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COMPARATIVE EFFECTS OF *ARBUSCULAR MYCORRHIZAL* AND DEGRADED SAWDUST ON GROWTH AND YIELD CHARACTER OF PEPPER (*CAPSICUM SPP*)

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ABSTRACT

The experiment was conducted to evaluate the effect of *Arbuscular mycorrhiza* and degraded sawdust on growth and yield characters of bell pepper (*Capsicum annum L.*) The experiment was 2x4 factorial arranged in a Completely Randomized Design (CRD)) with four replicates. The eight treatments were combinations of two early maturing varieties of bell peppers (PEP and Gombe) and soil amendments (degraded sawdust, *Glomus etunicatum* and steam sterilized homogenous soil as control (C). The two varieties of bell pepper differed significantly in growth and fruit parameters. Variety Gombe had higher plant height (22.2cm) and produced more fruits of bell pepper (1.7) than variety PEP inspite of its larger leaf area (23.1cm^2) by the latter. The results also showed that soil amendment with degraded sawdust alone and combination with *Glomus etunicatum* improved the growth parameters such as plant height, stem girth, leaf area as well as numbers of flowers and fruits of bell pepper. The interaction of pepper and soil amendments was significant on all the growth and yield parameters with varieties exhibiting differential reactions to the soil amendment treatments. Soil amendments with degraded sawdust and combination of degraded sawdust with *Arbuscular mycorrhiza* had positive effects on the growth and yield characters of both varieties of pepper used (PEP and Gombe).

Keywords: *Arbuscular Mycorrhizal* , Degraded Sawdust, Pepper.

INTRODUCTION

Bell pepper (*Capsicum annum*) is a native of tropics and believed to have originated from South America (Eshbaugh,1993) Bell pepper is a member of the Solanaceae family (Eshbaugh,1993) which also includes tomato, tobacco, eggplant and irish potato (Kelly and George,2006). The varieties of peppers and chillies can be grouped into sweet or bell or aroma pepper(Capsicum annum) and chillies or hot pepper (*Capsicum frutescens*) (Youndeowei *et al.,* 1986.

The fruit is orange, yellow or red in colour when ripe, many seeded and usually pungent (Eshbaugh,1993). *Capsicum annum* is an erect annual plant which grows to a height of 150cm and is strongly branched. (Eshbaugh,1993)

The economic importance of Pepper shows

that it contains both vitamins A and C and small quantities of fat, carbohydrates, protein, calcium and ascorbic acid Kelly and George,2006). Peppers are used in ginger manufacturing and other beverages. *Capsicum frutescens* (hot pepper) is used in medicine. It is used internally as a powerful stimulant and carminative. Carminative is a medicine for colic (colic is an acute pain in the abdomen or bowels) (Eshbaugh,1993).

Pepper production has increased in recent years worldwide due to its high nutritional value of pepper. One medium green bell pepper can provide up to 8% of recommended daily allowance (RDA) of vitamin A, 180% of vitamin C, 2% of calcium and 2% of iron. Kelly and George,2006).

Mycorrhizal is a symbiotic association between a fungus and the roots of a plant (Kirk *et al*., 2001). The fungus colonize the roots of a host plant, either intracellular or extracellularly. It is an important part of soil life. Through this the fungus acts as additional roots to the existing plant roots. The mycelia of the *mycorrhizal* fungus access immobile phosphate ions, and other minerals and make them available to the plants they colonize in a basic pH medium. (Asea *et al*., 1988; Kucey, 1988; Subhasini and Potty,1992; Salami and Osonubi, 2003).

Mycorrhizal plants are often more resistant to diseases, such as those caused by microbial soil-borne pathogens, and are also more resistant to the effects of drought. These effects are perhaps due to the improved water and mineral uptake in mycorrhizal plants. (Trappe, 1987; Arafat and He chaoxing 2011; Akintokun and Akintokun, 2012). Mycorrhiza helps to improve the soil structure by increasing water holding capacity of the soil and taps nutrients that could be leached by rain. Mycorrhizal fungi may also help to regulate the uptake of soil toxins, allowing plants to better tolerate salty or problem soil conditions (Arafat and He chaoxing 2011).

Mycorrhizal fungi stimulate root growth by allowing the plants to take up phosphorus and other nutrients more efficiently (Sasa *et al.,* 1987). The *Arbuscular mycorrhizal* also play important roles in inter and intra-specific transfer of carbon, phosphorus, and nitrogen from plant to plant (Amin and Hui-Lian, 2000). *Arbuscular mycorrhizal* are important for Nitrogen uptake which stimulates the growth and nutrition of other plant nutrients. Plants in mycorrhiza associations are, in general, healthier, sturdier and more disease resistant, that is reduced severity of diseases caused by pathogenic fungi, bacterial and nematodes than their counterparts which lack the association (Atayese *et al.*,1993,). The use of mycorrhiza inoculants can increase plant productivity by contributing to the survival rate of transplanted seedlings, improving plant rate, increasing disease resistance and improving the survival rate of plants in adverse conditions such as drought or infertile soils. Mycorrhizal plants also have the capability to withstand drought in area of sudden water shortage due to additional roots (Germina *et al*., 1997; Huixing,2005). The main absorption apparatus of mycorrhizal is the extension hyphae with a diameter of 2-5µm which penetrate soil pores inaccessible to root hairs (10-20um) and so absorb water that is not available to root hairs in non-mycorrhiza plants (Gong *et al*., 2000). Because the number of extension hyphae is far more than that of root hairs, the area of surface of *Arbuscular mycorrhizal* plant and soil interaction is increased greatly. In addition *Arbuscular mycorrhiza*l has capacity to change the architecture of the roots which increase the survival rate of mycorrhiza plant in the soil medium (Atkinson, 1994).

Organic matter is an important soil material. It consists of raw and partially decayed plant and animal residues. Organic matter binds soil particles, granules and aggregate together. It aids water penetration and aeration of plant roots in clayey soils and increases moisture holding capacity of sandy soils. It also adds some nutrients for plants and micro organisms. Sawdust is an organic material which can be used as mulch or possible additional nutrient to plant in areas where it is easily available. All living organisms are made of large amount of carbon (C) combined with small amount of nitrogen (N). The balance of these elements in an organisms is called the C:N ratio. This C:N ratio is an important factor for determining how easily bacteria can decompose organic waste during the composting process. Therefore, crop residues and organic waste such as sawdust could be added to soils as sources of plant nutrients and to improve the physical properties of the soil. The carbon to nitrogen ratio in sawdust and wood chips is 400:1. It can be used in making compost either as dry, wet or green materials. The dry materials included hay, leaves, corncobs, sawdust, straw and stalk of vegetables. The C: N ration of sawdust is 100-500:1 while micro organisms in compost use carbon (C) for energy and nitrogen (N) for protein synthesis (Steinegger and Janssen, 1993).

The high cost and non-availability of fertilizer to most farmers in Nigeria has affected agricultural production. Inward looking for alternatives becomes imperative to support ever increasing human population. Thus the main objective of this study was to evaluate the effect of mycorrhiza fungi and degraded sawdust on growth and yield of two varieties of bell peppers.

MATERIALS AND METHODS

Description of experimental site.

The experiment was carried out in the screen house of the University of Agriculture, Abeokuta (3°26'E; 7°10'N), Ogun State.

Experimental design and treatments.

The experiment had a 2x4 factorial arrangement fitted into a Completely Randomized Design (CRD)) with four replicates. The eight treatments were combinations of two early maturing varieties of bell peppers (PEP and Gombe) and soil amendments (degraded sawdust, *Glomus etunicatum* and steam sterilized homogenous soil as control (C). The details are shown below.

i. P_1 SD (PEP variety + degraded saw dust)
ii. P_1 AM (PEP variety + *Glomus etunica tum*)
iii. P_1 SDAM (PEP variety + degraded saw dust + *Glomus etunicatum*)
iv. P_1C (PEP variety + steam sterilized homogenous soil)
v. P_2SD (GOMBE variety + degraded saw dust)
vi. P_2SDAM (GOMBE variety + *Glomus etunicatum*)
vii. P_2SDAM (GOMBE variety + degrade sawdust + *Glomus etunicatum)*
viii. P_2C (GOMBE variety + steam sterilized homogenous soil)

Soil preparation

Soil free from chemical and herbicide application was used for this work. The soil was sieved using 2mm mesh and steamed sterilized for 3 hours at a constant temperature of 115°C. and was allowed to air cool for 3 days. The steam sterilized soil was used for nursery operations.

Sawdust preparation

Degraded sawdust was collected from sawmill and sterilized in order to avoid contamination at 115^{0}C for 3 hours. Every stony material was removed from the degraded sawdust collected.

Green house practices

The plants were nursed for 21 days in the nursery shed before transplanting into the green house. Each bucket was filled with 4kg soil and 1kg degraded sawdust (ratio 4:1) and watered at every other day with 200ml of water. Management practices such as weeding were carried out as need arises. GOMBE and PEP varieties (early maturing) collected from NIHORT were used for this work. The *Arbuscular mycorrhiza* was obtained from International Institute for Tropical Agriculture (IITA), Ibadan, Nigeria. 1kg of degraded sawdust was thoroughly worked into the soil with one plant set at the middle of each bucket. The soil was inoculated at 5cm depth with 100g stock inoculums of *Arbscular mycorrhiza*.

Data collection

The following agronomic data were collected at 7 days interval commencing from one week after transplanting (WAT) of seedlings.

Leaf Area: The leaf area was determined by measuring the length and breadth of established and full grown leaves per plant and the mean was multiplied with 0.63 constant LA = L x B x 0.63 (Salawu et al.,2008).

Plant height:The height of each plant was determined with the meter ruler.

Stem girth: A thread was used to surround each plant stem and the thread was placed on the ruler to measure the length.

Number of fruit per plant: This was determined by counting fruits per plant harvested for a period seventy day.

Number of flowers per plant: This was determined by counting flowers per plant at onset of flowering to 70 days after.

Fruit mass: The ripe fruits were harvested and the weight taken using electric sensitive scale.

Dry matter yield: Fresh harvested fruits were oven dried at 70^{0}C for 3 days to a constant weight using electric oven.

Data analysis

All data collected were subjected to Analysis of variance (ANOVA) and significant treatments means were separated using least significance difference (LSD) method.

RESULTS

The soil physicochemical parameters and mineral composition of sawdust are presented jointly in Table1. The soil $_P$H was 6.8, Sand 90.6%, clay 5.4% and silt 4%. In the degraded sawdust Lead (Pb) was absent. This showed the fitness of the material for crop production.

Effect of soil amendment on plant height of varieties of bell pepper

The two varieties differed significantly in plant height with Gombe having taller plants at 4, 8 and 12 WAT (Table 2). The soil amendments also had significant effect on plant height of pepper at 12 WAT. Pepper inoculated with *Glomus etunicatum (GE)* had shorter plants than those in soil with degraded sawdust (DS). The interaction of variety of pepper and soil amendment was significant at 4, 8 and 12 WAT (Table 3). Pepper planted with combination of DS and GE had the taller plants. Except where soil was inoculated with GE, variety Gombe had taller plants at 4 WAT, in all the treatments. However at 8 WAT, the plants of the two varieties with DS and Gombe without any amendment had heights comparable to the maximum for Gombe that received combination of GE and Ds. Gombe only had significantly taller plants at 8 and 12 WAT.

At 12 WAT, the two pepper varieties given DS and Gombe given DS+GE had plant heights comparable to the maximum with Gombe not given any amendment.

Table 1: Physico–chemical properties of soil used and chemical content of the decompose Sawdust

SOIL		DECOMPOSED SAWDUST	
pH	6.8	pH	9.2
%Sand	90.6	%N	2.56
%Clay	5.4	%O.M	34.5
%Silt	4.0	%O.C	19.8
%C	1.79	P(Cmol/kg)	9.2
%N	0.09	K(Cmol/kg)	6.5
Mg (Cmol/kg)	0.52	Ca(Cmol/kg)	2.3
Na (Cmol/kg)	0.22	Mg(Cmol/kg)	2.9
K (Cmol/kg)	0.13	Mn(Cmol/kg)	9.7
Mn (Cmol/kg)	0.34	Pb(Cmol/kg)	Not detected
ECEC(Cmol/kg)	2.96		
BASE SATURTION	97.64		
Available P(ppm)	2.90		
Zinc(Cmol/kg)	9.89		
Fe (Cmol/kg)	0.75		

Table 2: Effect of Soil Amendment on Plant Height of Bell Pepper in the Screen House at Alabata in 2008

	Plant Height (cm)		
TREATMENTS	**4WAT[1]**	**8WAT**	**12WAT**
<u>Variety (v)</u>			
PEP	7.7	12.6	15.5
GOMBE	12.3	19.4	22.2
S.E±	0.92	1.42	1.65
LSD (0.05)	1.57	2.45	2.84
<u>Soil amendments(s)</u>			
Degraded sawdust	9.6	18.7	22.3
Glomus etunicatum (GE)	9.6	13.8	15.8
Degraded sawdust + *Glomus etunicatum*	11.6	17.3	18.0
No amendment (control)	9.2	14.3	19.3
SE±	1.30	2.01	2.33
LSD(0.05)	NS	NS	5.67
SE± Interaction (vxs)	1.83	2.84	3.30

WAT: Weeks after transplanting

TABLE 3: Inter action of Variety and Soil Amendment on Plant Height of Bell Pepper in the Screen House at Alabata, 2008

	Plant Height (cm)					
SOIL AMENDMENTS	**VARIETIES**					
	4WAT		**8WAT**		**12WAT**	
	PEP	Gombe	PEP	Gombe	PEP	Gombe
Degraded sawdust	7.7	11.4	17.6	19.8	22.2	22.3
Glomus etunicatum (GE)	8.9	10.4	16.3	12.8	12.8	8.9
Degraded sawdust + Glomus etunicatum	6.8	16.4	12.4	22.1	13.4	22.5
No amendment (control)	7.4	11.00	10.1	19.6	13.5	25.1
LSD(0.05)		3.15		4.89	5.67	

1. WAT: Weeks after transplanting.

Effect of soil amendment on leaf area of varieties of capsicum annum

The plant of pepper variety PEP had significantly higher leaf areas at 8 and 12 WAT than those of Gombe. The soil amendment had significant effect on leaf area at 8 WAT and 12WAT (Table 4). Among the soil amendment treatments, combination of GE and SD (Sawdust) caused pepper leaf area comparable to the maximum obtained with sawdust alone. Pepper plants treated with the combination also had higher leaf area than those given GE alone and control.

Interaction of variety and soil amendments were significantly on leaf area at 4,8 and 12WAT (Table 5). At 4 WAT, the plants of the two varieties of pepper given sawdust and Gombe without soil amendment had leaf areas comparable to maximum with Gombe given GE and SD combination (Table 5). At this stage, PEP plants had significantly smaller leaf area than Gombe SD and GE combination were applied. At 8 WAT, only plants of PEP variety given combination of SD and GE.

The varieties only differed significantly in leaf areas when SD was applied with PEP having a larger value.

At 12 WAT, the highest leaf area was obtained with PEP pepper variety given SD. In all the other soil amendment treatments including the control, the two varieties had similar leaf areas.

Table 4: Effect of Soil Amendment on Leaf area of Bell pepper in the Screen House at Alabata in 2008

	Leaf Area (cm2)		
TREATMENTS	**4WAT**	**8WAT**	**12WAT**
<u>**Variety (v)**</u>			
PEP	7.5	13.0	14.3
GOMBE	9.1	10.0	9.3
SE±	NS	1.50	1.50
LSD (0.05)	NS	2.59	2.38
<u>Soil amendment (s)</u>			
Degraded sawdust	8.8	16.2	17.6
Glomus etunicatum (GE)	7.7	8.6	8.9
Degraded sawdust + *Glomus etnuicatum*	9.2	14.4	14.0
No amendment (control)	7.5	6.5	6.9
SE±	1.44	2.13	2.11
LSD (0.05)	3.51	5.18	3.61
SE± Interaction (vxs)	2.04	3.01	2.10

1. WAT: Weeks after transplanting

TABLE 5: Interaction of Variety and Soil Amendment on Leaf Area of Bell Pepper the Screen House at Alabata, 2008.

	Leaf Area (cm^2)					
SOIL AMENDMENTS	**VARIETIES**					
	4WAT		**8WAT**		**12WAT**	
	PEP	**Gombe**	**PEP**	**Gombe**	**PEP**	**Gombe**
Degraded sawdust	8.7	8.9	20.4	12.1	23.1	12.1
Glomus etunicatum (GE)	7.8	7.5	9.5	7.7	10.8	7.1
Degraded sawdust + *Glomus etunicatum*	6.6	11.8	16.4	12.3	17.2	10.9
No amendment (control)	6.6	8.3	5.4	7.7	6.7	7.1
LSD (0.05)	3.51		5.18		3.61	

1. WAT: Weeks after transplanting.

Effect of Soil amendment on stem girth of varieties of bell pepper

The soil amendments had significant effect on the stem girth of pepper at 4, 8 and 12 WAT (Table 6). Plants given combination of SD and GE at 4 and 8 WAT had stem girth comparable to the maximum with plants given SD which had the highest at 12 WAT. The interaction of variety and soil amendment was significant at 4, 8 and 12 WAT (Table 7). The two varieties given combination SD and GE as well as PEP variety given SD ahd stem girth comparable to the maximum with Gombe variety given SD at 4 WAT. At 8 WAT, the same trend was observed with PEP variety having the maximum. The least stem girth was observed in control soil amendment treatment. Plants of the two pepper varieties given the combination of the two amendments had bigger stem girth than those of the control at 4 WAT and those given GE alone in addition at 8 WAT. AT 12 WAT, PEP given SD had the highest stem girth while the variety had bigger girth than Gombe in all the pots given the three soil amendments.

Effect of soil amendment on number of fruits of varieties of bell pepper

Gombe variety of pepper produced significantly higher number of fruits than PEP at 10 and 12 WAT (Table 8). Pepper varieties given SD and combinations of SD and GE produced similar number of pepper fruit and were significantly higher than those of plants given GE alone and the control at 8 and 10 WAT. AT 12 WAT, pepper plants given SD produced the highest number of fruits while those given combination of SD and GE produced highest number than those with GE alone and the control.

The interaction of variety with soil amendment was significant on fruit number at 8, 10 and 12 WAT (Table 9). At 10 WAT, plants of Gombe pepper variety given SD and combination of SD and GE produced significantly higher number of fruits than those of the other variety x soil amendment combinations. At 12 WAT, the same promising treatments had higher number than all other treatments combination except variety PEP given SD. The latter combination only had fruit number comparable to Gombe variety given SD.

Table 6: Effect of Soil Amendment on Stem Girth of Bell pepper in the Screen House at Alabata in 2008

	Stem Girth (cm)		
TREATMENTS	**4WAT**	**8WAT**	**12WAT**
Variety (v)			
PEP	9.9	15.6	17.6
GOMBE	10.7	16.3	18.3
SE±	0.65	1.11	1.14
LSD (0.05)	1.12	1.90	1.96
Soil amendment (s)			
Degraded sawdust	11.8	19.7	21.6
Glomus etunicatum (GE)	9.7	13.8	17.6
Degraded sawdust + *Glomus etnuicatum*	11.3	17.6	17.3
No amendment (control)	8.4	12.5	15.3
SE±	0.91	1.56	1.14
LSD (0.05)	1.15	3.80	3.61
SE± Interaction (vxs)	1.21	2.21	2.10

1. WAT: Weeks after transplanting

TABLE 7: Interaction of Variety and Soil Amendment on Stem Girth of Bell Pepper in the Screen House at Alabata, 2008.

	Stem Girth (cm)					
SOIL AMENDMENTS	**VARIETIES**					
	4WAT		**8WAT**		**12WAT**	
	PEP	**Gombe**	**PEP**	**Gombe**	**PEP**	**Gombe**
Degraded sawdust	11.8	11.9	20.0	19.4	23.1	12.1
Glomus etunicatum (GE)	9.3	10.1	13.8	13.9	10.2	7.1
Degraded sawdust + *Glomus etunicatum*	10.9	11.8	18.3	17.0	17.2	10.9
No amendment (control	7.8	9.1	10.3	14.8	6.7	7.1
LSD (0.05)	1.15		3.80		3.61	

1. WAT: Weeks after transplanting.

Table8: Effect of Soil Amendment on Number of Fruit of Bell pepper in the Screen House at Alabata in 2008

	Number of Fruit		
TREATMENTS	**4WAT**	**8WAT**	**12WAT**
Variety (v)			
PEP	0.8	0.6	0.8
GOMBE	1.0	1.8	1.7
SE±	0.39	0.39	0.35
LSD (0.05)	0.62	0.67	0.60
Soil amendment (s)			
Degraded sawdust	1.5	1.5	2.0
Glomus etunicatum (GE)	0.1	0.8	0.9
Degraded sawdust + *Glomus etnuicatum*	1.5	1.9	1.5
No amendment (control)	0.5	0.6	0.6
SE±	0.55	0.55	0.50
LSD (0.05)	1.24	1.32	1.21
SE± Interaction (vxs)	0.72	0.77	0.70

1. WAT: Weeks after transplanting

TABLE 9: Interaction of Variety and Soil Amendment on Numbers of Fruit of Bell Pepper in the Screen House at Alabata, 2008.

	Number of Fruit					
SOIL AMENDMENTS					**VARIETIES**	
	4WAT		**8WAT**		**12WAT**	
	PEP	**Gombe**	**PEP**	**Gombe**	**PEP**	**Gombe**
Degraded sawdust	1.0	2.0	0.5	2.5	1.5	2.5
Glomus etunicatum (GE)	0.0	0.0	0.8	0.8	0.8	1.0
Degraded sawdust + *Glomus etunicatum*	1.3	1.8	1.0	2.8	0.8	2.3
No amendment (control)	1.0	2.2	10.3	1.0	0.3	1.0
LSD (0.05)	1.24		1.32		1.21	

1. WAT: Weeks after transplanting.

DISCUSSION

The pH of 6.8 for the steam sterilized soil shows that the soil was not acidic and can support the growth of pepper plant in conformity with the findings of Kelly and George (2006). The two varieties of pepper differed significantly in plant height, leaf area and number of fruits produced. The soil amendment had effect on the varieties of PEP and Gombe. This may be because of mineral provision by the soil arguments. This was in conformity with the findings of Esteban (2004) who also reported that organic matter add some nutrients to plants.

Degraded sawdust (DS) had significant effect on the plant height of Gombe variety than PEP variety. This maybe due to inherent genetic makeup in this variety thus the diferent response to the treatments applied. However this was in conformity with the findings of Olowokere *et al*.,(2013) who reported that crop residues and organic waste serve as sources of soil nutrients for plant and improve physical properties of soil. This was as a result of their ability to retain moisture content for the plants in the soil. This was as a result of their ability to retain moisture content for the plants in the soil and added nutrients due to their decomposition. Also, the combination of DS and *Glumus etunicatum* (GE) had positive influence on plant height of Gombe. This agrees with the findings of Akintokun and Akintokun (2010) who reported that plant with mycorrhiza association are sturdier, healththier than plants which lack the association. Marques et al., (2001) also reported that mycorrhiza has potential of making available additional nutrients while DS on the other hand furnishes the soil with other minerals which the plant needed for growth and development.

The combination of GE and SD, as well as SD alone had positive influence on the leaf area of Gombe and PEP varieties. This positive effect on leaf area agrees with earlier observations of Subhasini and Potty (1992) who reported that the growth promoting substances were secreted by the fungus. SD and combinations of SD + GE also had positive influence on the stem girth of both varieties of pepper and these agree with the study of Esteban (2004) and Gong et al, (2004).The number of fruits recorded from both varieties was affected by the treatment with Gombe given more number of fruits than PEP that was exotic.

It can be concluded that soil amendments with degraded sawdust and combination of degraded sawdust with Arbuscular mycorrhiza fungi had positive effects on the growth and yield characters of both varieties of pepper used (PEP and Gombe). However the effect of degraded sawdust on Gombe variety was more on PEP.

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