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Effect of Watering Regimes on Yield and Agronomic Traits of Exotic Groundnut Genotypes in Tanzania

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Authors' contributions

This work was carried out in collaboration between both authors. Both authors read and approved the final manuscript.

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ABSTRACT

Groundnut (*Arachis hypogaea* L.) production in rain fed regions of Africa is mostly affected by intermittent drought of different duration and intensity. Improvement of groundnuts for drought tolerance could increase production in drought prone areas. Therefore, this study aimed at (i) determining the effect of Watering regimes on yield and agronomic traits of exotic Groundnut genotypes and (ii) identifying drought tolerant genotypes as source material for breeding and drought tolerant varieties. Thirty groundnut genotypes were evaluated for drought tolerance under well watered and water stress conditions in the screen house at Sokoine University of Agriculture (SUA), Tanzania. A split plot design with four replications was used whereby the watering regimes were the main plots with varieties planted as subplots Data were recorded on plant height, number of pod/plant and pod yield/plant. Results showed that drought significantly reduced pod yield, number of pods/plant and plant height. Eleven genotypes namely; ICG 2106, ICR 48, ICGS 44, ICG 3053, ICG 11088, ICGV-SM 87003, ICG 12235, ICG 13723, ICGV 02271, ICGV 97182 and ICGV 91114 gave better pod yield and number of pods/plants in water stress conditions and are recommended for use in breeding program as drought tolerant varieties and sources for breeding materials.

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Keywords: Pod yield; watering regimes; groundnut genotypes; drought; number of pods.

1. INTRODUCTION

Groundnut (*Arachis hypogaea* L.) is the world's fourth most important source of edible oils, third most important source of vegetable protein and thirteenth most important crop. It has 44 to 50% edible oil, 25% easily digestible protein and 20% carbohydrate [1]. Groundnut is mostly cultivated as a rain fed crop by the resource poor farmers, hence affected by intermittent drought stress of different duration and intensities. Despite the importance of groundnut in Tanzania, its productivity is still low with an average of 718 kg ha^{-1} [2] compared to the potential yield of 1500 kg/ha [3]. Low groundnut productivity is caused mostly by drought among other abiotic stress. Most of the groundnut growing areas such as Dodoma, Singida, Shinyanga, Tabora and Mtwara in Tanzania are affected by intermittent drought of different duration and intensity. It may occur for a short time without severe adverse physiological impact but sometimes lasts throughout an entire growing season or even years, resulting in complete devastation of crops. Naturland [4] reported that groundnut require 500-1000 mm of rainfall which is well distributed during the growth period to produce optimum yields for the varieties which take more than 100 days to attain physiological maturity. Yield loss in groundnut caused by drought is estimated to be 56 – 85% depending on the stage of growth in groundnut that is affected by drought [5].

Drought at flowering may cause significant flower drop and low pod set whereby the magnitude of reduction depends on groundnut variety used [6]. In addition to yield loss, the qualities of products also decreases under drought stress [7]. Water deficits during flowering can result in a decrease in flowers number and a delay in time to flower (Lenka and Misra, 1973; Hemalatha et al. [8]). However, since only 15-20% of flowers result in pods that contribute to yield [9], reduction in flowers number arising from water deficits may not directly influence pod yield. Also groundnut can compensate for reduced flowers number resulting from water deficits by producing a flush of flowers once the stress has been relieved (Gowda and Hegde, 1986; Singh and Kumar, [10]).

Water deficits during pegging and pod set decrease yield primarily by reducing pod number. Groundnut cultivars differ in their pegging and pod set response to soil water deficits, some maintain a peg production efficiency (ratio of pod number to peg number) of about 0.8 irrespective of a drought applied during the early reproductive phase (17 – 72 days after planting) while other genotypes had an efficiency of only 0.15 during drought [11]. Therefore, this study aimed at (i) determining the effect of Watering regimes on yield and agronomic traits of exotic groundnut genotypes and (ii) identifying drought tolerant genotypes as source material for breeding and drought tolerant varieties.

2. MATERIALS AND METHODS

2.1 Experimental Site

The study was conducted at Sokoine University of Agriculture (SUA) farm which is located at S 06° 50' 24.7" and E 37° 38' 59.8", Morogoro, Tanzania. The mean annual rainfall at Morogoro is 1031 mm and temperature range 18.6 – 30.0°C. The temperature range was 25 - 31°C and the relative humidity was 85 – 95% in the screen house during the experiment period.

Thirty groundnut genotypes from reference set collection developed at ICRISAT, Patancheru, India were used Table 1.

2.2 Experimental Layout and Management

Thirty groundnut genotypes were evaluated for drought tolerance and yield under different watering regimes in a screen house. The experiment was planted on 15th December, 2012. A split plot design with four replications was used whereby the watering regimes were the main plots with varieties planted as subplots. Three seeds of each genotype were planted in a pot of 12 kg of soil with five drainage holes. Weeds were controlled by hand weeding and insects were controlled by spraying Thionex 35 EC at the rate of 2 ml/litre of water.

After sowing, 500 ml of water were applied to each pot and then twice on alternate days with 250 ml of water until the seedlings emergence. The plants were thinned to two individuals per pot at 7 days after sowing (DAS) and then to a single plant per pot at 14 DAS. The crops were irrigated with 2 litres of water at 5 days intervals from sowing to about flowering time, by compensating evapotranspiration. From there onwards, irrigation for water stressed plants (WS) was 2 litres of water after every 10 days and for well watered (WW) 2 litres of water were applied to each pot after every 5 days. The decision to irrigate was based on leaf wilting symptoms of WS plants, irrigation being supplied when the wilting score of a majority of WS plants reached a value of three and below score of two for WW plants [12].

Table 1. Botanical types and origin of 30 groundnut genotypes

S. no.	Genotype	Country of origin	Market type
1	55-437	America	Valencia
2	FLEUR 11	ICRISAT	Spanish
3	ICG 11088	ICRISAT	Virginia
4	ICG 11862	ICRISAT	Virginia
5	ICG 12235	ICRISAT	Virginia
6	ICG 12879	ICRISAT	Spanish
7	ICG 13723	ICRISAT	Virginia
8	ICG 1834	ICRISAT	Spanish
9	ICG 2106	ICRISAT	Spanish
10	ICG 2777	ICRISAT	Virginia
11	ICG 3053	ICRISAT	Virginia
12	ICG 3584	ICRISAT	Spanish
13	ICG 8106	ICRISAT	Valencia
14	ICG 8567	ICRISAT	Spanish
15	ICG 8760	ICRISAT	Virginia
16	ICG 97182	ICRISAT	Valencia
17	ICG 9961	ICRISAT	Virginia
18	ICGS 44	ICRISAT	Valencia
19	ICGV 02038	ICRISAT	Valencia
20	ICGV 02189	ICRISAT	Valencia
21	ICGV 02271	ICRISAT	Valencia
22	ICGV 02290	ICRISAT	Virginia
23	ICGV 88145	ICRISAT	Valencia
24	ICGV 91114	ICRISAT	Spanish
25	ICGV 95377	ICRISAT	Valencia
26	ICGV 97182	ICRISAT	Valencia
27	ICGV 99001	ICRISAT	Spanish
28	ICGV-SM 87003	ICRISAT	Spanish
29	ICR 48	India	Virginia
30	JL24	ICRISAT	Spanish

2.3 Data Collection and Analysis

At harvest time, data on plant height (cm) and number of pods per plant for each genotype were measured and recorded. After harvesting, the groundnut pods from individual plant were air dried separately and weighed to get pod yield/plant. The collected data, were analyzed using GenStat 14th edition Statistical package. A t-test analysis was performed to determine the effect of watering regimes for the measured parameters between the pairs of genotypes planted under the two watering regimes at 5% level of significance. Analysis of variance (ANOVA) was performed to test for significant differences among the genotypes in each watering regime for the measured traits following a mathematical model: $Y_{ij} = \mu + \alpha_i + \varepsilon_{ij}$. Where; Y_{ij} = the observed response, μ = the grand mean, α_i = the effect of the i^{th} genotype, ε_{ij} = is the random error [13]. The genotypes means were compared using Duncan's multiple range test at 5% level of significance.

3. RESULTS AND DISCUSSION

3.1 Pod Yield

Generally pod yield per plant was significantly reduced by water stress from 11.9 g/plant under well watering condition to 8.8 g/plant under water stress condition. The difference in pod yield per plant for each pair of groundnut genotype planted under two watering regimes obtained from t-test showed no significant to highly significant effect of watering regimes in pod yield per plant for the pairs of groundnut genotypes (Table 2). This study supports the previous findings, that drought stress significantly reduced pod yield in groundnut [14].

Analysis of variance revealed very high significant difference ($P \leq 0.001$) among groundnut genotypes for pod yield/plant under water stress and well watering conditions (Table 2). Pod yield per plant under water stress condition had a range of 4.1 – 10.9 g/plant. The highest pod yielding genotype under water stress condition was ICG 2106 which was followed by ICR 48, ICG 8106, ICGS 44, ICG 3053 and ICG 11088. Pod yield under well watering condition ranged from 7.1 to 15.9 g/plant. The highest pod yielding genotype under well watered condition was ICG 8106 which was followed closely by ICG 2777, ICG 11862, ICGV 95377 and ICGS 44.

3.2 Number of Pods per Plant

Drought stress reduced significantly the number of pods/plant to the average of 11 pods/plant while under well watering condition the average number of pods/plant was 15. Paired t-test showed highly significant difference ($P \leq 0.001$) for the number of pods per plant between well watering and water stress conditions (Table 2). The difference in number of pods/plant for each pair of groundnut genotype planted under two

Table 2. Mean pod yield, number of pods and plant height in well watered and water stress condition

Genotypes	Number of pods/plant			Plant height (cm)			Pod yield (g/Plant)		
	WW	WS	T-test	WW	WS	T-test	WW	WS	T-test
55-437	14cdef	11cdf	*	36f	35bcdef	ns	12.8bcdf	8.4bcde	*
FLEUR 11	12ef	8gh	*	44def	36abcdef	*	11.8bcdfghi	8.3bcde	*
ICG 11088	14cdef	11cdf	ns	50bcde	37abcde	*	12.2bcdfgh	9.9abc	ns
ICG 11862	16bcde	11cdf	*	46cde	37abcde	*	13.8abc	8.9abcd	**
ICG 12235	12ef	8gh	*	60a	43a	*	9.8ghij	8.6abcd	ns
ICG 12879	17abcd	14ab	ns	50bcde	33cdef	***	12.6bcdf	9.2abc	*
ICG 13723	17abcd	12bcd	*	43ef	35bcdef	ns	9.5hij	9.1abc	ns
ICG 1834	16bcde	12bcd	ns	48cde	33cdef	*	13.2abcdf	9.5abc	*
ICG 2106	18abc	13bc	ns	47cde	38abcde	ns	12.9bcdf	10.9a	ns
ICG 2777	21a	12bcd	*	45cdef	33cdef	*	14.5ab	8.8abcd	*
ICG 3053	17abcd	16a	ns	44def	29f	**	12.9bcdf	10.1abc	ns
ICG 3584	17abcd	10dfg	**	47cde	33cdef	*	12.2bcdfgh	8.5bcde	**
ICG 8106	14cdef	10dfg	*	47cde	38abcde	*	15.9a	10.3abc	*
ICG 8567	16bcde	12bcd	*	47cde	37abcde	*	12.1bcdfgh	9.1abc	*
ICG 8760	11f	6h	*	53abcd	36abcdef	*	7.1j	4.1f	*
ICG 97182	17abcd	13bc	ns	47cde	38abcde	*	13.4abcd	9.3abc	**
ICG 9961	14cdef	12bcd	ns	45cdef	35bcdef	*	10.5fghi	6.7de	**
ICGS 44	17abcd	12bcd	*	47cde	32def	**	13.5abcd	10.2abc	ns
ICGV 02038	15bcdef	11cdf	ns	47cde	37abcde	ns	12bcdfghi	8cde	*
ICGV 02189	16bcde	13bc	*	49bcde	37abcde	*	10.9dfghi	8.7abcd	*
ICGV 02271	12ef	10dfg	ns	42ef	32def	*	11.5cdfghi	9.1abc	ns
ICGV 02290	17abcd	12bcd	*	51abcde	38abcde	*	12.5bcdfg	8.2cde	*
ICGV 88145	12ef	10dfg	ns	49bcde	41ab	ns	12.2bcdfgh	9abcd	**
ICGV 91114	13def	9fg	*	54abc	40abc	*	10.5fghi	8.1cde	ns
ICGV 95377	19ab	14ab	*	46cde	40abc	ns	13.6abcd	8.9abcd	**
ICGV 97182	13def	12bcd	ns	60a	31ef	**	9.3ij	8.3bcde	ns
ICGV 99001	16bcde	13bc	ns	58ab	39abcd	*	7.6j	6.2ef	ns
ICGV-SM 87003	13def	13bc	ns	51abcde	37abcde	*	11.8bcdfghi	9.3abc	ns
ICR 48	13def	11cdf	ns	44def	32def	*	12bcdfghi	10.6ab	ns
JL24	15bcdef	10dfg	*	43ef	33cdef	*	13.1bcdf	9.1abc	*
Mean	15	11	***	48	36	***	11.9	8.8	***
CV (%)	21.6	20.8		14.3	16.3		16.6	19.4	
LSD	5	3		10	8		2.8	2.4	
Fpr.	**	***		**	ns		***	***	

*CV= Coefficient of Variation, LSD= List square difference, Fpr= variation ratio, ns= not significant, *, **, *** Significant at P ≤ 0.05, P ≤ 0.01 and P ≤ 0.001, respectively*

watering regimes obtained from t-test showed no significant to highly significant effect of watering regimes in number of pods/plant for the pairs of groundnut genotypes (Table 2).

Analysis of variance (Table 2) showed highly significance variance (P ≤ 0.001) in number of pods/plant among groundnut genotypes under water stress condition with the range of 6 to 16 number of pods/plant. The highest number of pods/plant under water stress condition was observed in ICG 3053 which was followed by ICG 12879, ICGV 95377, ICGV-SM 87003 and ICGV 99001.

Highly significant (Table 2) variation (P ≤ 0.01) among groundnut genotypes for the number of pods/plant under well watering conditions was observed. The number of pods/plant under well watering condition ranged from 11 to 21. The highest number of pods/plant under well watering condition was observed in ICG 2777 followed closely by ICGV 95377, ICG 2106, ICG 97182 and ICG 3053. Water deficits during pegging and pod set in groundnut reduce pod number while water deficits during pod filling generally reduce pod and kernel weight [11].

3.3 Plant Height

Groundnut shoot growth was significantly reduced by water stress to an average of 36 cm while under well watering condition the average plant height was 48 cm (Table 2). The difference in plant height for each pair of groundnut genotype planted under two watering regimes obtained from t-test showed no significant to highly significant effect of watering regimes in plant height for the pairs of groundnut genotypes (Table 2). Analysis of variance showed highly significant difference ($P \leq 0.01$) in plant height among genotypes under well watered condition while no significant difference ($P \leq 0.05$) was observed under water stress condition (Table 2). Stem growth in groundnut is reduced by water deficit through reduction in plant water status, photosynthesis and leaf expansion [11]. Therefore groundnut genotypes with non-significance difference in plant height under the two watering regimes have stable shoot growth.

4. CONCLUSION

The study revealed that, water stress significantly reduced pod yield, pod number and plant height. Genotypes ICG 8106, ICG 2777, ICG 11862, ICGV 95377 and ICGS 44 were identified as high pod yielding under well watered condition and ICG 2106, ICR 48, ICG 8106, ICGS 44, ICG 3053 and ICG 11088 as high pod yielding genotypes under water stress condition. Eleven genotypes were identified as drought tolerant based on their stability in pod yield in the two watering regimes, these includes ICG 2106, ICR 48, ICGS 44, ICG 3053, ICG 11088, ICGV-SM 87003, ICG 12235, ICG 13723, ICGV 02271, ICGV 97182 and ICGV 91114. The identified drought tolerance genotypes are good sources of drought tolerance genes to be used in groundnut breeding programs.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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