion National Engineering conference, Faculty of Engineering, Amadu Bello University, Zaria ABU NEC 2018; 003

[19] Adisarwanto T. The influence of planting method and mulching on soybean seed yield. In: Shanmugasundaram, S., Sulzberger, E. W., McLean, B. T. (eds.), Soybean in Tropical and Subtropical Cropping Systems. Asian Vegetable Research and Development Center, Shanhua, Taiwan 1985; pp 215-217.

ISSN: 2455-6939

Volume: 06, Issue: 03 "May-June 2020"

[20] Abou El-Magd, M. A., Elbassiony, M. and Fawzy Z. F. Effect of rice husk mulch with other chemical fertiklizer on growth, yield and quantity of some varieties of broccoli plants. J. Of Applied Science Res. 2006; 2 (10): 791-798.

[21] Ezeaku, P. I. Evaluation of legume crops as alternative source of fertilizer for maize production in Abakaliki, Southeastern Nigeria, J. Agrotech. Ext. 2001; 1: 1-9.

[22] Lawal, B. A., Adeboye, M. K. A. Tsado, P. A. Elebiyo M. G. and Nwajoku C. R.. Properties, classification and agricultural potentials of lateritic soils of Minna in sub-humid agroecological zone, Nigeria. International J. Dev. and Sust. 2012; 1(3): 903-911.

[23] IITA (International Institute for Tropical Agriculture) Selected methods for soil and plants analysis. Manual series No. 7. IITA Ibadan, Nigeria. 1982.

[24] Nelson, D. W. and Sommer L.E.. Organic carbon. Methods of soil analysis. Part 2 Agronomy Monograph 9. Agronomy Society of America, Madison. 1982; 570 – 571.

[25] Walkley, A. J. and. Black, I. A. Estimation of soil organic carbon by the chromic acid titration method. Soil Science. 1934; 37: 29-38.

[26] Gee, G.N. and Bauder J. W. Particle size distribution. In: A Klute (ed.). 2nd ed. Methods of Soil Analysis Part 1. Physical and Mineralogical Methods. 1986; pp 383–411.Madison, Wisconsin.

[27] Agbede, O.A. Understanding soil and plant nutrition. Salman press limited, Keffi, Nasarawa State, Nigeria. Ist Edition. 2009; pp 47-62

[28] Udo, E. J., Ibia, T. O. Ogunwale J. A. , Ano, A. O. and. Esu. I. E Manual of soil, plant and water analysis. Lagos: Sibon Books, Publishers Limited., Nigeria, 2009; 183.

[29] Yu-lin, LI, Jing, Duo, C.,Xin-yuan,W. and Xue-yong, Z. Effects of warming on soil nitrogen mineralization under different soil moisture conditions in the horqin sandy grassland. J.Desert Research 2013; 33 (6):1775-1781.

[30] Pakdel, P., Tehranifar, A Nemati, H. Lakzian A.and Kharrazi M.. Effect of different mulching materials on soil properties under semi-arid conditions in north eastern Iran. Wudpecker J. of Agricultural Res. 2013; 2(3):80 –85.

[31] Alharbi, A. Effect of mulch on soil properties under organic farming conditions in center of Saudi Arabia. Scientific proceedings international scientific-technical conference “agricultural machinery” 2017; 2: 230-236

ISSN: 2455-6939

Volume: 06, Issue: 03 "May-June 2020"

[32] Ahmed Z.I., Ansar M., Iqbal M., Minhas N.M. Effect of planting geometry and mulching on moisture conservation, weed control and wheat growth under rain-fed conditions. Pak. J. Bot. 2007; 39: 1189-1195.

[33] Rahman M.J., Uddin M.S., Bagum S.A., Mondol A.T., and Zaman M.M. Effect of mulches on the growth and yield of tomato in the coastal area of Bangladesh under rainfed condition. Int. J. Sustain. Crop Prod. 2006; 1:6-10.

[34] Chavan M.L., Phad, P.R. Khodke U.M. and Jadhav. S.B. Effect of organic mulches on soil moisture conservation and yield of *rabi* sorghum (M-35-1). Internat. J. agric. Eng., 2010; 2 (2): 323-328

