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Effects of Different Mulching Materials and Plant Densities on the Environment, Growth and Yield of Cucumber

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Abstract: *The effects of plastic films and rice hull mulches and plant densities on the environment, growth and yield of cucumber were studied at Abakaliki, in a 4 x 3 factorial experiment in three replications for two cropping seasons. Rice hull mulch had the highest vine length (145.5 cm), leaf area (184.63 cm^2), fruit weight (1.27 kg), fruit length (62.7 cm) and fruit diameter (9.43 cm) better than the unmulched and raised the average daily soil temperature from 28.1^{o}C - 27.4^{o}C, while transparent plastic mulch had the highest number of vine (5.2), number of leaves (32.5), number of fruits (7.98) and made the greatest improvement on the average daily soil temperature (28.8^{o}C). Plant spacing 50 cm x 40 cm gave rise to a profuse branched plants with longer vines (144.7 cm), greater number of leaves (35.2) and leaf area (181.05 cm^2), while fruit length of 20.4 cm and the highest fruit diameter (9.53 cm) resulted from the widest plant spacing of 50 cm x 50 cm. The closest plant spacing (50 cm x 30 cm) consistently produced the lowest values in all the vegetative and yield parameters considered except in fruit weight (1.0 kg). Both mulching and plant spacing are good crop production techniques, are highly recommended for the smallholder farmers of this zone, especially plastic film mulches and medium plant densities for efficient cucumber production and management.*
Keywords: *Plastic mulch, plant spacing, rice hull mulch, soil temperature, cucumber*

I. Introduction

Cucumber (Cucumis sativus L.) is one of the most important highly nutritional and popular member of the Cucurbitaceae family (cucumber, gourd, watermelon, cantaloupes, squash and pumpkins), cultivated for its fresh fruits and pickling (Lower and Edwards, 1986; Thoa, 1998), second after watermelon, fourth after tomato, cabbage and onion in Asia (Tatlioglu, 1997), second after tomato in Western Europe (Phu, 1997). Cucumber is an annual deep-rooted creeping vine crop, but can also grow on trellises or other supporting frames wrapping around with thin spiraling tendrils thereby improving fruit quality, yield and space utilization with large hairy leaves that form canopies over the cylindrical fruits. It is of Indian origin where it has been cultivated for 3000 years, but with new varieties and technologies, is now cultivated everywhere (warm and cool climates between 16^{0}C and 30^{0}C, but grows best during periods of warm nights and days) as field and green house crops (artificial conditions) and adapts to wide range of slightly acidic soil with good drainage. High temperature causes light green colour and bitterness in the fruits, but low humidity is best due to lower incidence of both foliar and fruit disease and needs water during blossoming and fruiting as moisture stress could cause blossom abortion (Cobel and Gosselin, 1990).

To be competitive in today's market place, plasticulture is a management tool that enables vegetable growers realize greater returns per unit land (Lamont, 1999), such as earliness of harvesting, higher yields per unit area (two to three times higher), cleaner and higher quality produce, more efficient use of water resources, reduced leaching of fertilizers especially on light sandy soils, more efficient use of fertilizer input through fertigation technology, reduced soil and wind erosion, potential decrease in the incidence of disease, better management of certain insect pests, fewer weed problem, reduced soil compaction and elimination of root pruning and opportunity for extended production cycles (double- or triple-cropping) with maximum efficiency (Marr and Lamont, 1992; Lamont and Poling, 1986). Plastic mulches have been used commercially on vegetables since the early 1960s to modulate the micro climate around the plant by modifying the radiation budget (absorbitivity vs. reflectivity) of the surface and decreasing the soil water loss, especially black and clear plastic films (Liakatas et al., 1986; Tanner, 1974) on soil and air temperature, moisture retention and vegetable yields (Emmert, 1957). A notable snag of this technology is the non biodegradable nature of the film sheets in current use until biodegradable films become available.

On the other hand, organic mulch materials such as grain straw, fresh or old hay, freshly-cut forage or cover crops, chipped brush, wood shavings, tree leaves, cotton gin waste, rice or buck wheat hulls, and other crop residues used as mulch are biodegradable, and if properly utilized, perform all the benefits of any mulch (soil and water conservation, enhanced soil biological activity and improved chemical and physical properties of the soil (Cooper, 1973; Murugan and Gopinath, 2001) with the exception of early season soil warming. However, its snag includes unavailability in adequate quantities at the place of use, hence must be transported to the place of need, and requires considerable manual labour spreading them, its decomposition may temporary reduce mineral nitrogen but, the natural phytotoxins released during decomposition may inhibit weed growth and crop plants (Wallace and Bellinder, 1992). All these may hamper yield of the crop to some extent, except some cautionary measures are taken.

Plant spacing is one of the important factors of crop production, because appropriate spacing of crops makes for efficient use of space and reduction of competition among plants with the same cultural requirements, enriches the nutrient content of the soil, repels pests and provides shade, improves the micro climate with reference to wind and moisture (Nguyen, 1989) and enhances the interaction between beneficial micro organisms within the rhizosphere of the soil (Nnoke, 2001). Lower and Edward (1986) observed that an increase in plant population usually results in reduction of size of plant frame and increases the overlapping of vines between rows. Many researchers reported the importance of selecting the optimum plant density for improving cucumber growth and yield (Hanna et al, 1991; Adams et al, 1993; Wanna et al, 1993; Akintoye et al, 2002; Choudhari et al, 2002; Ylimaz et al, 2002; El-Shaikh, 2002).

II. Materials And Methods

2.1 Description of the experimental site

Field experiments were carried out at the experimental farm of Faculty of Agriculture and Natural Resources Management, Ebonyi State University, Abakaliki, in the Southeastern zone of Nigeria for two cropping seasons from 2012 - 2013. The site is located at latitude 06^0 19` 407`` N and longitude 08$^0$ 07` 831`` E at an elevation of 447 m above sea level, in an area of 30.5m x 9m (274.5m^2). Clearing was manually done and thirty six (36) raised flat beds measuring 2m x 2m were constructed into three blocks of twelve plots separated by 0.5 m space, while 1m separated blocks.

2.2 Experimental design

The experiment design was a 4 x 3 factorial laid out in a Randomized Complete Block Design (RCBD) in three replications. Factor A was four mulching materials (transparent plastic mulch, black plastic mulch, rice hull mulch and a control), while factor B was three plant spacing [(50cm x 50cm (40,000 plant stands), 50cm x 40cm (50,000 plant stands) and 50cm x 30cm (66,666 plant stands)] to give a total of twelve treatment combinations. Cucumber variety ''Marketer'' was sown at the designated different plant populations two seeds per hole at a depth of 1.5cm to give plant stands per 4 m^2 bed of 16, 20 and 27, a blanket fertilizer application of compound of nitrogen, phosphorus and potassium (NPK 15:15:15) was made at the rate of 60 kg/ha (or 24 g/4m^2 i.e. 160 g of NPK 15:15:15) to augment the native soil fertility. Insects such as Zonocerus variegatus, lady bird beetle, etc. were controlled by the application of Pymethrin 0.60% powder and wood ash at the rate of 0.1kg or 100g/bed which gave a total of 3600 g (3.6 kg) at 1st to 6th weeks after sowing. Weeds were removed three times from the second week after planting. Harvesting of fruits commenced nine weeks after planting by hand picking when the dull green colour on the fruits changed to glossy green. The daily soil temperatures were measured using a 120^{o}C capacity thermometer in the morning (0630 GMT or 7.30 AM) and evening (1500 GMT or 4.00 PM) at two depths (15cm and 30cm) from the third week after planting to the first harvest. Days to 50% flower initiation (anthesis), vine length (cm) from the base of the plant to the terminal bud to the first harvesting, number of leaves per plants to the first harvest, number of branches per plant to the first harvest, leaf area (cm^2) per plant using graph method at first harvest, number of fruits per plot at each harvest, fruit weights (kg) per plot at each harvest, length of fruits (cm) per fruit with a measuring rule at each harvest and fruit diameter (cm) at the middle of the fruit where it is thickest using calipers.

2.3 Data analysis

All the data collected were statistically analyzed using the analysis of variance (ANOVA) procedure outlined by Steel and Torrie (1980) for factorial experiment, while separation of treatment mean effects was done using the Fisher's least significant difference (F-LSD) as illustrated by Obi (1986).

III. Results

Different mulching materials (Table 1) significantly ($p<0.05$) influenced both the morning (06.30GMT) and evening (16.00GMT) soil temperatures at both 15 cm and 30 cm depths and the average daily temperatures. The highest soil temperature (28.8^{0}C) was recorded under transparent plastic mulch (TPM) followed by black plastic mulch (BPM), and zero mulch, while the lowest soil temperature of 27.4^{0}C was obtained from the rice hull mulch (RHM). TPM had the greatest influence on the soil temperature more than other mulching materials in the evening periods (30.6^{0}C at 15cm and 29.3^{0}C at 30cm) and in the morning (27.7^{0}C at 15cm and 27.6^{0}C at 30cm), followed by BPM, the un-mulched soil, while the lowest came from the RHM.

Table 1: Modulating influence of different mulching materials on daily soil temperature (°C)

Mulches	Morning (06.30GMT)		Evening (16.00GMT)		Daily average
	15cm	30cm	15cm	30cm	
Zero mulch	26.8	27.2	29.7	28.6	28.1
TPM	27.7	27.6	30.6	29.3	28.8
BPM	27.2	27.5	29.9	28.4	28.3
RHM	26.4	26.8	28.6	27.9	27.4
F-LSD (P=0.05)	0.20	0.19	0.22	0.15	

KEY: TPM = Transparent plastic mulch, BPM = Black plastic mulch, RHM = Rice hull mulch

Mulching materials significantly ($p<0.05$) influenced two of the four growth parameters of cucumber (number of vines and length of vine) in Table 2. The highest number of vine was recorded from TPM plots (5.2cm), while the least number (4.0cm) was obtained from zero mulched plots. The longest vine per plant (145.5cm) was recorded from RHM plots, followed by TPM with (129.7cm), BPM with (125.8cm), and the least (124.7cm) was from zero mulched plots. Number of leaves and leaf area were not significant, although, the highest number of leaves (32.5) was recorded from transparent plastic mulched plots, while the largest leaf area (184.6cm^2) was obtained from the RHM, followed by TPM (178.9cm^2), BPM (175.0cm^2), and the least was from the zero mulched plots.

Table 2: Effect of different mulching materials on growth parameters of cucumber

Mulch	Number of leaves	Leaf area (cm^2)	Number of vine	Vine length (cm)
Zero mulch	31.1	170.8	4.0	124.7
TPM	32.5	178.9	5.2	129.7
BPM	32.1	175.0	4.3	125.8
RHM	31.2	184.6	4.3	145.5
F-LSD (p=0.05)	Ns	Ns	0.53	9.29

KEY: TPM = Transparent plastic mulch, BPM = Black plastic mulch, RHM = Rice hull mulch.

Plant spacing significantly ($p<0.05$) promoted all the growth parameters of cucumber (Table 3). The highest number of leaves (35.2), the largest leaf area (187.2cm^2), the highest number of vine (5.1) and the longest vine length (144.7cm) were obtained from plant spacing 50 cm x 40 cm, followed by 50 cm x 30 cm (31.4 leaves, 174.8 cm^2 leaf area, 4.3 vines and 125.3 cm vine length/plant), while the least was obtained from plant spacing 50cm x 50cm in the same order.

Table 3: Effect of plant spacing on growth parameters of cucumber

Spacing	Number of leaves	Leaf area (cm^2)	Number of vine	Vine length (cm)
50cm x 30cm	28.7	170.0	4.0	124.3
50cm x 40cm	35.2	187.2	5.1	144.7
50cm x 50cm	31.4	174.8	4.3	125.3
F-LSD (p=0.05)	3.57	14.09	0.62	10.72

Mulching materials significantly ($p<0.05$) influenced the yield parameters (weight of fruits (kg) and days to 50% flowering) of cucumber (Table 4). The weight of fruits produced under RHM (1.27 kg) and TPM (1.07 kg) was heavier than those under BPM (0.87 kg) and under zero mulch (0.67 kg). The earliest bud break (27.8 days to 50% anthesis) was recorded on the rice hull mulched and zero mulched plots, while the highest number of days (32.0) was recorded on TPM and BPM (29.2 days). Number of fruits, fruit length (cm) and fruit diameter (cm) were not significant, although the highest number of fruits (9.2) was obtained from transparent plastic mulch, followed by black plastic mulch (7.8) and rice hull mulch (6.3), while the least (5.5) was obtained from zero mulched plots. The longest fruit (20.7 cm) was obtained under RHM and under TPM (20.6 cm).

Table 4: Effect of different mulching materials on yield parameters of cucumber

Mulches	No. of fruits	Wt of fruits (kg)	Fruit length (cm)	Fruit diameter	Days to 50% anthesis
Zero mulch	5.5	0.7	20.0	9.33	27.8
TPM	9.2	1.1	20.6	9.40	32.0
BPM	7.8	0.9	20.3	9.36	29.2
RHM	6.3	1.3	20.7	9.43	27.8
F-LSD (p=0.05)	Ns	0.15	Ns	Ns	2.12

KEY: TPM = Transparent plastic mulch, BPM = Black plastic mulch, RHM = Rice hull mulch

The three plant spacing experiment on cucumber yield (Table 5) did not significantly ($p<0.05$) influence all the yield parameters of cucumber except fruit diameter (cm) with the largest fruit diameter (9.53cm) obtained from the widest plant spacing (50cm x 50cm). Plant spacing had no significant effect on number of fruits produced, weight of fruits (kg), length of fruit (cm) produced and days to 50% flowering of the cucumber crop used. The longest time bud break was obtained at 50cm x 40cm while the shortest time to flowering was recorded on 50cm x 30cm (28.7days).

The interaction effect of mulching materials x plant spacing on the number of leaves per cucumber plant (Table 6) significantly ($p<0.05$) increased the number of leaves more than their separate effects. The number of leaves was more where 50cm x 40cm plant spacing was mulched with BPM (39.0) and with TPM (36.4), followed by black plastic mulch with the widest plant spacing (34.9). The medium plant spacing (50cm x 40cm) had the highest mean number of leaves (35.2) followed by 50 cm x 50 cm with 31.4 leaves and 50 cm x 30 cm with 28.7 leaves. Although, mulching did not significantly ($p<0.05$) improve the mean number of leaves, yet TPM had the highest mean number of leaves (32.5), followed by BPM (32.1), while RHM and zero mulched pots had a uniform mean number of leaves (31.0).

Table 5: Effect of plant spacing on yield parameters of cucumber

Spacing	No. of fruit	Fruit wt.(kg)	Fruit length (cm)	Fruit diameter(cm)	Days to 50% anthesis
50cmx30cm	7.15	1.0	20.1	9.25	28.9
50cmx40cm	7.98	0.98	20.4	9.38	30.0
50cmx50cm	6.48	0.93	20.8	9.53	28.7
F-LSD p=0.05)	Ns	Ns	Ns	0.18	Ns

Table 6: Mulching x plant spacing interaction effect on number of leaves

Mulches	Plant spacing			
	50cm x 30cm	50cm x 40cm	50cm x 50cm	Mean
Zero mulch	31.6	31.2	30.6	31.1
TPM	28.6	36.4	32.6	32.5
BPM	22.4	39.0	34.9	32.1
RHM	32.1	33.9	27.5	31.2
Mean	28.7	35.2	31.4	

KEY: TPM = Transparent plastic mulch, BPM = Black plastic mulch, RHM = Rice hull mulch
F-LSD ($p=0.05$) = Ns for comparing two mulching means
F-LSD ($p=0.05$) = 3.57 for comparing two spacing means
F-LSD ($P=0.05$) = 5.65 for comparing two mulching x spacing interaction means

Mulching materials x plant spacing interaction on number of vines per plant (Table 7) significantly ($p<0.05$) improved the number of vines of cucumber plant, where TPM combined with the widest spacing (50cm x 50cm) to produce the highest number of vines per plant (5.8), followed by rice hull mulched plot with 50 cm x 40 cm (5.4 vines). However, plant spacing of 50cm x 40cm produced the highest mean number of vines (5.1), while the lowest mean number of vine was obtained from 50cm x 30cm plant spacing (4.0). The TPM consistently produced the highest mean number of vines (5.2), while other mulched and unmulched plots produced a uniform mean number of vines (4.0).

The interaction effect of mulching materials x plant spacing on the vine length of cucumber (Table 8) significantly ($p<0.05$) influenced the vine length per plant of cucumber. The longest vine length (161.5cm) was obtained at the interaction of RHM and the narrowest plant spacing (50cm x 30cm), followed by 151.8cm obtained at the interaction of zero mulch with 50cm x 40cm. The mean vine length of 144.7cm was produced at the medium plant spacing 50cm x 40cm, while the mean vine length of 145.5cm was obtained from RHM. The shortest mean vine length was obtained from the zero mulched plots (124.7cm) and from the closest plant spacing 50cm x 30cm (124.3cm).

Table 7: Mulching x plant spacing interaction effects on number of vines

Mulches	Plant spacing			
	50cm x 30cm	50cm x 40cm	50cm x 50cm	Mean
Zero mulch	3.3	4.8	4.0	4.0
TPM	4.8	4.9	5.8	5.2
BPM	3.4	5.2	4.3	4.3
RHM	4.3	5.4	3.2	4.3
Mean	4.0	5.1	4.3	

KEY: TPM = Transparent plastic mulch, BPM = Black plastic mulch, RHM = Rice hull mulch
F-LSD ($P=0.05$) = 0.53 for comparing two mulching means
F-LSD ($P=0.05$) = 0.62 for comparing two spacing means
F-LSD ($P=0.05$) = 0.30 for comparing two mulching x spacing interaction means

Table 8: Mulching x plant spacing interaction effect on vine length (cm) of cucumber

Mulches		Plant spacing		
	50cm x 30cm	50cm x 40cm	50cm x 50cm	Mean
Zero mulch	98.2	151.8	124.2	124.7
TPM	125.9	148.3	115.0	129.7
BPM	111.6	133.6	132.1	125.8
RHM	161.5	145.2	129.9	145.5
Mean	124.3	144.7	125.3	

KEY: TPM = Transparent plastic mulch, BPM = Black plastic mulch, RHM = Rice hull mulch
F-LSD (P=0.05) = 9.29 for comparing two mulching means
F-LSD (P=0.05) = 10.72 for comparing two plant spacing means
F-LSD (P=0.05) = 5.36 for comparing two mulching x spacing interaction means

Mulching materials x plant spacing interaction effect on fruit weight of cucumber (Table 9) significantly ($p<0.05$) improved the weight of cucumber plant. The weight of fruits was more where 50cm x 30cm spacing combined with RHM (1.3kg) and where RHM combined with 50cm x 40cm (1.3kg). Plant spacing alone (50cm x 30cm) did improve the mean weight of fruits better than other plant spacing evaluated although, the improvement was not significant. RHM had the highest mean number of fruits (1.27kg), followed by TPM (1.07kg).

Table 9: Mulching x plant spacing interaction effect on fruit weight (kg) of cucumber

Mulches		Plant spacing		
	50cm x 30cm	50cm x 40cm	50cm x 50cm	Mean
Zero mulch	0.6	0.9	0.5	0.67
TPM	1.0	1.2	1.0	1.07
BPM	1.1	0.5	1.0	0.87
RHM	1.3	1.3	1.2	1.27
Mean	1.0	0.98	0.93	

KEY: TPM = Transparent plastic mulch, BPM = Black plastic mulch, RHM = Rice hull mulch
F-LSD (P=0.05) = 0.15 for comparing two mulching material means
F-LSD (p=0.05) = Ns for comparing two plant spacing means
F-LSD (P=0.05) = 0.08 for comparing two mulching x spacing means

The effect of mulching materials x plant spacing interaction on fruit diameter per cucumber plant (Table 10) significantly ($p<0.05$) increased the diameter of fruits more than their separate effects. The diameter of fruits was more where 50cm x 50cm plant spacing combined with TPM (9.9cm) and where RHM combined with 50cm x 50cm (9.6cm). Plant spacing alone (50cm x 50cm) did improve the mean diameter of fruits better than other plant spacing evaluated. Although, different mulching materials did not significantly ($p<0.05$) improve the mean diameter of fruits, RHM had the highest mean fruit diameter (9.43cm), followed by TPM (9.4cm).

Table 10: Mulching x plant spacing interaction on fruit diameter of cucumber

Mulches		Plant spacing		
	50cm x 30cm	50cm x 50cm	Mean	50cm x 40cm
Zero mulch	9.5	9.3	9.2	9.33
TPM	9.1	9.2	9.9	9.4
BPM	9.3	9.4	9.4	9.36
RHM	9.1	9.6	9.6	9.43
Mean	9.25	9.38	9.53	

KEY: TPM = Transparent plastic mulch, BPM = Black plastic mulch, RHM = Rice hull mulch
F-LSD (p=0.05) = Ns for comparing two mulching means
F-LSD (P=0.05) = 0.09 for comparing two plant spacing means
F-LSD (P=0.05) = 0.18 for comparing two mulching x plant spacing means

IV. Discussion

5.1 Soil temperature measurement

The effect of different mulching materials on the daily average soil temperature was strongly influential in both morning (06.30GMT) and evening (16.00GMT) periods at both 15 cm and 30 cm depths. This is consistent with the findings of Schales and Sheldrake (1963) who observed that soil temperature under a plastic mulch depends on the thermal properties (reflectivity, absorbitivity or transmittancy) of a particular material in relation to incoming solar radiation. They indicated that clear plastic film mulch is usually covered with condensed water droplets underneath which is transparent to incoming short wave radiation but is opaque to outgoing long wave infrared radiation. They too observed that much of the heat lost to the atmosphere from a bare soil by infrared radiation is retained by clear plastic mulch thus day time soil temperatures under clear plastic mulch are generally 4.8^0C higher at a 5cm depth, and 3.5^0C higher at a 10cm depth, compared to bare soil. Transparent plastic mulch absorbs little solar radiation but transmits 85-95%, though this depends on the thickness and degree of opacity of the polyethylene and allows the penetration and transmission of light energy in the soil. This is probably the reason why transparent plastic film is used in solarization (sterilizing) of the soil as it generates enough heat to kill soil pathogens, especially, nematodes, fungi, etc. (Messian, 1992). Transparent plastic mulch is therefore recommended in such seasons and locations experiencing low soil temperatures, whereas the black plastic mulch would be preferred in the absence of the transparent films or where the temperature is warmer.

On the other hand, the low soil temperature recorded under the rice hull mulch may be attributed to the fact that it retains moisture better than others on the soil surface because of latent heat of vaporization. Perhaps, if the soil temperature is measured in the afternoon, the temperature may be higher when the water must have reached steaming point, which cools off in the evening (16.00GMT). The bare soil in the evening may still retain heat within the soil particles, which was why it felt hotter and produced higher temperature than rice hull mulch. Under black plastic mulch during the day time, soil temperatures are generally 2.8^0C higher at a 5cm depth and 1.7^0C higher at a 10cm depth, compared to those of bare soil. Ham and Kluitenberg (1994) found that the degree of contact between the mulch and soil (thermal contact resistance), can greatly affect the performance of mulch. Plant density has no effect on soil temperature and was not reported.

5.2 Vegetative growth

Mulching significantly promoted vegetative growth over the non-mulching treatment. The mulched plots produced plants with greater number of vines, number of leaves, leaf area and vine length. This may be as a result of the good environment modulation potentials of mulching technology. Stable moisture content and well textured soil leading to unrestricted expanded root growth and subsequent increase in nutrient absorption. This observation confirms the report of Ba (1992) who found that the non- mulched plots produced cucumber plants with the least plant height, number of branches, flowers, and fruits. Menezes et al. (1974), Chung (1987) and Aliudin (1986) reported that mulches conserved more soil moisture, enhanced vegetative growth and yield contributing characters of garlic. Black polyethylene mulch significantly improved plant height, number of branches, flower size and yield (Arora et al., 2002). Grass-mulched soil maintained high moisture content to a depth of 60cm and Hatfield et al. (2001) reported a 34-50% reduction in soil water evaporation (Adeoye, 1984), crop residues (grasses, lantana leaves, sorghum, cotton and maize stubbles) as mulches reduces moisture losses, irrigation requirement (Anonymous, 2003) slows surface runoff (Rathore et al., 1998), caused bell pepper (Capsicum annum cv. California wonder) perform better at water deficits from 25% to 75% and enhanced high water use efficiency (Thakur et al., 2000). Liu et al. (2002), Chawla (2006), Khurshid et al. (2006) and Muhammad et al. (2009) agreed that mulching improves the ecological environment of the soil, increases soil water contents, reduces infiltration rate, increases the total intake of water due to formation of loose soil surface, reduces sealing of soil particle pores, reduces wind and water erosion and weed problems, decomposed crop residue improves soil aggregation, fertility and increases crop yields (Gupta, 1985; Gupta and Gupta, 1986; Vander et al., 1986; Bennett et al., 1966; Mahrer et al., 1984; Clough et al., 1990; Mitsuo and Le, 1978; Van Derwerken and Wilcox, 1988; Erenstein, 2002) and conserves higher soil moisture up to 55% (Rajput and Singh, 1970; Black, 1973; Koni, 1983; Abu-Awwad, 1998; Abu-Awwad, 1999). Plant spacing of 50cm x 40cm produced the longest vines, highest number of leaves, leaf area and number of vines. The closest plant spacing (50cm x 30cm) consistently gave least values in all vegetative parameters measured.

5.3 Yield parameters

The mulched plants consistently produced the highest number of fruits, diameter of fruits, fruit weight, length of fruit and days to 50% anthesis. Dygima and Demkouma (1986) reported black polyethylene mulch on egg plant and tomato yielding 3.3 times and 2.3 times higher than without mulch since it creates good environment for crops (Thakur et al., 2000).

The highest fruit length and diameter of fruits was obtained at plant spacing of 50cm x 50cm, while the number of fruits was highest at 50cm x 40cm and fruit weight was highest at the closest spacing (50cm x 30cm), the diameter of fruit and length of fruit increased as the plant spacing increased while weight of fruit decreased as the plant spacing increased from 50cm x 30cm, 50cm x 40cm to 50cm x 50cm. Kultur et al. (2001) observed that the number of fruits yield per plant and average fruit weights were higher with wider spacing (36,300 plants/ha) than closer (75,600 plants/ha), but yield and fruit number per hectare were lower with muskmelon (Paulo et al., 2003; Ogden, 1970; Ford, 1975; Windle and Franz, 1979). Increased plant density has also been shown to decrease cucumber yield decades ago (Kira et al., 1953; Shinozaki and Kira, 1961). Gebologlu and

Saglam (1997) got the highest fruit yield from 20cm within row spacing. Our findings disagree with Evan (1982) with closer plant spacing (75cm x 30cm) giving significant higher yield than wider plant spacing of (75cm x 40cm). Nerson (2005) found both fruit and seed yields increase with increasing plant population, while Pham (1990) got the highest yield (57 t/ha) from 80cm x 45cm with cucumber and Luiz et al. (1994) got the highest total and marketable yield of watermelon from 2.0m x 1.5m plant spacing.

V. Conclusion

The results of the experiment showed that the soil temperature of crop growing environment, vegetative and yield parameters of cucumber were significantly improved by the application of different mulches and plant densities. It is therefore recommended that famers in Abakaliki and its environs who may wish to embark on small and medium scale production of cucumber should adopt the plant spacing of 50cm x 40cm (50,000 plants per hectare) and/ or with mulching practices especially, the cheaper rice hull mulch for maximum yield of cucumber.

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