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Effects of drought and flooding on beans (*Phaseolus vulgaris* L.) and groundnut (*Arachis hypogaea* L.): a comparison

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Abstract

Effects of drought and flooding on bean (*Phaseolus vulgaris* L.) and groundnut (*Arachis hypogaea* L.) were carried out and compared. Plant growth parameters, biomass content, chlorophyll, ash and soil metal content were studied. The result showed that bean was 21.3cm, 21.8cm and 21.1cm for control, drought and flooding while groundnut recorded 19.9cm, 102.3cm and 18.6cm for control, drought and flooding respectively. Biomass composition recorded little or no variation in fresh weight of stem in bean while groundnut varies from 4.77g – 5.05g accordingly. Leaf recorded highest value of fresh weight to be 6.44g recorded in bean cultivated in drought soil with the least recorded to be 3.61 in the control and flooded soil for groundnut plant. The result of the study showed that drought and flooding had relatively positive effects on the growth properties of bean and groundnut as both plants were able to germinate and grow under both conditions.

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Introduction

Plant's adaptive potentials to environmental factors like drought and flooding effects soil environment (Mensah *et al.,* 2006). Growth of plant is affected by deficit of water which affects germination of seeds. Although, the use of glycol and glucose solution to stimulate growth in water deficit areas has been reported (Mensah and Okpere, 2000), the rate of drought is still unpredictable and determining factor in crop growth across some regions in the world (Cerekovi*et al.,* 2013). Factors such as ability of soil to store water, rainfall pattern and soil evaporation are responsible for possible drought incident which in turn influence plant growth (Blum, 2005). The outcome of drought are expressed in leaf area reduction, stunted height and dry mass of plants (Pagter *et al.,* 2005) as well as reduction in plant yield (Ratnakumar and Vadez, 2011).

Water availability is important in the process of growth. However, excess water in the form of flooding also result to water stress and causes difficulty in seed germination as some seeds are sensitive to excess water (Sesay, 2009). The duration of flood as experienced by plant in a waterlogged condition is a factor which determines the response of plant growth and yield (Gomathi *et al.,* 2014). Several research on the effects of drought and flooding conditions on sugarcane has been documented (Gomathi *et al.,* 2014; Viator *et al.,* 2012). The study of Wuebker *et al.* (2001) showed that germination was interrupted by flooding and waterlogged condition. In recent times, climate change and environmental degradation occurring in Nigeria and particularly in the Niger Delta Region has resulted in several factors including flooding and drought.

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This has resulted in devastating effects on the production of food for the teaming population.

Based on the context of drought and flooding, this study was carried out to determine the comparative effects of drought and flooding on bean (*Phaseolus vulgaris* L.) and groundnut (*Arachis hypogaea* L.).

Materials and methods

Experimental procedures

The study was conducted between September, 2018 and January, 2019 in Site II, Delta State University. Seeds were sourced locally and used soil sample obtained from virgin soil close to Ethiope River, Abraka, Delta State. The experiment was set up in a complete randomized block design with three replicates for both flooding and drought. Plant parameters studied include plant height, number of leaves, leaf area, number of dead leaves, biomass content, chlorophyll, ash content and soil metal content. The method of Famuwagun and Agele (2010) was adopted for planting. The bowls were perforated at the bottom to allow water from the soil to flow. Three seeds were sown in each plastic bowl. Flooding was done by applying excess water to the plants daily for six (6) weeks throughout the experiment. The bowls were later wrapped with polyethylene bag to avoid runoff of water from the bowl. Drought was induced by restriction of water from the plants with application of water every two weeks.

Determination of plant growth parameters

Plant parameters such as plant height, number of leaves, leaf area, flower production, number of dead leaves, biomass, ash content and chlorophyll and metal content of the soil were determined. Plant height was taken by measuring the plant from the base to the tip using a graduated meter rule (Khan *et al.,* 2008). Number of leaves was determined by counting the leaves of a specific plant throughout the study. Leaf area was measured by multiplying the length and breadth of the leaf. Number of dead leaves was recorded by counting the number of fallen leaves. The biomass (fresh and dry weight) was obtained by weighing the plant after harvest for fresh weight and drying the plant in oven for five days and the weight recorded.

Chlorophyll content was determined by collecting the first three leaves of the plant and immersed in 20 ml of 80% acetone in a MacCkonkey bottle for 24 hours. Four curvette, one containing acetone and three containing the samples were made. The curvette were read on a spectrophotometer to obtain the chlorophyll contents of the plant (Pramod *et al.,* 2015). The ash content was determined by transferring empty crucible into oven and dry for about 30 minutes at 105^{o}C. The crucible were transferred into a dessicator and allowed to cool for about one hour. The weight of the crucible was recorded as M_1. The sample was added and the weight taken as M_2. The crucible was transferred with the sample into furnace and the temperature set at 350^{0}C for about one hour. The temperature was increased to about 550^{0}C till the sample was completely ashed to white. The crucible was then transferred to the dessicator and allowed to cool for about one hour and weighed.

Results and discussion

The study showed that both drought and flooding had different effects on the growth of the plants compared to the control although there were slight variations in some of the parameters examined during the study. Bean recorded 21.3, 21.8 and 21.1 cm for control, drought and flooding while groundnut recorded 19.9, 102.3 and 18.6 cm for control, drought and flooding respectively with highest value recorded in drought subjected groundnut (102.3 cm) while the least was 18.6cm recorded in groundnut subjected to flooding (Table I). There was little or no difference in bean grown drought and flooded soils as well as the control. The plant recorded 9.8, 9.55 and 9.23 cm for control, drought and flooded soils, respectively. Also, groundnut recorded highest value of 41.3 in flooded soil followed by 25.1 and 18.7 for drought and control respectively (Table II). From the results, there were relatively high leaf area in all the plants with the highest value of 477.6 cm^2 recorded in drought cultivated

Table I. Height of plants subjected to flooding and drought

Plants	Weeks after planting						Mean
	2	3	4	5	6	7	
Control							
Beans	10.8	15.9	20.0	21.8	27.3	32.0	21.3
Groundnut	7.5	10.4	18.7	21.2	28.3	33.3	19.9
Drought							
Beans	11.0	17.4	20.0	23.0	27.5	32.2	21.85
Groundnut	6.8	10.9	15.7	17.8	23.2	27.9	10.23
Flooded							
Beans	12.0	16.4	19.9	22.1	25.5	30.7	21.1
Groundnut	9.3	11.1	18.0	19.2	24.7	29.5	18.6

Table II. Number of leaves of plants subjected to flooding and drought

Plants	Weeks after planting						Mean
	2	3	4	5	6	7	
Control							
Beans	3.2	5.0	8.7	10.0	14.9	17.0	9.8
Groundnut	5.8	10.1	11.3	25.3	21.0	38.7	18.7
Drought							
Beans	3.9	5.0	8.1	10.3	12.0	18.0	9.55
Groundnut	10.1	18.9	25.3	24.7	30.3	41.3	25.1
Flooded							
Beans	5.0	7.1	9.0	10.0	11.0	13.3	9.23
Groundnut	15.0	25.9	36.0	46.0	54.3	70.3	41.3

groundnut while the least value of 199.2cm^2 was recorded in the control plant. Beans recorded leaf area of 3.11 and 357.8 cm^2 for flood and drought cultivated soils, respectively (Table III). The results of this study showed that both drought and flooding had general effects on groundnut and bean, although drought positively affected the growth of groundnut plant resulting in extensively high plant height. While flooding reduced the plant height of groundnut as indicated by changes in plant height, leaf area and dry weight. The results are comparable to those of Rahman *et al.* (2000). The decrease in plant height was proportional to the extent of drought conditions imposed on the plant. This is also similar to the results of Liu *et al.* (2014) who reported that plant height was not significantly affected by flooding. Similarly, Wright *et al.* (2017) found that plant species were less affected by flood. According to Anjum *et al.* (2017) drought stress imposes alteration in some crucial plant developmental processes including plant height, leaf area and dry matter. As observed in this study the effect established that leaf area increased under severe water stress and that on the removal of the stress, the rate of growth of the leaf was also similar as in the control. In the present studies, similarities and differences have been recorded in the effects that flooding and drought have on groundnut and bean plants. Due to the generation of hypoxia, flooding reduces water absorption and stomatal conductance, causing plants such as bean and groundnut to wilt in a similar way as if it is under drought conditions (Mensah *et al.,* 2006).

In the results of flower production, groundnut recorded 1.7, 2.3 and 2.0 for control, drought and flooded soil, respectively in terms of flower production (Table IV). The mean value of the number of dead leaves was 1.53, 0.233 and 1.1 for

Table III. Leaf area of plants subjected to flooding and drought

Plants	Weeks after planting						Mean
	2	3	4	5	6	7	
Control							
Beans	474.3	264.4	223.2	433.6	450.0	465.1	385.1
Groundnut	27.3	122.7	164.7	255.5	301.3	323.8	199.2
Drought							
Beans	96.53	242.9	323.1	466.6	580.2	517.7	357.8
Groundnut	303.6	148.1	321.8	681.4	690.1	720.3	477.6
Flooded							
Beans	473.4	249.4	302.4	251.6	271.8	322.2	311.8
Groundnut	285.8	304.2	453.8	466.6	482.2	499.1	415.3

Table IV. Flower production of plants subjected to flooding and drought

Sample	Weeks after planting		
	5	6	7
Control			
Beans	0	0	0
Groundnut	1.0	1.7	1.7
Drought			
Beans	0	0	0
Groundnut	2.0	2.0	2.3
Flooded			
Beans	0	0	0
Groundnut	2.0	1.3	2.0

Table V. Number of dead leaves of plants subjected to flooding and drought

Samples	Weeks after planting				Mean
	4	5	6	7	
Control					
Beans	1.0	1.7	1.7	1.7	1.53
Groundnut	6.3		1.3	2.3	2.48
Drought					
Beans	0.3	0	0	0.6	0.225
Groundnut	3.3	2.0		0.6	1.48
Flooded					
Beans	1.0	1.7	1.7	0	1.1
Groundnut	2.7	1.0	2.3	0	1.5

Table VI. Fresh / dry weight and ash content of plants subjected to flooding and drought

	Fresh weight			Dry weight			Ash content		
	Stem	Leaf	Root	Stem	Leaf	Root	Stem	Leaf	Root
Control									
Beans	5.05	3.70	1.99	0.79	0.74	0.38	75%	81.1%	39.5%
Groundnut	5.16	3.61	1.07	1.14	1.15	0.25	50%	68%	69%
Drought									
Beans	6.74	6.44	1.69	1.03	1.06	0.38	39%	32%	24%
Groundnut	5.19	3.66	1.29	0.99	0.73	0.37	62%	77%	14%
Flooded									
Beans	4.77	5.17	1.53	0.86	1.00	0.34	77%	3%	44.1%
Groundnut	5.66	3.61	1.48	1.13	0.88	0.41	36%	46%	73%

control, drought and flooded bean plant, respectively. Also, groundnut recorded 2.48, 1.48 and 1.5 for control, drought and flooded soils, respectively (Table V). The results indicated little or no variation in fresh weight of stem in bean while groundnut varies from 4.77–5.05g accordingly with leaf recording highest value of fresh weight to be 6.44g in bean cultivated in drought soil while the least was recorded to be 3.61g in the control and flooded soil for groundnut plant. Also, there was no significant difference in fresh weight of root in the control, flooded and drought soil. The results of the dry weight of stem recorded 0.79, 1.03 and 0.89g for bean and 1.14, 0.99 and 1.13g for bean and groundnut in control, drought and flooded soils, respectively while leaf fresh weight recorded 0.74, 1.06and 1.0g for bean and 1.15, 0.73 and 0.88g for groundnut, respectively. The ash content was highest in the bean plant grown in control (81.1%) in leaf

Table VII. Chlorophyll content of plants subjected to flooding and drought

	Chlorophyll(a)	Chlorophyll (1a)	Mean
Control			
Bean	0.20	0.60	0.80
Groundnut	0.24	0.61	0.85
Flood			
Bean	0.26	0.52	0.78
Groundnut	0.35	0.38	0.73
Drought			
Bean	0.29	0.55	0.84
Groundnut	0.25	0.61	0.86

Table VIII. Metal content of drought and flooded soil

Code	N	P	K	Na(g)	Ca(g)	Mg (g)
Control						
Beans	0.260	0.214	2.540	0.170	2.000	1.485
Groundnut	0.171	0.231	2.900	0.284	2.581	0.914
Drought						
Beans	0.273	0.281	1.767	0.321	2.481	1.103
Groundnut	0.211	0.214	2.109	0.397	3.009	0.780
Flooded						
Beans	1.521	0.248	2.813	0.400	2.489	1.480
Groundnut	1.281	1.118	2.315	0.600	2.222	1.321

followed by groundnut (77%) for drought and in stem for flooded soil (Table VI). The result showed that chlorophyll was highest in drought soil with beans having 0.86% chlorophyll. This was followed by the control in groundnut with 0.85% chlorophyll (Table VII). Soil potassium and calcium were relatively higher in all soil samples compared to soil nitrogen, phosphorus and sodium. Although, magnesium varies slightly from potassium and calcium in all samples (Table VIII). However, result from the present study shows difference from other study, where crops exposed to drought and prolonged drought experienced a reduction in growth (Thanankorn *et al.,* 2016). This is also similar to the report of Farooq *et al.* (2009), Larcher (2003) and Hidaka and Karim (2007). Also, Zeid and Shedeed (2006) reported on the effects of water deficit while, Liu *et al.* (2014) showed that flood incidence reduced root length.

Conclusion

The result of the study showed the effects of water regime and drought condition on the growth of leguminous crops. On the basis of chlorophyll content under both drought and flooding conditions, it could be inferred from the present study that both groundnut and bean plant are drought resistant able to withstand flooding. Both severe drought and continuous flooding resulted in low yield in terms of pods/plant and seed yield/plant. Some plants did not flower at all under flooding while others showed high abortion rate of floral parts. However, there is need to examine the long term effects of these conditions in order to establish the actual environmental conditions favourable for both plants.

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