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Evaluation of Some Morphological Criteria to Drought Tolerance on Seedling of Bambara Groundnut [*Vigna subterranea* (L.) Verdc.] using Polyethylene Glycol (PEG6000)

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ABSTRACT

Background: Bambara groundnut has the ability to drought tolerance and has high nutritional value and is one than Legume crops untapped, which need attention. Therefore in this research, it will look at the relationship between osmotic stress caused by a concentration of PEG and drought tolerance to get some genotypes has ability drought tolerance.

Methods: The experiment was conducted in the Tissue culture Laboratory, Department of Agronomy, Faculty of Agriculture, the University of Brawijaya, Malang, Indonesia in January-March 2019. The objective of the experiment was an evaluation of some morphological criteria to drought tolerance on the seedling for thirty genotypes of Bambara groundnut using polyethylene glycol (PEG) 6000 by three concentrations (0%, 5% and 10%). A complete randomized design was used for this experiment with three replicates.

Result: The 10% PEG was the most suitable concentration to select Bambara groundnut lines for drought tolerance. Genotypes give different responses to concentrations of PEG. In susceptible lines, there are germination constraints, such as Prevent and germination delayed, the formation of hypocotyl length, root length, fresh weight and dry matter, while drought-tolerant lines can germinate normally. Obtained six lines that were tolerant to drought, five local, namely BBL 1.1, PWBG 5.2.1, PWBG 6, SS 2.4.2, SS 3.4.2 and one from Thailand which is Tvsu 86.

Key words: Bambara groundnut, Drought tolerance, Polyethylene glycol, Selected lines.

INTRODUCTION

Drought is a complex physical-chemical process connected with almost all aspects of biology needed of plants to increase the uptake of water, which is usually more available deep down in the soil (Abobatta, 2016), is one of the factors that can decrease growth and production, so that required a variety that has the ability to sustain cellular metabolism and growth during the stress. As well as, current global climate change has made this condition more serious (Michel *et al.*, 1973). There are many agricultural plants has the ability of tolerance most transient water stress such as Wheat (Dhanda *et al.*, 2004), Sorghum (Bibi *et al.*, 2010), Maize (Kaydan *et al.*, 2008) and some legume crops, such as soybean, Bambara groundnut which considered is one of the legumes which is widely cultivated in the west, central Africa and Asia and is third in importance in the SSA among grain legumes after groundnut (Mohammed *et al.*, 2020), it considers one of the important crops due to the presence of large commercial potential and nutritional value high. It serves as an important source of protein in the diets of a large percentage of the population in Africa (Chandra *et al.*, 2019), where its seeds contain 63 per cent carbohydrate, 19 percent protein and 6.5 per cent oil and a good source of fiber, calcium, iron and potassium, highly caloric and vitamins (Hasan *et al.*, 2018; Temegne *et al.*, 2018). The crop is grown by subsistence farmers in Africa under traditional low input agricultural systems. It is grown mainly for its edible protein, which has high lysine content and therefore has a beneficial complementary effect when consumed with cereals that are low in lysine (Swanevelder, 1998; Swanson *et al.*, 1985).

As well as, Bambara groundnut has characteristics to growth in the marginal soil and also tolerant into the drought condition and also have value in crop rotations as a source of residue nitrogen for the subsequent crop through nitrogen fixation (Hasan *et al.*, 2018; Ncube *et al.*, 2007) and Despite its importance and increase protein, Bambara groundnut cultivation is limited by its sensitivity to pathogens and low and unpredictable yields for the majority of semi-arid tropics (Atta *et al.*, 2004).

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Therefore, Bambara is still one than legume crops untapped, which need attention and research to define the nutritional value as well as look for on some genotypes has the ability on drought tolerance and maintain stomata open and growth within their capacity at low levels of water potential and intensification of its production and in particular the creation of improved varieties to overcome the numerous cultural constraints for the plants.

Selection for drought tolerance at the early stage of seedling using PEG traits is a potentially cheaper method than conventional planting and as a screening agent has been widely used for plant drought screening (Stanton *et al.*, 1966). Therefore in this research, it will look at the relationship between osmotic stress caused by a concentration of PEG and drought tolerance to Bambara groundnut. The main objective of this research is an evaluation of some morphological criteria to drought tolerance on the seedling of Bambara Groundnut using polyethylene glycol (PEG6000).

MATERIALS AND METHODS

The Laboratory experiment carried out in the Tissue Culture Laboratory, Department of Agronomy, Faculty of Agriculture, the University of Brawijaya, the City of Malang Indonesia in January-March 2019. The objective of the experiment was an evaluation of some morphological criteria to drought tolerance on the seedling of Bambara groundnut using polyethylene glycol (PEG6000). It tested thirty genotypes (twenty-nine genotypes local from Indonesia) and one genotype of Thailand is Tvsu 86)). A complete randomized design was used for this experiment with three replicates. It used PEG with a molecular weight of 6000 (PEG6000) as a catalyst for dehydration by three concentrations 0%, 5% and 10% developed by dissolving 5g and 10g of PEG per 100 mL distilled water with add to the solution 6.5g, 10g and 30g Agar per 1000 ml to concentration 0%, 5% and 10% PEG respectively with heating and mixing, then distributed the media on the bottles and left to cooled and then the samples were placed inside the autoclave for a 1:00 hour to a 1:30 hour for sterilization. The samples were taken outside the autoclave out and left at the planting room for three days.

The seeds were placed in a detergent liquid solution for five mints, in a 0.5% fungicide solution for 10 mints and in a 5% hypochlorite solution for 5 mint for sterilized and then the seeds were washed three times with distilled water. Then it attended bottles containing on Agar as a witness throughout the experiment. One seed to each genotype of Bambara was planted in each bottle and to each concentration where the total of bottles for each the genotypes 30 bottles x 3 replicates = 90 bottles for concentration 0% (control), 90 bottles for concentration 5% and 90 bottles for concentration 10%, the total bottles for all concentrations were 270 bottles for all genotypes any 270 seed for all genotypes for three concentrations. It covered the bottles and all the bottles were placed in the room of germination to growth. It was Prepare at laboratory temperature (25°C) (Lhuillier-Soundélé *et al.*, 1999).

After germination of seeds, the number of germinating seeds was manually counted on each day. A seed was considered to be germinated when the emergence of both axes (plumule and radicle) had become visible to the range of 5 mm (Evaneri, 1957). Plants dry weight were recorded after drying in an oven at 70°C for 24 hours (Pond *et al.*, 2004) and the other data were recorded. A complete randomized design with one factor was used for this experiment. One-way ANOVA test was conducted to test whether there are differences in the average of parameters generated by the treatment/group factor.

RESULTS AND DISCUSSION

The number of days of planting until germination

Table 1 and Fig 1 show that the average number of days of planting until germination for each all genotypes was looked significantly different from each other. The highest average in concentration 10% in genotypes PWBG 4.1.1, PWBG 5.3.1 and SS 1.4.2 at 25.67±0.58 were very late of germination, while the lowest average was in genotype

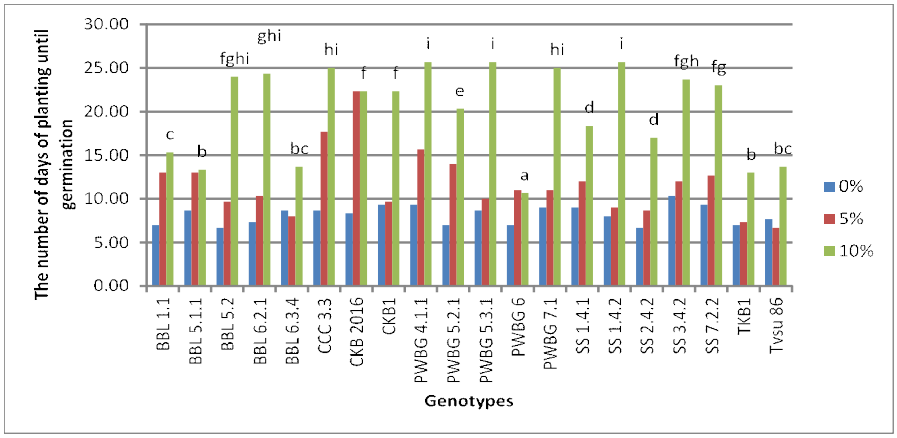


Fig 1: Difference in number of days of planting until germination between twenty genotypes of Bambara groundnut using concentration 0, 5 and 10% PEG.

Table 1: Difference in number of days of planting until germination between thirty genotypes of Bambara groundnut using concentration 0, 5 and 10 % PEG.

Genotypes	Concentration			
	0%	5%	10%	
BBL 1.1	7.00	13.00	15.33	c
BBL 5.1.1	8.67	13.00	13.33	b
BBL 5.2	6.67	9.67	24.00	fghi
BBL 6.2.1	7.33	10.33	24.33	ghi
BBL 6.3.4	8.67	8.00	13.67	bc
BBL 9.1	11.00	16.33	-	-
CCC 1.5	16.33	22.33	-	-
CCC 1.6	12.67	16.33	-	-
CCC 2.1.2	7.33	13.33	-	-
CCC 2.2.2	13.00	23.33	-	-
CCC 2.5	6.33	13.00	-	-
CCC 3.3	8.67	17.67	25.00	hi
CKB 2016	8.33	22.33	22.33	f
CKB1	9.33	9.67	22.33	f
PWBG 1.1.1	13.33	6.33	-	-
PWBG 1.2.1	8.33	13.33	-	-
PWBG 3.1.2	14.67	14.00	-	-
PWBG 4.1.1	9.33	15.67	25.67	i
PWBG 5.2.1	7.00	14.00	20.33	e
PWBG 5.3.1	8.67	10.00	25.67	i
PWBG 6	7.00	11.00	10.67	a
PWBG 7.1	9.00	11.00	25.00	hi
SS 1.4.1	9.00	12.00	18.33	d
SS 1.4.2	8.00	9.00	25.67	i
SS 2.4.2	6.67	8.67	17.00	d
SS 3.4.2	10.33	12.00	23.67	fgh
SS 4.4.2	8.33	12.33	-	-
SS 7.2.2	9.33	12.67	23.00	fg
TKB1	7.00	7.33	13.00	b
Tvsu 86	7.67	6.67	13.67	bc



Fig 2: Germination performance of PWBG 6 (A) BBL 9.1 (B) Bambara genotypes *in vitro* condition on MS medium subjected to 0, 5 and 10% PEG.

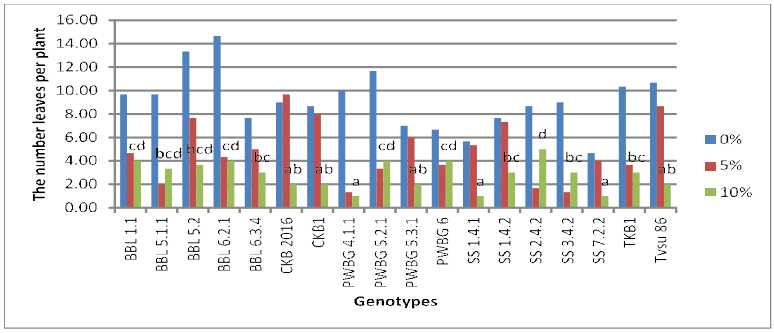


Fig 3: The difference in the number of leaves per plant between eighteen genotypes of Bambara groundnut using concentration 0, 5, 10% PEG.

Table 2: The difference in the number of leaves per plant between thirty genotypes of Bambara groundnut using concentration 0, 5, 10% PEG.

Genotypes	Concentration			
	0%	5%	10%	
BBL 1.1	9.67	4.67	4.00	cd
BBL 5.1.1	9.67	2.00	3.33	bcd
BBL 5.2	13.33	7.67	3.67	bcd
BBL 6.2.1	14.67	4.33	4.00	cd
BBL 6.3.4	7.67	5.00	3.00	bc
BBL 9.1	9.00	4.00	-	-
CCC 1.5	8.00	1.00	-	-
CCC 1.6	9.00	4.00	-	-
CCC 2.1.2	11.00	6.33	-	-
CCC 2.2.2	11.67	2.67	-	-
CCC 2.5	9.67	5.67	-	-
CCC 3.3	10.67	-	-	-
CKB 2016	9.00	9.67	2.00	ab
CKB1	8.67	8.00	2.00	ab
PWBG 1.1.1	11.00	7.00	-	-
PWBG 1.2.1	11.33	9.67	-	-
PWBG 3.1.2	7.67	4.33	-	-
PWBG 4.1.1	10.00	1.33	1.00	a
PWBG 5.2.1	11.67	3.33	4.00	cd
PWBG 5.3.1	7.00	6.00	2.00	ab
PWBG 6	6.67	3.67	4.00	cd
PWBG 7.1	1.67	-	-	-
SS 1.4.1	5.67	5.33	1.00	a
SS 1.4.2	7.67	7.33	3.00	bc
SS 2.4.2	8.67	1.67	5.00	d
SS 3.4.2	9.00	1.33	3.00	bc
SS 4.4.2	9.00	4.00	-	-
SS 7.2.2	4.67	4.00	1.00	a
TKB1	10.33	3.67	3.00	bc
Tvsu 86	10.67	8.67	2.00	ab

PWBG 6 at 10.67±1.15 faster of germination compared with other genotypes.

Osmotic stress caused than a concentration of 10% PEG inhibit genotypes BBL 9.1, CCC 1.5, CCC 1.6, CCC 2.1.2, CCC 2.2.2, CCC 2.5, PWBG 1.1.1, PWBG 1.2.1, PWBG 3.1.2, SS 4.4.2 of germination. As well as, it delayed the germination of all genotypes which have the ability to germination in this concentration compared with control 0%. It was noted there was a difference between genotypes in water imbibition rate because of osmotic stress caused on concentrations PEG, as Structural changes during imbibition typical found in genotypes were observed, this is consistent with studies (EL SHIMI *et al.*, 1980; Koné *et al.*, 2015; Saio *et al.*, 1973; Swanson *et al.*, 1985) which indicated reveals differences between legumes in water imbibition rate and both structural and textural changes occurring in legumes during imbibition to water.

The number of leaves per plant

Table 2 and Fig 3 show the average number of leaves per plant for the genotypes and which indicate a significant difference among some genotypes. The highest average in concentration 10% was in genotype SS 2.4.2 at 5.00±1.00 and the lowest average was in genotypes PWBG 4.1.1, SS 1.4.1 and SS 7.2.2 at 1.00±0.00. As well as, these genotypes showed maintain a higher total of leaves that maybe it could preserve their higher leaf water potential in the stressed environments compared to other genotypes.

Osmotic stress caused by a concentration of 10% PEG inhibits genotypes CCC 3.3 and PWBG 7.1 formation of leaves. As well as, it lessens the number of leaves to all genotypes which have the ability to the formation of leaves compared with control 0%. no formation of leaves and a reduced number of leaves perhaps due to less water absorption and a decrease in external osmotic potential by PEG (Karjalainen *et al.*, 1987).

Hypocotyl length (cm)

Table 3 and Fig 4 illustrate that the average Hypocotyl length for each genotype was looking significantly different from

each other. The highest average in concentration 10% was in genotype PWBG 5.2.1 at 4.07±2.57, while the lowest average was in genotype SS 7.2.2 at 0.50±1.00 compared with other genotypes.

Osmotic stress caused by a concentration of 10% PEG inhibits genotypes CCC 3.3, PWBG 7.1 formation of hypocotyl length. As well as, reduces hypocotyl length for the rest of genotypes compared with control 0%.

Table 3: Difference in the hypocotyl length (cm) between thirty genotypes of Bambara groundnut using concentration 0, 5 and 10 % PEG.

Genotypes	Concentration			
	0%	5%	10%	
BBL 1.1	9.17	4.17	3.50	bc
BBL 5.1.1	8.67	3.13	2.60	bc
BBL 5.2	10.57	6.00	2.67	bc
BBL 6.2.1	8.83	4.83	3.33	bc
BBL 6.3.4	9.23	2.67	3.23	bc
BBL 9.1	8.83	3.00	-	-
CCC 1.5	7.33	1.50	-	-
CCC 1.6	10.33	2.83	-	-
CCC 2.1.2	6.33	4.17	-	-
CCC 2.2.2	11.00	3.33	-	-
CCC 2.5	8.00	3.50	-	-
CCC 3.3	9.57	-	-	-
CKB 2016	7.40	4.33	1.73	ab
CKB1	9.00	7.00	2.77	bc
PWBG 1.1.1	8.50	4.17	-	-
PWBG 1.2.1	10.17	5.17	-	-
PWBG 3.1.2	9.83	5.33	-	-
PWBG 4.1.1	10.00	2.33	1.50	ab
PWBG 5.2.1	8.83	2.67	4.07	c
PWBG 5.3.1	5.67	4.50	2.00	abc
PWBG 6	7.57	3.33	3.97	c
PWBG 7.1	1.67	-	-	-
SS 1.4.1	6.00	3.83	2.43	abc
SS 1.4.2	7.00	3.00	2.50	abc
SS 2.4.2	9.67	2.83	4.00	c
SS 3.4.2	9.00	2.90	3.00	bc
SS 4.4.2	8.00	3.17	-	-
SS 7.2.2	5.20	2.67	0.50	a
TKB1	7.27	3.30	2.77	bc
Tvsu 86	9.87	5.87	1.70	ab

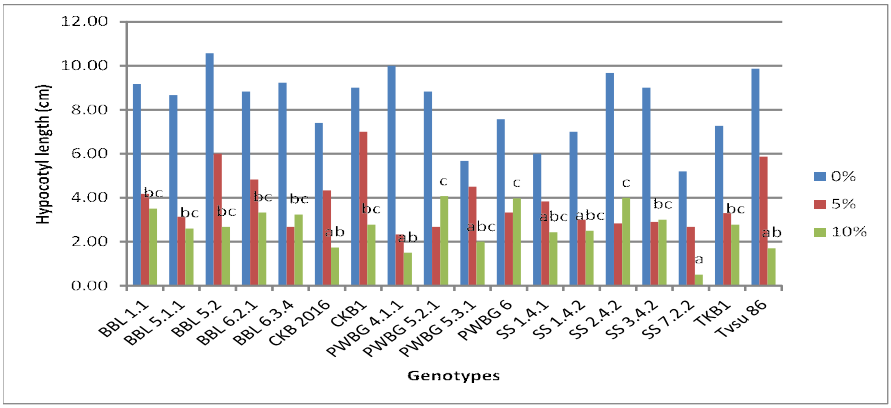


Fig 4: Difference in the hypocotyl length (cm) between eighteen genotypes of Bambara groundnut using concentration 0, 5 and 10% PEG.

It was noted there was a difference between genotypes in hypocotyl length because of osmotic stress caused on concentrations PEG, results in dwarfed plants, because of the effect on stem elongation and cells expansion, this is consistent with studies (Achard *et al.*, 2009; Vettakkorumakankav *et al.*, 1999). Which indicated a reduction in endogenous gibberellins (GAs) content results in dwarfed plants with reduced stem elongation, leaf development, aberrant flowering and fruit set and gibberellins (GAs) play an important role in controlling cell elongation through their effects on expansion and division for cells.

Root length (cm)

Table 4 and Fig 5 which illustrates that the average root length for each genotype was looked significantly different from each other. The highest average in concentration 10% was in genotype BBL 1.1 at 17.33±0.58 and the lowest average was in genotype PWBG 5.3.1 at 1.00±0.00 compared with other genotypes.

Osmotic stress caused by a concentration of 10% PEG inhibits genotypes CCC 3.3, PWBG 7.1 formation of root length. While it no affects genotype BBL 1.1. But it reduces root length for the rest of genotypes compared with control 0%. Some genotypes maintain in concentration 10% a higher total of roots that maybe it gives the strength it on the look for the water until it could preserve their higher root water potential in the stressed environments compared to other genotypes. this is consistent with a study that indicates drought tolerance mechanisms in the plants are different where the growth of each organ can be affected differentially by water deficits as a morphological adaptation that modifies the plants' water use efficiency, the leaves may decrease their growth rate, while in the same plant the roots may continue growing vigorously at the same water potential resulting in morphological modifications of its structure and this may result in a relative increase in roots compared with the plant shoot, however, in some cases, there is greater root growth in relative and absolute and in this situation a

Table 4: Difference in the root length (cm) between thirty genotypes of Bambara groundnut using concentration 0, 5 and 10% PEG.

Genotypes	Concentration			
	0%	5%	10%	
BBL 1.1	17.50	16.33	17.33	d
BBL 5.1.1	15.87	8.10	7.50	ab
BBL 5.2	16.00	12.90	10.13	bc
BBL 6.2.1	15.50	14.00	5.00	ab
BBL 6.3.4	15.43	12.67	2.50	a
BBL 9.1	12.00	11.17	-	-
CCC 1.5	19.50	1.50	-	-
CCC 1.6	17.50	11.33	-	-
CCC 2.1.2	21.17	16.33	-	-
CCC 2.2.2	14.00	6.00	-	-
CCC 2.5	22.50	12.33	-	-
CCC 3.3	19.00	-	-	-
CKB 2016	20.00	12.87	1.33	a
CKB1	10.23	8.10	3.60	ab
PWBG 1.1.1	13.17	8.67	-	-
PWBG 1.2.1	17.00	12.67	-	-
PWBG 3.1.2	15.33	5.00	-	-
PWBG 4.1.1	22.50	14.83	10.00	bc
PWBG 5.2.1	20.50	14.67	14.67	cd
PWBG 5.3.1	17.77	12.50	1.00	a
PWBG 6	16.97	16.33	5.87	ab
PWBG 7.1	17.50	-	-	-
SS 1.4.1	24.03	15.17	2.13	a
SS 1.4.2	28.67	22.33	4.00	ab
SS 2.4.2	17.67	16.67	2.00	a
SS 3.4.2	22.03	16.50	6.00	ab
SS 4.4.2	23.17	8.67	-	-
SS 7.2.2	27.17	12.70	4.00	ab
TKB1	18.17	3.83	7.50	ab
Tvsu 86	18.50	17.83	4.07	ab

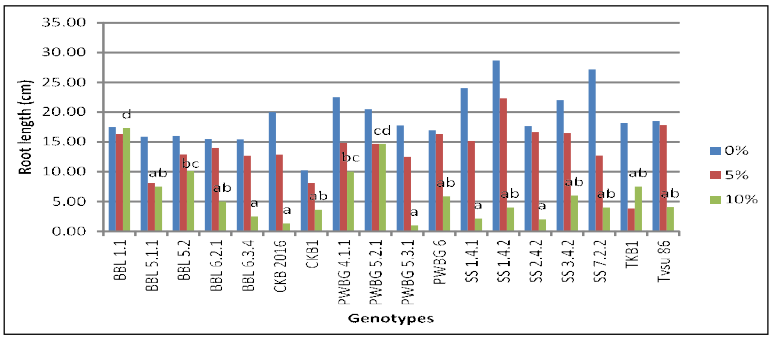


Fig 5: Difference in the root length (cm) between eighteen genotypes of Bambara groundnut using concentration 0, 5 and 10% PEG.



Fig 6: Root performance of BBL 1.1 (A) CKB 2016 (B) Bambara genotypes *in vitro* condition on MS medium subjected to 0, 5 and 10% PEG.

Table 5: Difference in fresh weight of the seedling (g) between thirty genotypes of Bambara groundnut using concentration 0, 5 and 10% PEG.

Genotypes	Concentration			
	0%	5%	10%	
BBL 1.1	4.70	2.50	1.80	bcde
BBL 5.1.1	4.59	2.52	2.00	bcde
BBL 5.2	6.47	3.97	2.61	def
BBL 6.2.1	7.06	4.82	2.02	bcde
BBL 6.3.4	6.42	3.39	2.29	cdef
BBL 9.1	5.23	3.67	-	-
CCC 1.5	5.94	1.94	-	-
CCC 1.6	6.17	2.51	-	-
CCC 2.1.2	6.00	3.40	-	-
CCC 2.2.2	4.92	2.56	-	-
CCC 2.5	6.31	3.00	-	-
CCC 3.3	6.33	-	-	-
CKB 2016	5.17	2.80	1.82	bcde
CKB1	4.45	3.51	1.64	bc
PWBG 1.1.1	4.95	3.54	-	-
PWBG 1.2.1	4.68	3.50	-	-
PWBG 3.1.2	3.16	2.22	-	-
PWBG 4.1.1	5.03	5.16	1.50	bc
PWBG 5.2.1	7.50	3.82	3.17	fg
PWBG 5.3.1	4.82	2.88	1.18	ab
PWBG 6	5.99	4.98	2.32	cdef
PWBG 7.1	4.96	-	-	-
SS 1.4.1	6.20	4.19	2.65	ef
SS 1.4.2	9.38	6.48	2.43	cdef
SS 2.4.2	7.37	5.11	2.37	cdef
SS 3.4.2	8.55	6.06	3.80	g
SS 4.4.2	9.54	5.87	-	-
SS 7.2.2	9.10	4.68	1.68	bcd
TKB1	4.47	2.45	1.89	bcde
Tvsu 86	4.13	2.75	0.65	a

substantial improvement in water use efficiency can be achieved by the plants (Pire *et al.*, 2007).

Fresh weight (g)

It can be seen from Table 5 and Fig 7 average fresh weight of the seedling for genotypes was looked significantly different from each other. The highest average in concentration 10% was in genotype SS 3.4.2 at 3.80±0.30, while the lowest average was in genotype Tvsu 86 at 0.65±0.15.

Osmotic stress caused by a concentration of 10% PEG inhibits genotypes CCC 3.3, PWBG 7.1 gives fresh weight. While it reduces fresh weight for the rest of genotypes compared with control 0%.

The water stress caused a reduction in fresh weight for genotypes caused by a reduction in growth, quantity because water stress has a great impact on the physiological and biochemical process of plants (Bolat *et al.*, 2014). Where, it can reduce nutrient uptake and transport and alter phytohormone metabolism and signaling, as well as general metabolism in plants, more intense drought stress, may limit a plant's ability to acclimate, resulting in severe plant responses, such as stomata closure and a large reduction in photosynthesis. Such decreases in metabolism are accompanied by a reduction in growth and are considered as survival mechanisms in response to the severity of the stress (Litvin *et al.*, 2016). Thus it will be an effect on fresh weight for plants.

Dry matter (g)

Table 6 and Fig 8 shows the average of dry matter of the seedling for each genotype was looking significantly different from each other. The highest average in concentration 10% was in genotype SS 3.4.2 at 1.01±0.03 and the lowest average was in genotype Tvsu 86 at 0.18±0.00 compared with other genotypes.

Osmotic stress caused by a concentration of 10% PEG lessens a dry matter of most genotypes which have the ability to the give of dry matter and all genotypes showed a progressive decrease in total plant dry weight as water deficit

Table 6: Difference in dry matter of the seedling (g) between thirty genotypes of Bambara groundnut using concentration 0, 5 and 10% PEG.

Genotypes	Concentration			
	0%	5%	10%	
BBL 1.1	0.49	0.44	0.35	b
BBL 5.1.1	0.52	0.49	0.52	def
BBL 5.2	0.73	0.67	0.55	ef
BBL 6.2.1	0.72	0.68	0.48	cde
BBL 6.3.4	0.71	0.63	0.62	f
BBL 9.1	0.89	0.45	-	-
CCC 1.5	0.51	0.46	-	-
CCC 1.6	0.53	0.51	-	-
CCC 2.1.2	0.65	0.55	-	-
CCC 2.2.2	0.57	0.55	-	-
CCC 2.5	0.64	0.61	-	-
CCC 3.3	0.60	-	-	-
CKB 2016	0.56	0.49	0.41	bc
CKB1	0.59	0.52	0.52	def
PWBG 1.1.1	0.69	0.33	-	-
PWBG 1.2.1	0.55	0.46	-	-
PWBG 3.1.2	0.35	0.30	-	-
PWBG 4.1.1	0.74	0.52	0.49	cde
PWBG 5.2.1	0.83	0.59	0.76	g
PWBG 5.3.1	0.62	0.45	0.45	cde
PWBG 6	0.76	0.63	0.44	cd
PWBG 7.1	0.59	-	-	-
SS 1.4.1	1.15	0.93	0.73	g
SS 1.4.2	1.35	1.10	0.74	g
SS 2.4.2	1.13	0.94	0.95	h
SS 3.4.2	1.28	0.95	1.01	h
SS 4.4.2	1.28	1.05	-	-
SS 7.2.2	1.31	1.02	0.74	g
TKB1	0.60	0.48	0.51	cde
Tvsu 86	0.76	0.41	0.18	a

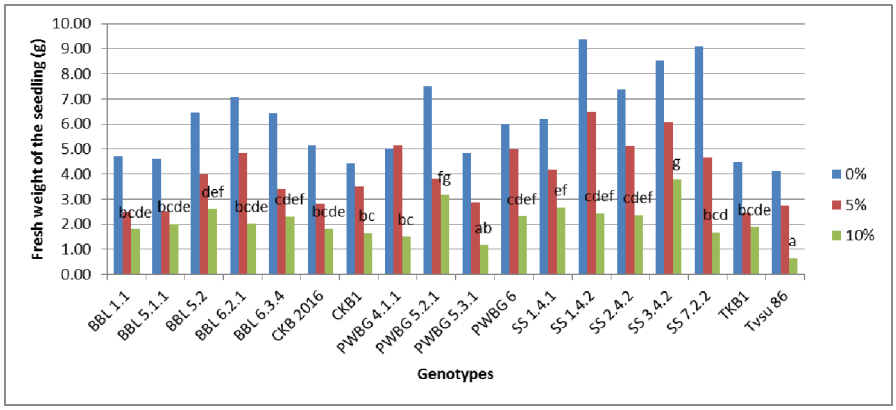


Fig 7: Difference in Fresh weight of the seedling (g) between eighteen genotypes of Bambara groundnut using concentration 0, 5 and 10 % PEG.

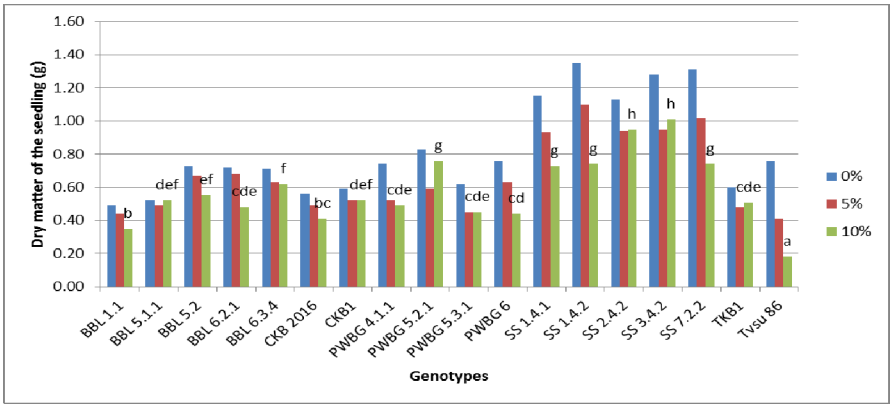


Fig 8: Difference in dry matter of the seedling (g) between eighteen genotypes of Bambara groundnut using concentration 0, 5 and 10% PEG.

increases, however, it no affects genotype BBL 5.1.1 compared with control 0%. Maybe because of genetic effects and environmental factors that affect the structure of plants and the lack of water and drought and it is one of the major constraints that limit crop production and quality and numerous recent studies have shown the negative effect of water stress on cellular membranes and organelles such as mitochondria and chloroplasts and causing cellular content leakage outside the cell (Bolat *et al.*, 2014), consequently water stress will affect the photosynthetic apparatus and on the amount of radiation that could be intercepted and utilized and leaf biomass yield and water-use efficiency (WUE) for edible or total biomass production are likely to vary between plants of the same species or different species. It is this difference in WUE that confers an ecological advantage to the more efficient species (Hassen *et al.*, 2007).

CONCLUSION

Osmotic stress caused by a concentration of 10% PEG inhibit genotypes BBL 9.1, CCC 1.5, CCC 1.6, CCC 2.1.2, CCC 2.2.2, CCC 2.5, PWBG 1.1.1, PWBG 1.2.1, PWBG 3.1.2, SS 4.4.2 of germination. As well as, inhibits genotypes CCC 3.3 and PWBG 7.1 than the formation of leaves, these genotypes of Bambara were regarded as drought sensitive. In addition, osmotic stress caused by a concentration of 10% PEG delayed the germination of all genotypes which have the ability to germination in this concentration compared with control 0%. It was noted there was a difference between genotypes in water imbibition rate because of osmotic stress caused on concentrations PEG and the genotypes showed differences in drought tolerance, where genotype PWBG 6 showed speed in germination. As well as, BBL 6.2.1, PWBG 5.2.1 and SS 2.4.2 had a higher number of leaves. also, the genotype PWBG 5.2.1 was the longest hypocotyl. While genotype BBL 1.1 was the longest root. In addition, genotype SS 3.4.2 was the highest fresh weight. Furthermore, genotypes SS 2.4.2, SS 3.4.2 were the highest dry matter compared with other genotypes. The genotypes BBL 1.1, PWBG 5.2.1, PWBG 6, SS 2.4.2, SS 3.4.2 and Tvsu 86 performed better and were classified as drought tolerant. However, these genotypes need to be tested in the field under drought conditions and assess their performance.

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