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Impact of Different Mulching Materials on the Growth and Yield of Watermelon (*Citrullus lanatus)* in Abakaliki, Southeastern Nigeria

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Abstract
Field trials were carried out in 2009 and 2010 dry season plantings to evaluate the effects of different mulching materials on the growth and yield of watermelon in Abakaliki, South eastern Nigeria, in a 2 x 5 factorial experiment arranged in a randomized complete block design (RCBD) in three replications. Factor A consisted of two watermelon cultivars (koalack and sugar baby), while factor B was five different mulching materials (black plastic mulch, transparent plastic mulch, rice hull mulch, grass mulch and a control). The plots were irrigated twice daily (morning and evening) enough to make moisture available for the plants. Sugar baby cultivar performed better than koalack. All the mulching materials were significantly ($p<0.05$) different from the control on all the growth and yield parameters. However, rice hull mulch was better in enhancing watermelon performance, followed by transparent plastic mulch, then black plastic mulch, while the least came from the control. On the other hand, the treatments generally increased moisture content which also increased the crop yield over the control.
Keywords: Watermelon, mulch, moisture, growth and yield parameters.

1. Introduction

Vegetable crop production is on the increase all over the world both in urban, peri-urban and rural areas as the majority of people (vegetarians and vegans) are seeking for solutions in plants and herbs to the myriads of human ailments assaulting the dignity of man. Nigeria has favourable ecological conditions for enough production of vegetables for her growing human populations, but the resource poor farmers are facing serious problems of price fluctuations, inclement weather conditions such as dry spell, moisture shortage, high temperature and solar radiation regimes, glut due to poor storage conditions, biotic and abiotic stresses, scourge of high pest and disease incidence, physiological disorders such as fruit crack and sun scotch, all of which affect vegetable crop production in Nigeria (Uzo, 1983, FAO, 1988). In view of this, some cultural practices such as mulching is used to regulate the soil temperature, moisture content, weeds, pests and diseases control. It is known that plant development and yield increase occur with balance of soil temperature when there are differences between night and day time temperatures, in which mulching plays great role, to increase yields, promote early harvest, reduce fruit defects, reduce evaporation from the soil surface, prevent weed growth, modify soil temperature and reduce insect number in vegetable production (Splilittstoesser, 1990), the effectiveness of which depends on the type of mulching materials used.

In this region, soil moisture is generally limited and crop growth is stressed by drought during the growing season, resulting in decreased and unsustainable crop yield (Li, 2003). Many researchers investigated mulch application on different vegetable species such as tomato (Arin and Ankara, 2001), eggplant (Carter and Johnson, 1998), watermelon (Brinen and Locascio, 1979, Farios-Larios and Orozco-Santoz, 1997, Libik and Swiek, 1994, in different parts of the world. Development of new technologies and especially application of polyethylene films as mulch have enhanced yield (Brinen, 1979). These days, usage of polyethylene films and fertigation are widely adopted by commercial production of watermelon (Sanders and Schltheis, 1999, McCann *et al*., 2007, Romic *et al*., 2003). Different mulching materials have different effectiveness for enhancing performance because of their different capacities in absorbing moisture due to their aggregate nature in allowing air circulation (Carlson and Wilson, 1997; Mozunder *et al*., 2005), while others have detrimental effects including higher occurrence of pests and reduced agronomic performance of the crops (Khan *et al*., 2005). Rweyemamu *et al*. (1998) reported that mulching was effective in controlling weeds and emphasised that rice hull mulch was more effective than dry grass mulch. According to studies by Carlson and Wilson (1997), baggase and chopped palm fronds were the best in controlling weeds, while juniper and blue spruce had adverse effects on Bermuda weed without affecting production of tomato and radish. On the other hand, pine mulch was not recommended for use in tomato due to its adverse effects on soil pH, tomato health and production. It is therefore, important to investigate the relative effectiveness of mulch types on environmental and micro-climate conditions, vegetable production, net revenue generation and production costs reduction for possible recommendation and use by the farmers. Soil mulching with plastic films is very beneficial because cucurbits, watermelon being one of them, are very shallow rooting and do not like being hoed (Messiaen, 1992). Against

this backdrop therefore, the objective of this research was to test the effects of available, affordable mulching materials in this zone on the growth and yield of watermelon.

2. Research methods

Experiments were conducted at the research farm of the Faculty of Agriculture and Natural Resources Management, Ebonyi State University, Abakaliki, during the dry season of 2009 and 2010. The treatments were five mulching materials (transparent plastic mulch (TPM), black plastic mulch (BPM), dry grass mulch (DGM), rice hull mulch (RHM) and a control) and two common local watermelon varieties (koalack and sugar baby) grown in Nigeria, which were organized in a factorial experiment arranged in a randomized complete block design (RCBD) in three replications. Each replication contained ten (10) plots giving a total of 30 plots in the experiment, each plot measured 4 x 4 m (8 m^2) allowing 0.5 m between adjacent plots, while 1.0 m separated each replicate or block. Flat beds were used and were manually prepared using the large West African dwarf hoe, while seeds were sown at 2-3 cm depth, 4 x 4 m apart starting at the end of January each year. Weeds were removed as at when required by hand picking especially on the control plots and dry grass mulched plots during the crop growing periods. The vegetative growth and yield parameters were measured and recorded, while the data collected were analysed using the General linear Model in Minitab and the treatment means were compared using Turkey´s test while the residual effects of treatments were also tested using Anderson Darling´s test.

3. Results

The number of branches produced by the two watermelon varieties were significantly ($p<0.05$) influenced by the type of mulches used in both 2009 and 2010 (Table 1). Sugar baby consistently maintained the highest number of branches in 2009 (7.07) and 2010 (8.07) than koalack which produced 5.20 branches in 2009 and 7.33 in 2010. Black plastic mulch influenced the highest number of branches (8.00), followed by transparent plastic mulch (6.83), then grass mulch (6.50) in 2009, whereas in 2010, it was rice husk that influenced the highest number of branches (9.83), followed by transparent plastic mulch (8.67), then by black plastic mulch (8.00). However, sugar baby responded better to black plastic mulch (10.00) branches, followed by transparent plastic mulch (8.33) branches in 2009, and also had the highest number of branches under rice husk (10.00) and koalack (9.67), followed by transparent plastic mulch (9.00) in 2010. Mulching materials generally influenced significant number of branches in the two varieties. Plots unmulched showed the least number of branches of all the number obtained from other treatments.

Table 1: Effect of mulching materials on the number of branches of the two watermelon varieties during 2009 and 2010 dry season plantings.

		Varieties		
Year	Treatments	Sugar baby	Koalack	Mean
2009	Mulching Materials			
	Control (zero)	3.33b	3.33b	3.33B
	Black plastic	10.00a	6.00a	8.00A
	Grasses	7.33a	5.67a	6.50A
	Rice husk	6.33a	5.67a	6.00A
	Transparent plastic	8.33a	5.33a	6.83A
	Mean	7.07a	5.20a	
	SE±	SE_V=1.42	SE_M=0.90	SE_{MV}=2.01
2010	Control (zero)	6.00d	5.67d	5.83E
	Black plastic	8.67c	7.33b	8.00C
	Grasses	6.67d	5.67d	6.17D
	Rice husk	10.00a	9.67a	9.83A
	Transparent plastic	9.00b	8.33b	8.67B
	Mean	8.07a	7.33a	
	SE±	SE_V=0.31	SE_M=0.19	SE_{MV}=0.43

Treatments are significantly different if they do not share a letter (s) in common at adjusted P value <0.05

High significant influence on the leaf area index (LAI) was obtained in the two varieties from the mulching materials used in the experiments (Table 2). Koalack exhibited the largest LAI of 1.03 in 2009, while sugar baby was largest in 2010 (1.09). Rice husk influenced the largest LAI of 1.86 in 2009, followed by transparent plastic

mulch (1.00), whereas only under rice husk LAI reached 1.16. However, koalack in 2009 dry season planting achieved the highest LAI of 2.71 under rice husk and sugar baby attained a LAI of 1.06, 1.00 and 1.28 under black plastic mulch, rice husk and transparent plastic mulch respectively, while in 2010, koalack and sugar baby attained 1.04 and 1.27 under rice husk. Sugar baby also attained an equal LAI of 1.06 under the control and black plastic mulch and 1.08 under transparent plastic mulch in 2010.

Table 2: Effect of mulching materials on the leaf area index (LAI) of two watermelon varieties during 2009 and 2010 dry seasons.

		Varieties		
Year	Treatments	Sugar baby	Koalack	Mean
2009	Mulching Materials			
	Control (zero)	0.5b	0.59b	0.57B
	Black plastic	1.06b	0.67b	0.87B
	Grasses	0.96b	0.45b	0.71B
	Rice husk	1.00b	2.71a	1.86A
	Transparent plastic	1.28ab	0.71b	1.00B
	Mean	0.97a	1.03a	
	SE±	SE_V=0.37	SE_M=0.23	SE_{MV}=0.52
2010	Control (zero)	1.06ab	0.67b	0.87A
	Black plastic	1.06ab	0.92ab	0.99A
	Grasses	0.96ab	0.79ab	0.88A
	Rice husk	1.27a	1.04ab	1.16A
	Transparent plastic	1.08ab	0.71ab	0.89A
	Mean	1.09a	0.83a	
	SE±	SE_V=0.15	SE_M=0.10	SE_{MV}=0.22

Treatments are significantly different if they do not share a letter (s) in common at adjusted P value<0.05.

The result in Table 3 shows that the different mulches significantly (P<0.05) influenced the vine length of the two watermelon varieties in the experiment. The first planting year 2009, seemed to be more favourable for the two watermelon varieties in that sugar baby and koalack exhibited flourishing long vines than in 2010. The longest vine length of 195.3cm was produced by sugar baby variety and koalack had also long vines up to 172.2cm, whereas in 2010, koalack had only 69.47cm and sugar baby had just 74.73cm. The longest vine length of 262.3cm was recorded from rice husk mulch, followed by transparent plastic mulch (201.3cm), while the shortest vine was recorded from zero mulched plots (the control). The mulches depressed vine lengths in 2010 significantly, except rice husk that had up to 117.50cm as against the immediate longest vine length of 69.50cm from transparent plastic mulch. The varieties responded favourably at interaction with rice husk on vine length far better than other mulches across both years, with 213.3cm obtained from koalack and 311.3cm from sugar baby in 2009, and 115.00cm from koalack and 120.00cm from sugar baby in 2010. There was also significant variety x mulch interaction effect on vine length in both years with emphasis in 2009, where the differences in vine length is wider.

Table 3: Effect of mulching materials on vine length (cm) of two watermelon varieties during 2009 and 2010 dry seasons.

		Varieties		
Year	Treatments	Sugar baby	Koalack	Mean
2009	Mulching Materials			
	Control (zero)	131.3b	106.00b	118.70B
	Black plastic	198.0a	143.00b	170.50B
	Grasses	188.0a	144.00b	166.00B
	Rice husk	311.3a	213.30a	262.30A
	Transparent plastic	148.0a	254.70a	201.30A
	Mean	195.30a	172.20a	
	SE±	SE_V=34.14	SE_M=21.59	SE_{MV}=48.27
2010	Control (zero)	50.33c	52.67c	51.50C
	Black plastic	72.33b	62.33bc	67.33B
	Grasses	57.00c	52.33c	54.67C
	Rice husk	120.00a	115.00a	117.50A
	Transparent plastic	74.00b	65.00b	69.50B
	Mean	74.73a	69.47a	
	SE±	SE_V=3.20	SE_M=2.02	SE_{MV}=4.52

Treatments are significantly different if they do not share a letter (s) in common at adjusted P value <0.05

The effect of variety on the number of leaves per plant was not significantly (P>0.05) different in both years, however, there were more number of leaves in 2009 than in 2010, and sugar baby produced more number of leaves (94.47) than koalack variety (83.53) (Table 4). Black plastic (106.00) and transparent plastic (105.50) mulches recorded the highest number of leaves during the 2009 trial, while the least number of leaves was observed where no mulch was applied (66.83). Number of leaves (91.67) was also highly influenced by rice husk mulch as the third mulching material in 2009 and as the mulching material with the highest number of leaves (41.67) in 2010. Variety x mulch interaction effect on the number of leaves was significantly (P<0.05) different in both years. Koalack under black plastic mulch (116.67) produced the highest number of leaves, followed by transparent plastic mulch (102.00) in 2009, but it was sugar baby under rice husk mulch (45.00) that was significantly higher than all other treatments under the two varieties. Koalack under zero mulch produced the smallest number of leaves (47.00) in 2009 and (14.67) in 2010 in all the variety x mulch intractions in the trial.

Table 4: Effect of mulching materials on the number of leaves of two watermelon varieties during 2009 and 2010 dry seasons.

		Varieties		
Year	Treatments	Sugar baby	Koalack	Mean
2009	Mulching Materials			
	Control (zero)	86.67ab	47.00b	66.83B
	Black plastic	95.33ab	116.67ab	106.00A
	Grasses	83.33ab	66.67ab	75.00AB
	Rice husk	98.00ab	85.33ab	91.67AB
	Transparent plastic	109.00a	102.00a	105.50A
	Mean	94.47a	83.53a	
	SE±	SE_V=18.51	SE_M=11.70	SE_{MV}=26.17
2010	Control (zero)	16.33b	14.67b	15.50C
	Black plastic	24.67b	20.67b	22.67B
	Grasses	20.00b	17.00b	18.50B
	Rice husk	45.00a	38.33a	41.67A
	Transparent plastic	23.00b	20.00b	21.50B
	Mean	25.80a	22.13a	
	SE±	SE_V=1.99	SE_M=1.26	SE_{MV}=2.81

Treatments are significantly different if they do not share a letter (s) in common at adjusted P value <0.05

The number of fruits obtained from koalack variety was significantly (P<0.05) higher than sugar baby in 2010, whereas it was statistically similar in 2009 (Table 5). Koalack produced 5.13 fruits in 2010, where sugar baby produced 3.80 fruits, whereas in 2009, koalack produced 5.47 fruits which is not significantly different from 5.20 fruits produced by sugar baby. Black plastic mulch produced the highest number of fruits (9.17), followed by rice husk mulch (7.17) in 2009, whereas the reverse is the case in 2010 where rice husk produced the highest number of fruits (7.00), followed by black plastic mulch with 4.83 fruits. The lowest number of fruits (approximately 3) was recorded from the zero mulch in both years. Variety x mulch interaction was significant with the highest number of fruits (10.00) and the lowest number (1.00) obtained from sugar baby under black plastic mulch and under the control respectively in 2009, whereas koalack under rice husk produced the highest fruit number (8.67) among other treatment combinations in 2010, followed by 5.00 fruits obtained from black plastic mulch. On the other hand, sugar baby under rice husk mulch produced the highest number of fruits 5.33 in the second planting.

Table 5: Effect of mulching materials on the number of fruits of two watermelon varieties during 2009 and 2010 dry season plantings.

		Varieties		
Year	Treatments	Sugar baby	Koalack	Mean
2009	Mulching Materials			
	Control (zero)	1.00b	4.00ab	2.50B
	Black plastic	10.00a	8.33a	9.17A
	Grasses	2.67b	3.67ab	3.17B
	Rice husk	8.33a	6.00a	7.17A
	Transparent plastic	4.00ab	5.47a	4.67AB
	Mean	5.20a	5.47a	
	SE±	SE_V=1.67	SE_M=1.06	SE_{MV}=2.36
2010	Control (zero)	2.67c	3.67bc	3.17C
	Black plastic	4.67b	5.00b	4.83B
	Grasses	3.00bc	4.00b	3.50C
	Rice husk	5.33b	8.67a	7.00A
	Transparent plastic	3.33bc	4.33b	3.83C
	Mean	3.80a	5.13a	
	SE±	SE_V=0.61	SE_M=0.39	SE_{MV}=0.87

Treatments are significantly different if they do not share a letter (s) in common at adjusted P value <0.05

The weight of fruits of watermelon varieties was significantly (P<0.05) influenced by the different mulching materials in the two year trials (Table 6). Sugar baby variety produced 3.80tons of fruits, while koalack produced 2.62tons of fruits in 2009, and also in 2010 koalack produced 3.59tons, while sugar baby yielded 3.32tons of fruits. Rice husk mulch caused significant increase of 5.18tons fruit weight in 2009, followed by transparent plastic mulch with 4.05tons of fruits, whereas in 2010, rice husk mulch had the heaviest fruit weight of 5.32tons, while all other treatments maintained a uniform fruit weight of approximately 3.00tons. However, rice husk mulch recorded the heaviest fruit weight of 7.07tons with sugar baby, followed by transparent plastic mulch (4.48tons), while the least fruit weights (1.57tons and 1.93tons) were recorded under the control and dry grass mulch in 2009. Koalack under rice husk produced the heaviest fruit weight (6.87tons) in 2010 where sugar baby attained a fruit weight of 3.77tons and 3.87tons under black plastic mulch.

Table 6: Effect of mulching materials on the fruit weight (tons/plant) of two watermelon varieties during 2009 and 2010 dry season plantings.

		Varieties		
Year	Treatments	Sugar baby	Koalack	Mean
2009	Mulching Materials			
	Control (zero)	1.57b	1.37b	1.47A
	Black plastic	3.93ab	2.68ab	3.31A
	Grasses	1.93b	2.13ab	2.03A
	Rice husk	7.07a	3.28ab	5.18A
	Transparent plastic	4.48ab	3.62ab	4.05A
	Mean	3.80a	2.62a	
	SE±	SE_V=1.26	SE_M=0.79	SE_{MV}=1.78
2010	Control (zero)	2.90b	2.60b	2.75BC
	Black plastic	3.87b	2.93b	3.40B
	Grasses	3.03b	2.57b	2.80BC
	Rice husk	3.77b	6.87a	5.32A
	Transparent plastic	3.03b	2.97b	3.00B
	Mean	3.32a	3.59a	
	SE±	SE_V=0.47	SE_M=0.29	SE_{MV}=0.67

Treatments are significantly different if they do not share a letter (s) in common at adjusted P value <0.05

4. Discussion

4.1 Growth parameters

Mulch application significantly influenced all the plant growth parameters considered in this study (number of branches, leaf area index, number of leaves and vine length), which agrees with the report of other researchers. Vine length obtained from these mulches was longest under rice husk, followed by transparent plastic mulch, while it was shortest under the control in both years. Sugar baby produced longer vine length than koalack variety in both years. Similar results were reported by Cater and Johnson (1988) that growth indices and development of eggplant improved with mulches. In the same vein, Messiaen (1992) reported that cucurbits respond well to mulching practice since the soil environment would be conditioned in such a way that the growth of the plant is favourably enhanced. There were also significant differences among the mulch applications in terms of number of leaves as transparent plastic mulch in the first year influenced more number of leaves, while in the second year rice husk recorded the highest number of leaves. Sugar baby also responded well to mulching with high number of leaves, while smaller leaf area index of plants was sustained where no mulch was applied showing that mulching practice enhances plant growth.

4.2 Yield parameters

Early flowering and fruit formation were firstly observed on white plastic mulch then black plastic mulch in all of the study years when compared to control. The earliest germination and fruiting among the varieties was recorded under koalack. This is in agreement with Bonanno and Lamoent (1987) who reported that using mulch influences early yield in vegetable production. Rice husk and black plastic mulches were significantly better than the zero mulch (control) in all the components of yield studied. Similarly, white plastic mulch significantly excelled over the control in all the component of yield varieties for the cropping seasons.

The significant varietal differences on some of the components of yield of watermelon suggest the potentials and the inherent superiority of watermelon varieties for exploiting its production. Thus sugar baby has an inherent potential for production of more fruits despite the fact that koalack have more vegetative growth. Varieties of water melon can be selected for the superiority in resisting cracking, sun scotch and blossom end rot disease of fruits. Variety can be selected for cultivation in order to meet the fruit quality market demands. In general, mulching seemed to promote better performance of water melon varieties in most of the yield parameters. Khan (2005) reported that organic mulch has been found to have multiple advantages in culture, resulting to enhanced physiological efficiency of the plants. These advantages include soil moisture conservation, suppression of weeds, maintaining soil structure, optimizing soil temperature and enriching the soil with organic matter.

Watermelon like any other horticultural crops needs intensive application of nutrient and moisture. Utilization of nutrients in the soil depends on efficient mobilization which in turn is a function of moisture availability. Thus mulch has a direct impact on plant performance by supplying moisture and indirect impact on nutrient availability through enhanced mobilization of the nutrients from the soil. Fruit weight and number of fruits were influenced by mulches. These parameters were found significantly different among mulch applications and watermelon varieties in all the cropping seasons. The highest fruit weight and number of fruits were obtained under rice husk application in this study. There were significant differences among the watermelon varieties in terms of these parameters in all this study. Koalack produced the highest fruit weight and number of fruits. This is in agreement with Farios–Larios and Orozco-Stantos (1997) who reported that marketable fruits from the mulch treatments were higher than those produced on bare soil. Similarly, Bonanno and Lamont (1987), Brinen and Locascio (1979), Carter and Johnson (1988) all of them reported that total and early yields increased with polyethylene mulches.

5. Conclusion

Farmers should therefore be encouraged to apply mulch as a crop husbandry practice for moisture availability during the off season. In their effects on yield parameters, rice husk and black plastic mulches were more effective followed by white plastic mulch. It is therefore, recommended that rice husk mulch should be used as mulch by farmers especially in rice growing areas like ours where this by product is generated in large amounts. It was evidently observed in this our work that rice husk mulch greatly influenced the growth and yield parameters and sometimes compared favourably with other mulch types, such that if any of this becomes scarce, this by product can be effectively utilized. Using this product as mulch can help cleanse the environment, prevent pollution, save and reclaim threatened lands and increase soil fertility.

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