The Journal of Animal & Plant Sciences, 21(3): 2011, Page: 525-530
ISSN: 1018-7081

EFFECTIVENESS OF ORGANIC MULCH ON THE PRODUCTIVITY OF MAIZE (*ZEA MAYS* L.) AND WEED GROWTH

D. F. Uwah and G. A. Iwo

Department of Crop Science, University of Calabar, Nigeria.
Corresponding Author: e-mail: dfu55@yahoo.ca

ABSTRACT

A two-year field experiment was conducted during the dry seasons of 2007/2008 and 2008/2009 on the acidic coastal plain soils of south eastern Nigeria to evaluate the effectiveness of organic mulch on the productivity of maize (*Zea mays* L.) and weed growth. Five mulch rates (0, 2, 4, 6, and 8 t/ha) were laid in a randomized complete block design with four replications. Soil moisture reserves were highest at the 8 t/ha mulch rate, followed by 6 t/ha rate. The unmulched control plots had the highest weed infestation, lowest soil moisture reserves, shortest plants and least number of leaves/plant. Weed infestation at the unmulched plots were higher by as much as more than 6 and 11 times those at 6 and 8 t/ha rates respectively. Plant height and number of leaves/plant were maximized at 8 t/ha rate, while dry stover yield, weight of grains/cob and grain yield/ha peaked at 6 t/ha rate. The grain yield obtained at 6 or 8 t/ha rates was more than double that of the unmulched control plots.

Key words: Growth; Maize; Mulch; Soil moisture; Weed infestation; Yield.

INTRODUCTION

In the humid area of Calabar, south eastern agroecological zone of Nigeria, the soils used predominantly for farming are *ultisols* characterized by their coarse texture and low organic matter content. They are equally low in CEC, with little or no mineral reserves, have low water holding capacity, low pH, highly leached and structurally unstable (Sanchez *et al.,* 1987; Brady and Weil, 1996). Under natural vegetative cover, these soils maintain a close system because plant nutrients are brought from the deeper horizons by tree roots and incorporated in the surface through litter fall. Erosion is held in check by the canopy cover which dissipates rainfall energy, and by the plant residue cover on the floor which halts runoff and soil loss. With the continuous accumulation of these plant residues, organic matter content of the soil is increased which invariably increases the CEC and hence soil fertility is maintained.

However, with the removal of vegetation and subsequently cropping, fertility maintenance becomes a serious problem. The indicators are rapid decline of organic matter and soil nutrients, high soil acidity and erosion which culminate in sharp decline in crop yields. The numerous soil problems are further compounded by the seasonality and erratic distribution of rainfall which results in varying periods of dry spells separated by wet periods (Enwezor *et al.,* 1981). Such dry spells create problems in crop production in that crops are subjected to severe moisture stress which could lead to total crop failure if it coincides with critical growth periods. On the other hand, during periods of heavy rainfall, when field crops have not yet developed sufficient canopy to dissipate raindrop impact, erosion becomes a very serious problem. Furthermore, high temperatures experienced in the area, encourage excessive evapo-transpiration which ultimately leads to severe soil moisture stress.

There is therefore the need to develop farm management practices that would conserve moisture in the soil to tide crops over during periods of dry spells and protect the soil against erosion during erosive storms. Mulching is one of the management practices for increasing water use efficiency and weed control in crop fields (Unger and Jones, 1981). Different types of materials such as wheat straw, rice straw or husk, plastic film, grass, wood, sand, oil layer, etc. are used as mulch (Khurshid *et al.,* 2006; Seyfi and Rashidi, 2007). Mulch provides a better soil environment, moderates soil temperature, increases soil porosity and water infiltration rate during intensive rain and controls runoff and erosion as well as suppresses weed growth (Bhatt and Kheral, 2006; Anikwe *et al.,* 2007; Sarkar and Singh, 2007; Glab and Kulig, 2008). Organic mulches perform additional functions of increasing soil organic matter content, and CEC, enhance biological activity, improve soil structure and increase plant nutrients after decomposition (Tian *et al.,* 1994; Lal, 1995).

Studies carried out in Nigeria and elsewhere have shown that mulches not only conserved soil moisture and prevented erosion they also increased soil fauna and flora activities, suppressed weeds and maintained high crop yields (Kurshid *et al.,* 2006; Anikwe *et al.,* 2007; Seyfi and Rashidi, 2007; Essien *et al.*, 2009). Most studies conducted in Nigeria were in the savanna zones and their findings may not be quite applicable to the humid region due to ecological differences. There is therefore the need to carry out a quantitative evaluation of the influence of mulches on growth and yield of crops in this region. The present investigation was carried out to determine the effect of organic mulch on maize performance and weed suppression in the rainforest agroecology of south eastern Nigeria.

MATERIALS AND METHODS

The experiment was carried out for two consecutive dry seasons (2007/2008 and 2008/2009) at the Teaching and Research Farm of the Department of Crop Science, University of Calabar. Calabar is located along the humid coastal region of south eastern Nigeria (4^o 57^IN, 8^o19^I E; 37m above sea level). This rainforest zone receives about 3000mm to 3500mm rainfall annually during the rainy season which extents from March to November while the dry season is from December to February. The rainfall pattern is bimodal with long (March-July) and short (September-November) rainy seasons separated by a short dry spell of uncertain length usually in August. The mean annual temperature ranges from 27 to 35^{o}C (Harold, 1970; CRBRDA, 1995). The soil is acidic in nature classified as *ultisols,* low in pH, organic matter, nutrient status and usually have multiple nutrient deficiencies (Sanchez *et al;* 1987; Brady and Weil, 1996). The experiments investigated the response of hybrid maize (*Zea mays* L.) variety *Oba super* 2 to five levels of organic mulch (0, 2, 4, 6 and 8t/ha) made up of Ganba grass *(Andropogom gayanus* Kunth var. gayanus). The grass was harvested and oven-dried at 70^{o}C to a constant weight before applying to plots a week after crop emergence.

The experiment was laid out in a randomized complete block design with four replications. The sites were cleared of vegetation with machetes, ploughed and marked out into blocks of 6 plots each. Each gross plot size was 1.5 x 3.0m and the net plot size from which growth and yield attributes were estimated was 1m x 1.5m. Plots were separated by a path of 1m while blocks were kept at a distance of 1.5m between them. Soil samples were collected from the sites at depths 0-30cm during land preparation and analyzed for physico-chemical properties using standard procedures (IITA, 1982) (Table I). Planting was done on flat beds on 4th December in both years. Three seeds were sown per stand with a spacing of 25cm x 75cm and the seedlings were thinned to one per stand two weeks after sowing (WAS) to give 24 plants per plot and 53,333 plants per hectare. NPK 15:15:15 fertilizer at the rate of 400kg/ha was applied by side banding 10cm away from the seedling at two weeks after sowing while urea (46%N) was used for top dressing 7 WAS at the rate of 60kg N/ha, 15cm away from the plants. Manual weeding was done twice at 5 and 9 WAS by hand pulling and hoeing. Harvested weeds from each plot were oven-dried at 70^{o}C to a constant weight for weed dry matter yield determination. The plots were watered twice daily morning and evening with 40 litres of water/plot per day. Soil moisture reserves of plots were monitored gravimetrically every two weeks starting from 3 WAS at 0-15cm depth with soil auger at four different spots in each plot. Samples were bulked, placed in moisture cans, weighed and oven-dried to a constant weight at 105^{o}C. Cobs were harvested at maturity 12 WAS, dried to 12% moisture content and from the eight plants in each net plot area, we determined plant height, number of leaves/plant, dry stover yield, grain weight/cob and grain yield/hectare. Data for each year were subjected to analysis of variance as described in Snedecor and Cochran (1967) and treatment means were compared using Fisher's Least Significant Difference (LSD) at 5% level of probability (Gomez and Gomez, 1984).

RESULTS AND DISCUSSION

Table I shows the nutrient status of the experimental soils during 2007/2008 and 2008/2009. The soils were sandy loam, low in nitrogen (N) and Potassium (K), but high in phosphorus (P). The organic carbon and pH were higher in 2008/2009 than 2007/2008 dry season. The 2007/2008 dry season experienced relatively lower amount of total rainfall (231.3mm as against 292.8mm) and mean relative humidity (79.3% as against 82.8%) than the 2008/2009 season (Table 2). The influence of mulch on percent soil moisture reserves is depicted in table 3. The maximum mean percent soil moisture contents were observed at mulch treatment applied at 8 t/ha in both seasons. At all the sampling periods in both seasons, the control had the lowest percent moisture contents. The tallest plants were obtained with the highest rate of mulch in all sampling periods in both seasons except at 3 WAS in 2007/2008 season where the 6 and 8 t/ha rates produced plants that did not differ significantly (Table 4). This was followed by the 6 t/ha mulch rate that produced significantly taller plants than the others in both years and at all sampling periods. The 0 t/ha rate at all sampling periods in the two seasons produced the shortest plants. The number of leaves per plant was maximized also at 8 t/ha mulch rate in all sampling periods in both seasons while the control produced the least (Table 5).

Influence of mulch on weed infestation is shown in table 6. The unmulched plots had the highest weed infestation while the 8t/ha mulch rate experienced the lowest. The weed suppressive effect at 2, 4 and 6 t/ha mulch rates were statistically similar but significantly higher than that of the control in 2007/2008 season. Similar trend was observed in the 2008/2009 season except that the weed suppressive ability of mulch rates at 4, 6 and 8 t/ha were not significantly different. Averaged over the two seasons, the total weed dry matter yield obtained at the control, was over eleven times higher than the 8 t/ha mulch rate and more than six times above the 6 t/ha mulch rate. Dry stover yield increased significantly with each increment in mulch rate up to the 6 t/ha rate but not further in the two seasons (Table 6). Mean maximum dry stover yield (24.29 t/ha) was obtained at 8 t/ha mulch rate, followed by 21.62 t/ha obtained at 6t/ha mulch rate. The 4 and 2 t/ha mulch rates however, produced 17.82 t/ha and 15.82 t/ha dry stover yield respectively. Increasing the mulch rates from zero to 2, 4, 6 and 8 t/ha resulted in corresponding increases in dry stover yield by 19.0, 34.3, 63.4 and 83.5% respectively.

Weight of grains per cob obtained at 6 and 8 t/ha mulch rates across the seasons were statistically at par but higher than other mulch rates (Table 6). The least weight of grains/cob occurred at the control in both seasons. The total grain yield produced at 2 and 4 t/ha mulch rates were statistically similar but lower than those obtained at 6 and 8 t/ha rates which however, had similar grain yield, but all the mulched plots had higher grain yields than the control in both seasons (Table 6). Across the seasons, the 6 and 8 t/ha rates produced more than twice the total grain yield obtainable from the unmulched control plots.

Table 1: Physico-chemical properties of top soil (0 – 30cm) of experimental fields at Calabar.

Composition	Year	
	2007/2008	2008/2009
Physical composition (g/kg)		
Sand	790	830
Silt	20	40
Clay	190	130
Textural class	Sandy loam	Sandy loam
Chemical characteristics		
pH in H_2O (1:2.5)	5.0	5.5
pH in 0.01m $CaCl_2$ (1:2.5)	4.0	5.0
Organic carbon (g/kg)	11.5	12.3
Available P (mg/kg)	89.4	86.8
Total N (g/kg)	1.2	1.3
Exchangeable bases (cmol/kg)		
Ca	1.2	2.2
Mg	0.5	1.0
K	0.1	0.3
Na	0.1	0.2
CEC	4.6	6.2
Base saturation (g/kg)	413.0	596.8

Table 2: Meteorological data at the trial sites during the dry seasons of 2007/2008 and 2008/2009.

Year/Month	Rainfall	Temperature		Relative Humidity (%)
	Mm	Min	Max	
Dec. **2007**	31.1	23.5	30.5	76
2008				
January	15.1	22.2	31.1	73
February	1.0	23.5	34.1	70
March	184.1	24.2	32.2	86
Dec. **2008**	77.1	23.4	31.6	80
2009				
January	89.7	23.9	32.3	85
February	38.5	24.1	32.8	84
March	87.5	24.6	33.3	82

Source: Nigeria Meteorological Unit (NIMET) Margaret Ekpo International Airport, Calabar.

Table 3: Effect of mulch on soil moisture content (%) in the top 0-15cm in experimental plots in 2007/2008 and 2008/2009 dry seasons at Calabar.

Treatment	3 WAS		5 WAS		7 WAS		9 WAS	
	2007/ 2008	2008/ 2009	2007/ 2008	2008/ 2009	2007/ 2008	2008/ 2009	2007/ 2008	2008/ 2009
Mulch (t/ha)								
0	10.3	14.6	6.6	8.6	9.8	10.4	11.6	12.2
2	14.0	15.5	8.5	10.5	12.4	13.6	12.9	12.8
4	15.1	17.6	9.4	12.4	13.0	15.2	13.8	14.2
6	17.2	21.3	10.8	15.3	16.8	18.9	14.2	16.3
8	20.1	23.6	11.9	17.6	18.5	20.6	15.8	17.9
LSD (0.05)	1.47	2.26	1.48	1.85	2.19	2.15	1.18	1.78

Table 4: Effect of mulch on plant height (cm) of maize in 2007/2008 and 2008/2009 dry seasons at Calabar

Treatment	3 WAS		5 WAS		7 WAS		9 WAS	
	2007/2008	2008/2009	2007/2008	2008/2009	2007/2008	2008/2009	2007/2008	2008/2009
Mulch (t/ha)								
0	35.8	50.8	49.5	76.0	69.9	102.2	98.9	144.9
2	38.6	52.8	60.0	86.9	97.6	149.3	115.3	156.7
4	41.6	57.9	75.2	97.0	119.5	160.6	128.7	165.8
6	43.9	60.5	98.9	119.2	139.5	173.6	151.3	172.8
8	46.1	62.4	106.7	128.4	150.6	196.5	176.7	210.6
LSD (0.05)	2.25	1.62	1.73	1.82	1.54	2.35	3.25	4.41

Table 5: Effect of mulch on number of leaves per plant of maize in 2007/2008 and 2008/2009 dry seasons at Calabar.

Treatment	3 WAS		5 WAS		7 WAS		9 WAS	
	2007/2008	2008/2009	2007/2008	2008/2009	2007/2008	2008/2009	2007/2008	2008/2009
Mulch (t/ha)								
0	5.5	5.9	8.1	8.3	11.6	11.3	11.5	11.9
2	6.3	6.2	8.7	8.4	11.9	11.7	11.9	12.0
4	7.0	7.2	8.8	8.8	12.1	12.3	12.7	13.1
6	7.2	7.2	9.2	9.5	12.3	12.6	12.9	13.5
8	7.7	7.8	9.8	10.0	12.5	12.7	13.1	13.8
LSD (0.05)	0.05	0.21	0.28	0.31	0.20	0.32	0.20	0.33

Table 6: Effect of mulch on weed infestation (t/ha), dry stover yield (t/ha), weight of grains/cob (g) and grain yield (t/ha) of maize in 2007/2008 and 2008/2009 dry seasons at Calabar.

Treatment	Weed infestation (t/ha)		Dry Stover yield (t/ha)		Weight of grains/cob (g)		Grain yield (t/ha)		Grain yield (t/ha)
	2007/2008	2008/2009	2007/2008	2008/2009	2007/2008	2008/2009	2007/2008	2008/2009	Mean
Mulch (t/ha)									
0	1.72	2.45	10.75	15.72	68.83	76.23	1.89	2.43	2.16
2	0.70	1.32	12.51	19.19	86.32	90.42	3.26	3.69	3.48
4	0.64	1.14	14.32	21.32	90.28	105.17	3.88	4.21	4.05
6	0.27	0.34	17.95	25.29	110.20	118.83	5.32	5.72	5.52
8	0.14	0.22	20.25	28.32	113.42	123.24	5.42	5.96	5.69
LSD (0.05)	0.554	0.932	2.710	3.542	4.253	5.723	1.218	1.257	1.238

The growth rate and grain yield of maize were higher in the 2008/2009 trial than the 2007/2008 possibly due partly to the higher amount of rainfall recorded during that season and the fact that the 2008/2009 trial site had higher soil pH, organic carbon, N and K contents than that of the 2007/2008 site. This resulted in higher soil moisture reserves throughout that season and may have accounted for the better crop performance and yield obtained (Tables I and 2). This agree with the findings of Khurshid *et al.,* (2006) who ascribed positive yield response in maize to increased water contents in soils due to reduced evaporation in mulched plots. Highest soil moisture reserves were observed in plots mulched at 6 and 8 t/ha rates throughout the sampling periods. This might be attributed to the fact that the thick mulch layers protected the soil surface against solar radiation thereby reduced evaporation and enhanced favourable moisture storage (Wicks *et al.,* 1994). Lal (1974), working on soils in south western Nigeria, attributed the low soil moisture content in unmulched maize plots partly to high weed infestation.

Plant height and number of leaves per plant were maximized at 8 t/ha mulch rate, while dry stover yield, weight of grains per cob and grain yield per hectare peaked at 6 t/ha mulch rate above which no discernible increases were observed in these attributes. When averaged over the two seasons increases in mulch rates from 0 to 2 t/ha, increased grain yield by 61%, further increase to 4 t/ha, increased yield by 87.5% while a further increase to 6 t/ha, brought about a further increase in yield by 155.6 percent. A much further increase to 8 t/ha however, resulted in only a negligible increase of 7.8% in grain yield. It appears that the 6t/ha rate emerged a better choice than 8t/ha probably due to the phenomenon of decreasing returns. These results are consistent with those of Lal, (1974), Lal (1978), IITA (1983), Wicks *et al.,* (1994), and Lal (1995) who reported that early maize growth was retarded by higher mulch levels as a result of reduced soil temperature but maize grew taller and faster under greater mulch levels subsequently due to increased soil moisture and adequate temperature which stimulated root development and growth. These results are also in consonance with IITA (1983), Bhatt *et al.,* (2004), Khurshid *et al.,* (2006) that mulching with crop residue at the rate of 4 and 6 t/ha not only affected both physical and chemical properties of the soil but also maintained good grain yield. The difference in growth and yield attributes observed between the mulched and unmulched plots may be attributed to the higher soil moisture reserves in the mulched plots since higher soil moisture is known to enhance efficient use of fertilizer while the excellent solar radiation during the growth seasons encouraged higher photosynthetic rates which culminated in the higher yields obtained.

The average weed infestation in maize plots in both seasons showed that each increment in mulch rate, increased weed suppressive ability of mulch up to the highest rate. Essien *et al.,* (2009) showed that the frequency of weeding was more in unmulched than in mulched plots since mulches have the ability to smother weeds depending on their thickness. Lal (1995) observed that mulching reduced weed competition to such an extent that maize grain yields were doubled. Results from this trial are in agreement with these findings as differences in grain yield between the unmulched plots and those at 6 or 8 t/ha mulch rates were more than double (Table 6).

Conclusion: The study has shown that organic mulch has the potential of improving crop growth and yield as well as suppressing weed growth thereby providing a conducive environment for maize production. Our data indicated that optimum performance of maize on the acidic coastal plain soils of Calabar, Nigeria would be achieved by applying organic mulch at 6t/ha during the dry season cropping.

REFERENCES

Anikwe, M. A. N., C. N. Mbah, P. I. Ezeaku and V. N. Onyia (2007). Tillage and plastic mulch effects on soil properties and growth and yield of cocoyam (*Colocasia esculenta)* on an ultisol in south eastern Nigeria. *Soil and Tillage Res*., 93:264-273.

Bhatt, R., K. L. Khera and S. Arora (2004). Effect of tillage and mulching on yield of corn in the submontaneous rainfed of Punjab India. *Int. J. Agric. Biol*; 6 (1):126-128.

Bhatt, R. and K. L. Khera (2006). Effect of tillage and mode of straw mulch application on soil erosion in submontaneous tract of Punjab, India. *Soil and Tillage Res*., 88:107-115.

Brady, N. C. and R. R. Weil (1996). *The nature and properties of soil* (11th ed.) Prentice-Hall Inc. New Jersey, USA, 740pp.

Cross River Basin and Rural Development Authority, (1995). *Cross River Basin News*. A Biennial News Letter, Jan.-Aug. Vol. 1 No. 7.

Enwezor, W. O., E. J. Udo and R. A. Sobulo (1981). Fertility status and productivity of acid sands. In: Acid sands of south eastern Nigeria. Monograph Vol. 1. *Soil Sci. Soc. of Nig*, pp 56-73.

Essien, B. A., J. B. Essien, J. C. Nwite, K. A. Eke, U. M. Anaele and J. U. Ogbu (2009). Effect of organic mulch materials on maize performance and weed growth in the derived savanna of south eastern Nigeria. *Niger. Agric. J*. 40(1):255-262.

Glab, T. and B. Kulig, (2008). Effect of mulch and tillage system on soil porosity under wheat *(Triticum aestivum). Soil and Tillage Res*., 99:169-178.

Gomez, K. A. and A. A. Gomez (1984). *Statistical procedures for Agricultural Research* (2nd ed.). John Wiley and Sons, New York 680pp.

Harold, A. A. (1970). *College Atlas*. Macmillan Publishers Ltd., Lagos, Nigeria.

IITA (1982). *Selected methods of soil and plant analysis.* International Institute of Tropical Agriculture *Manual Series* No. 7 Ibadan. Nigeria.

IITA (1983). *Maize production under no-tillage system*. International Institute of Tropical Agriculture Research Highlight pp30-31, Ibadan, Nigeria.

Khurshid, K., M. Iqbal, M. S. Arif and A. Nawaz (2006). Effect of tillage and mulch on soil physical properties and growth of maize. *Int. J. Agric. Biol.,* 8(5):593-596.

Lal, R. (1974). Soil temperature, soil moisture and maize yield from mulched and unmulched tropical soils. *Pl. Soil,* 40:129-43.

Lal, R. (1978). Influence of within and between row mulching on soil temperature, soil moisture, root development and yield of maize. *Field Crops* 1:127-139.

Lal, R (1995). Tillage and mulching effects on maize yield for seventeen consecutive seasons on a tropical alfisol. *J. Sustain. Agric*., 5:79-93.

Sanchez, P. A., E. R. Stoner and E. D. Pushparajah (1987). *Management of acid tropical soils for sustainable agriculture.* Proc. IBSRAM Inaugural Workshop. Bangkok, Thailand, 107pp.

Sarkar, S. and S. R. Singh (2007). Interactive effect of tillage depth and mulch on soil temperature, productivity and water use pattern of rainfed barley (*Hordium vulgare* L.). *Soil and Tillage Res.,* 92:79-86.

Seyfi, K. and M. Rashidi (2007). Effect of drip irrigation and plastic mulch on crop yield and yield components of cantaloupe. *Int. J. Agric. Biol.,* 9:247-249.

Snedecor, C. W. and W. G. Cochran (1967). *Statistical methods*, Iowa State Uni. Press, USA; 507pp.

Tian, G., B. Kang and L. Brussoard (1994). Mulching effects of plant residue with chemically contrasting composition of maize growth and nutrient accumulation. *IITA Res*., 9:7-11.

Unger, P. W. and R. Jones (1981). Effect of soil water content and a growing season straw mulch on grain sorghum. *J. Soil Sci. Soc. Am*. 45(1):129.

Wicks, G. A., D. A. Crutchfield and O. C. Burnside (1994). Influence of wheat *(Triticum aestivum)* straw mulch and metolachlor on corn (*Zea mays* L.) growth and yield. *Weed Sci*. 42:141-7.