Original Research Article

Phenotypic expressions of Pepper in treatments of *Glomus deserticola*, *Pleurotus pulmonarius* compost and Poultry manure

Abstract

The response of five varieties of pepper was investigated at the research farm of the Department of Botany, University of Ibadan. Five treatments of *Glomus deserticola* (AMF), poultry manure (PM), *Pleurotus pulmonarius* (SMC) were inoculated into 5 kg of sterile soil in poly pots, while uninoculated served as control. The treatment and varieties produced highly significant ($p<0.01$) effects on the total number of fruit, while total fresh weight was highly significant for treatment. Jos pepper and treatment combinations of AMF + PM produced the highest mean for the total number of 24.07 and 25.87 fruits, while Bell pepper had highest total fresh weight and dry weight of 12.15g and 12.05g respectively. The leaf length, leaf width, the number of leaves, number of branches and stem girth of Long pepper were significantly higher with 9.20cm, 4.63cm, 110.01cm, 5.89cm and 0.82cm respectively, while plant height (48.82cm) and stem height (30.27cm) of cherry pepper had the highest. The plant height was positive and strongly correlated ($p< 0.01$) with stem height, leaf width, leaf length, number of leaves and stem girth at r= 0.84, 0.80, 0.83, 0.79 and 0.60 respectively. Also, there was a positive association between the total number of fruits and total fresh weight (r= 0.56). However, the selection of Jos, Bell, Long and Cherry pepper based on morphological and yielding traits as a result of individual and combined treatments of *Glomus deserticola, Pleurotus pulmonarius* compost, and poultry manure could play major roles in food security.

Keywords: Phenotypic traits, food security, bioinoculants, pepper, variability

0.0. Introduction

Pepper (*Capsicum annum)* is an important vegetable grown in Nigeria and other parts of the humid and semi arid tropics (Aliyu, 2000). The different varieties of *C. annum* grown which include Bird pepper, Cayenne pepper or Red pepper, Bell pepper, Long pepper also called Indian long pepper, Cherry pepper and Thai pepper. Their fruits vary in sizes, shapes, colour, and pungency and culinary uses (Eldon Everhart *et al*., 2009).

It is commonly used as condiments, while the non pungent species of *C. annum* are eaten raw as salad, while the stronger flavoured types (Chilies) are popularly used in all kinds of cookery as pungent spices, and also used in seasoning sauces in soup and other dishes (Alabi, 2006). The leaves of sweet pepper are sometimes eaten as vegetable in Gabon and are reported to have carcascidal and molluscicidal potential due to the presence of active essential oil ((Irvine, 1956; Walker and Sillans, 1961; Kloos and McCullough, 1982).

The adverse effects of excessive inorganic fertilizers on crops, pollution of water basins, destruction of microbes and insects. Therefore, the adoption of arbuscular mycorrhizal fungi biotechnology and other bioinoculants which could serve as alternative to chemical fertilizers necessitated this study.

Bio-inoculants are natural and organic fertilizers that conserve nitrogen and enrich the soil nutrients, for the benefit of plants (Olawuyi *et al.,* 2012). Arbuscular mycorrhizae Fungi

(AMF) associate symbiotically with the roots of plant improve the uptake of phosphorus due to the short transmission distance of phosphate ions in the soil for plants' survival and growth (Osonubi *et al.,* 1991; Odebode *et al.,* 2001, Schwarzott *et al.,* 2001, Gemma *et al.,* 2005; Olawuyi *et al*., 2011; Olawuyi *et al.,* 2012). AMF fungi also play key role in nutrients cycling and protection of plants against environmental and biotic stresses (Harley & Smith, 1989; Odebode, 2005; Olawuyi *et al.,* 2013, 2014). The interactions of arbuscular mycorrhizal fungi and other bioinoculants in genetic improvement of crops had enhanced yield, and reduced the challenges of pollution and toxicity of the soil (Jonathan *et al*., 2013; Olawuyi *et al*., 2014).

Poultry Manure (PM) is an organic waste from poultry birds consisting of bird's faeces, waste food, feathers and increases soil carbon, organic nitrogen and exchangeable calcium resulting to pH increase. It causes slow release of macro nutrients most especially phosphorous which may lead to slow growth and poor yield of plant (Sunassee, 2001; Nwangburuka *et al*., 2012). It has also been used to improve the soil structure apart from enhancing the growth and yield of vegetable plants (Nwangburuka *et al*., 2012b).

Spent Mushroom Compost (SMC) also known as spent mushroom substrate (SMS) or mushroom soil has become a popular organic soil amendment for the establishment and maintenance of agricultural and horticultural crops. It is also a viable and useful by-product in mushroom farming (Fidanza, 2009; Jonathan *et al.,* 2013). This growth medium which constitute the mixture of agricultural materials such as; straw from horse stables, hay, poultry litter, ground corn cobs, cottonseed hulls, cocoa shells, peat moss, and other natural organic substances improve plant growth in poor or marginal soils (Fidanza, 2009).

The study investigated the morphological and yield variability response of pepper to *Glomus deserticola, Pleurotus pulmonarius* and Poultry manure.

1.0. MATERIALS AND METHODS

1.1. Study location and Soil sample

The experiment was conducted in the nursery Farm of the Department of Botany, University of Ibadan, Nigeria from February, 2013 to May, 2013.

The soil sample was collected from Sultan Bello Hall garden, University of Ibadan, and bagged in black polythene bags punched with 6 tiny holes to prevent water logging.

1.2. Research design and Treatments

The experiment was factorially laid out in a 5x5 arrangement of a complete randomized design with three replicates. Five accessions of peppers cultivated in the study were labeled G, H, I, J and K. They are; Accession G – Bell Pepper (Tatase), Accession H – Long Pepper , Accession I – Jos Pepper, Accession J – cherry Pepper (Bawa), Accession K – Thai Pepper (Ata Ibile).

A total of seventy five (75) plants which comprised of five treatments were evaluated in this study; T1– 2.5g of Arbuscular mycorrhizal Fungus (AMF) plus 2.5g of Poultry Manure (PM), T2 – 5g of Arbuscular mycorrhizal Fungi (AMF) only, T3 - 5g of Poultry Manure (PM) only, T4 - 5g of Spent Mushroom Compost (SMC) only , T5 – Control

1.3. Sources of Bio-inoculants and Plant material

Arbuscular mycorrhizal Fungus (*Glomus deserticola*) was obtained from the Department of Botany, University of Ibadan, Ibadan. The Poultry Manure (PM) was collected from the Poultry farm of University of Ibadan, Ibadan, while the Spent Mushroom Compost (SMC) was obtained from a mushroom industry in Ibadan.

The Bell, Long and Jos pepper were purchased from Agboju and OTO markets respectively in Lagos, while Cherry and Thai peppers were bought from Bodija market in Ibadan (Table 1).

1.4. Method of planting and Agronomic practices

Twenty seeds each of pepper accession were raised by planting in sterile polythene bag filled with 7kg soil at the nursery of Department of Botany. After 2 weeks each accession was transplanted into 4kg of soil in the nursery. The inoculation of *G. deserticola,* poultry manure and spent mushroom compost were done according to the standard procedure. Watering of plant and weeding of unwanted plant were carried out from time to time.

1.5. Determination of morphological and yield traits

1.5.1. Growth assessment

The following number of leaves, plant height (cm), stem height (cm), stem girth (cm) and leaf area were growth parameters evaluated at 7 days intervals according to the standard methods.

1.5.2. Harvesting and evaluation of pepper for yield traits

The fruits were harvested at week from the 13th to 19th week after planting at unripen stage. After harvesting, the fruits were weighed and kept in envelopes (labelled according to the plants, treatment and replicate) and air dried. The fresh and dry weight of the fruits were determined.

1.5.3. Statistical Analysis

The data were subjected to analysis of variance (ANOVA) using SPSS version 16.0, while Duncan Multiple Range Test (DMRT) was further used to separate treatment means $p<0.05$.

Table 1: Sources and collection of Pepper accessions

Varieties	PEPPER TYPE	NAME OF MARKET/ TOWN	STATE
Bell Pepper (Tatase)	Sweet	Agboju Market / Lagos	Lagos
Long Pepper	Sweet	OTO / Lagos	Lagos
Jos Pepper	Hot	OTO / Lagos	Lagos
Cherry Pepper (Bawa)	Hot	Bodija / Ibadan	Oyo
Thai Pepper (Ata Ibile)	Hot	Bodija / Ibadan	Oyo

2.0. RESULTS

The result in table 2 showed the mean square effects of accessions and treatments of bioinoculants on yield. The accession produced highly significant ($p<0.01$) effect on total number of fruit, while the effect of treatments of bioinoculants was significantly expressed on total number of fruit and total fresh weight.

There were significant differences ($p<0.05$) in the response of pepper accessions to morphological parameters (Table 3). The plant and stem height of cherry pepper were significantly different from other accessions, while the leaf length, leaf width, number of leaves, number of branches and stem girth were significantly higher in long pepper. The number of flowers was significantly expressed in Jos pepper compared to other accessions.

The result of the effect of treatment combinations of bioinoculants on growth characters of pepper is shown in table 4. The combinations of AMF + PM is significantly ($p<0.05$) higher for all the characters but not significantly ($p>0.05$) different for plant height and stem girth in all the treatments, and stem height in pepper treated with poultry manure. The application of ; AMF only and SMC only, AMF only and PM only, PM only and SMC only were not significantly different for stem height and number of leaves; number of branches and leaves as well as leaf width, leaf length and number of leaves respectively (Table 4).

The result in table 5 shows that the treatment combinations of *Glomus deserticola* and poultry manure is significantly ($p< 0.05$) higher for total number of fruit than control, while *G. deserticola* only and poultry manure only did not express significant effect on total number of fruit. The addition of poultry manure only and combined treatments of *G. deserticola* were significantly higher for total fresh weight, while the effects of control and treated pepper with *Pleurotus pulmonarius* were non significant (Table 5). The untreated and sole treated with *G. deserticola* and poultry manure were significantly higher for total dry weight of pepper, while combinations of *G. deserticola* and poultry manure as well as pepper solely treated with *P. pulmonarius* were not significantly different at $p> 0.05$.

The result of the effect of accession on yield of pepper is shown in table 6. The Long and Jos pepper were significantly ($p<0.05$) higher but not different for total number of fruit, while Bell pepper and Thai pepper were non-significant. The total fresh weight of Jos and Bell pepper were significantly higher than other pepper, while total dry weight of bell pepper was higher significantly compared to others. The Jos and Cherry pepper as well as Long and Thai pepper were not significantly ($p>0.05$) different from each other (Table 6).

The plant height is positive and strongly correlated ($p<0.01$) with stem height, leaf width, leaf length, number of leaves and stem girth with r=0.84, 0.80, 0.83, 0.79 and 0.60 respectively. The stem height is positively associated with leaf width, leaf length, number of leaves and number of branches per plant at $p<0.01$; r=0.80, 0.81, 0.61, and 0.51 respectively. The leaf width is positive and strongly correlated with leaf length (r=0.95) and number of leaves (r=0.66), but related with number of branches (r=0.59) and stem girth (r=0.51), while the association between the leaf width and number of flowers, week after planting, and accessions were positive but not related. Also, there was positive association between leaf length and number of leaves, number of branches and stem girth at $p<0.01$; r=0.68, 0.57and 0.54 respectively. The number of leaves is positive correlated with number of flowers, number of branches and stem girth at r=0.57, 0.65, and 0.59 respectively while there was positive association between week after planting and stem girth (r=0.71, $p< 0.05$) (Table 7).

There is no significance in the relationship between treatment and total number of fruits and accessions, while there is a negative and non significant correlation between treatment, total fresh weight and total dry weight. There is high significance and positive correlation between total number of fruits and total fresh weight alone (r=0.56), while there is negative and no correlation between total dry weight and accessions (Table 8).

Table 2: Mean Square effects of Accessions and Treatments of *Glomus deserticola, Pleurotus pulmonarius* Compost and Poultry Manure on yield of pepper

Sources of Variation	Df	Total Number of Fruit	Total Fresh Weight	Total Dry Weight
Treatment	**4**	**507.55****	**114.16****	**10.20ns**
Accession	**4**	**858.58****	**170.80^{ns}**	**64.54ns**
Replicate	**2**	**113.65^{ns}**	**24.99^{ns}**	**15.88ns**
Error	**64**	**160.18**	**24.99^{ns}**	**39.34**
Total	**75**			
Corrected Total	**74**			

** P< 0.01 highly significant, * P< 0.05 significant, ns= non significant

Table 3: Effect of accessions on eight morphological characters of pepper

Accession	Plant Height (cm)	Stem Height (cm)	Leaf Width (cm)	Leaf Length (cm)	Number of Leaves	Number of Flowers	Number of Branches	Stem Girth (cm)
Bell Pepper (Tatase)	17.64^{d}	13.72^{d}	1.95^{d}	4.49^{d}	55.17^{c}	3.60^{c}	4.00^{b}	**0.53^{c}**
Long Pepper	43.54^{ab}	29.61^{a}	4.63^{a}	9.20^{a}	110.01^{a}	7.63^{b}	5.89^{a}	**0.82^{a}**
Jos Pepper	29.07^{c}	17.82^{c}	2.87^{c}	5.62^{c}	81.81^{b}	14.04^{a}	4.29^{b}	**0.61^{bc}**
Cherry Pepper (Bawa)	48.82^{a}	30.27^{a}	3.58^{b}	8.12^{a}	89.25^{ab}	8.81^{ab}	3.71^{b}	**0.78^{a}**
Thai Pepper (Ata Ibile)	38.47^{b}	21.84^{b}	3.05^{bc}	7.00^{b}	81.54^{b}	7.33^{b}	3.96^{b}	**0.75^{ab}**

Means with the same letter in the same column are not significantly different at P> 0.05 using Duncan's Multiple Range Test (DMRT)

Table 4: Effect of treatment combinations of *Glomus deserticola, Pleurotus pulmonarius* compost and Poultry manure on eight morphological characters of pepper

Treatments	Plant Height (cm)	Stem Height (cm)	Leaf Width (cm)	Leaf Length (cm)	Number of Leaves	Number of Flowers	Number of Branche	Stem Girth (cm)

							s	
AMF +PM	37.89^{a}	25.13^{a}	3.73^{a}	7.86^{a}	95.47^{a}	12.38^{a}	5.24^{a}	0.77^{a}
AMF only	33.81^{a}	21.39^{ab}	2.92^{b}	6.44^{b}	83.60^{ab}	9.00^{ab}	4.29^{ab}	0.67^{a}
PM only	36.69^{a}	24.53^{a}	3.38^{ab}	7.23^{ab}	80.24^{ab}	6.09^{b}	4.53^{ab}	0.70^{a}
SMC *only*	37.44^{a}	23.28^{ab}	3.20^{ab}	6.82^{ab}	78.04^{ab}	7.02^{ab}	4.00^{b}	0.71^{a}
Control	32.66^{a}	19.85^{b}	2.95^{b}	6.28^{b}	73.78^{b}	7.27^{ab}	3.93^{b}	0.67^{a}

Means with the same letter in the same column are not significantly different at P> 0.05 using Duncan's Multiple Range Test (DMRT)

AMF- Arbuscular Mycorrhizal fungi (*Glomus deserticola*), PM- Poultry Manure, SMC- Spent Mushroom Compost (*Pleurotus pulmonarius*)

Table 5: Effect of *Glomus deserticola, Pleurotus pulmonarius* compost and Poultry Manure on the yield of pepper

Treatment	Total Number of Fruit	Total fresh Weight	Total Dry Weight
Glomus deserticola + Poultry Manure	25.87^{a}	10.38^{a}	9.80^{ab}
Glomus deserticola only	18.80^{ab}	4.53^{b}	10.11^{a}
Poultry Manure only	21.60^{ab}	11.67^{a}	11.62^{a}
Pleurotus pulmonarius compost	10.53^{bc}	9.43^{ab}	9.49^{ab}
Control (Untreated)	7.47^{c}	7.75^{ab}	10.01^{a}

Means with the same letter in the same column are not significantly different at P> 0.05 using Duncan's Multiple Range Test (DMRT)

Table 6: Effect of Accessions on the yield of pepper

Accession	Total Number of Fruit	Total Fresh Weight	Total Dry Weight
Bell Pepper (Tatase)	7.87[b]	12.15[a]	12.05[a]
Long Pepper	21.87[a]	10.13[ab]	11.16[ab]
Jos Pepper	24.07[a]	11.11[a]	8.01[b]
Cherry Pepper (Bawa)	11.53[ab]	5.84[bc]	7.91[b]
Thai Pepper (Ata Ibile)	8.93[b]	4.51[c]	11.89[ab]

Means with the same letter in the same column are not significantly different at P>0.05 using Duncan's Multiple Range Test (DMRT)

Table 7: Correlation among morphological characters and growth stages of pepper

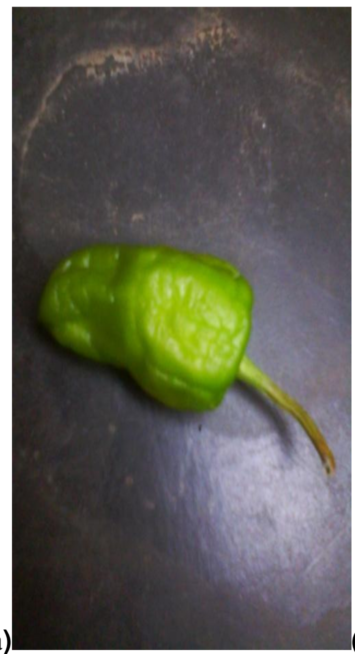
	Plant Height	Stem Height	Leaf Width	Leaf Lenght	Number of Leaves	Number of Flowers	Number of Branches	Week After Planting
Stem Height	0.84**							
Leaf Width	0.80**	0.80**						
Leaf Length	0.83**	0.81**	0.95**					
Number of Leaves	0.79**	0.61**	0.66**	0.68**				
Number of Flowers	0.45	0.34	0.32	0.28	0.57*			
Number of Branches	0.48	0.51*	0.59*	0.57*	0.65**	0.25		
Stem Girth	0.60**	0.47	0.51*	0.54*	0.59**	0.34	0.47	0.71**

*, ** significant at $P < 0.05$ and $P < 0.01$ respectively ns= Non-significant at $P < 0.05$ and $P < 0.01$ respectively

Table 8: Correlation matrix of yield related traits of pepper

	Treatment	Total Number of Fruit	Total Fresh Weight	Total Dry Weight
Total number of Fruit	0.08*			
Total Fresh Weight	-0.01	0.56**		
Total Dry Weight	-0.00	-0.01	0.06	

*, ** significant at P < 0.05 and P < 0.01respectively ns= Non-significant at P < 0.05 and P < 0.01 respectively

(a)

(b)

(c)


(d)  (e)  (f) 

Plate A: Fruit of bell pepper, Plate B: Fruits of Long Pepper, Plate C: Bell Pepper treated with AMF + PM Showing the leaves, fruits and flower, Plate D: Long pepper treated with PM only, Plate E: Long Pepper treated with AMF + PM, Plate F: Jos pepper treated with AMF + PM

(g)  (h) 

(i)  (j) 

Plate G: Jos pepper treated with AMF only, Plate H: Cherry pepper (Control), Plate I: Thai pepper treated with AMF only, Plate J: Thai pepper treated with AMF+PM

3.0. DISCUSSION

It is apparent from the results that growth of pepper plant can be improved when inoculated with appropriate AMF+PM and AMF only, under well watered condition. Significant increase in plant height, number of leaves, stem girth was recorded in AMF+PM and AMF only inoculated plants. This increase in growth characters can be attributed to the mycorrhizal activity in stimulating the absorption of the nutrition from the surrounding soil to the host plants (Smith and Smith, 1999; Nelson and Jenson, 1999). Plants inoculated with Mycorrhiza had improved growth performance which agreed with the reports of Slankis, (1973) that the symbiotic association of the fungi also provides the host with substance to enhance their growth such as auxin, gibberellins and cytokinnins. From the result, it was observed the pepper plants treated with SMC only are the tallest, this shows that SMC is responsible for increase in the height of pepper plant which agreed with the report of Idowu and Kadiri (2013). The positive and highly significance between the characters number of leaves, number of flowers, number of branches and stem girth shows that number of flowers, number of branches and stem girth are determinants of number of leaves indicate that these attributes are the most important component for yield selection and direct selection for these characters as similarly confirmed by Nwagburuka *et al.* (2012) and Olawuyi *et al.* (2014).

Ekanayake *et al.* (2004) reported that AMF can increase the plant biomass and rate of photosynthesis. Poulton et al., (1998) also confirmed that AMF can act as phytostimulators, and can alter the pattern of gene expression, cellular programing and organ development of host plant. Nowadays, biofertilizer is an alternative to chemical fertilizer to increase soil fertility and crop production in sustainable farming. Furthermore, the use of biofertilizer has gained momentum in recent years since chemical fertilizers are expensive and cause hazardous effect to plants (Aseri *et al.*, 2008).

4.0. CONCLUSION

The other advantages of using biofertilizer are; low cost, lead to soil enrichment with nutrients, compatible with long term sustainability and eco-friendly. However, the amount of nutrients provided by the bioinoculants is determinants of the needs of crops for high yields. The integration of AMF+PM, AMF only, PM only, SMC only in pepper production as bioinoculants should be applied by farmers to enhance better yield of the crops.

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