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Influence of water stress on growth and yield components of selected pigeonpea genotypes

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Abstract: Drought and high temperature mostly influence growth and development of pigeonpea, resulting in forced maturity. Though these stresses have a drastic impact on reducing productivity of pigeonpea, limited efforts have been made towards development of pigeonpea genotypes having tolerance to these abiotic stresses. Therefore, this study was carried out to identify pigeonpea genotypes that can tolerate water stress. A greenhouse experiment was conducted at Upper Kabete field station of the University of Nairobi, Kenya, using fifteen selected pigeonpea genotypes based on ICRISAT descriptors. The fifteen plants were grown under drought stress levels of 40% and 80% field capacity (FC) in comparison to non-drought stress (100% FC) condition in a randomized complete block design with a factorial arrangement with three replications. Data was collected on plant growth, physiological and yield attributes. Drought stress reduced 100 seed weight by 14.9 %, number of pods (31.9%) and pod diameter (25%). At the lowest moisture level (40 % FC), drought stress reduced pod weight by 84 %, pod length (2 %), Chlorophyll content (11.9 %) and shell weight (2.4 %). However, reduction of moisture level to 80% FC recorded an increase in pod weight (5.5 %) and pod length (3.4 %) and no significant effect on chlorophyll content and number of seeds per pod. Genotypes ICEAPs 182022, 182014, 182013, 19023 and 86012 performed better in relation to growth and yield despite the increased levels of drought stress. The few identified genotypes can be utilized as potential parents in breeding for drought tolerance.

Key Words: Drought tolerance, field capacity, physiological traits, pigeonpea, water stress,

Introduction

In the tropics, one of the most significant environmental challenges to plant survival, production, and food security is drought (Ifejika et al., 2010). Pigeonpea is still one of the legumes that can withstand drought the best, and it is frequently the one of the crop that produces some grain production during dry spells when other legumes like field beans will have wilted and maybe dried up (Odeny, 2007). Because of its deep roots and osmotic adjustment (OA) in the leaves, the pigeonpea is better able to endure prolonged drought than many other legumes (Subbarao et al., 2000). Compared to other drought-tolerant legumes like cowpea, the legume also maintains photosynthetic function under stress more effectively (Khatun et al., 2021). Additionally, because of its distinctive polycarpic flowering behavior, the crop can shed reproductive structures in reaction to stress(Khan et al., 2023). Pigeonpea is a smallholder crop, thus it does not require a lot of imported inputs in Africa. However, compared to many other legumes, it can fix up to 40 kg of nitrogen (N) per hectare and produces more nitrogen per unit area from plant biomass (Mugi et al., 2022). Although one of the most plentiful elements on earth, nitrogen is also the nutrient that limits agricultural productivity the most. Pigeonpea's capacity to fix nitrogen is desired for environmentally friendly agricultural production (Mugi et al., 2022). Pigeonpea rarely needs inoculation since it can nodulate on Rhizobium, which is naturally present in most soils, but most legumes need it to maximize their capacity for fixing nitrogen (Musokwa and Mafongoya, 2021). The effectiveness of vesicular-arbuscular mycorrhizae (VAM) fungi has been observed to be highest in pigeonpea when compared to cowpea and groundnut, even in the event that the legume is inoculated (*Arachis hypogea* L.). Pigeonpea development, particularly in vertisols, is improved by vesicular-arbuscular mycorrhizae (VAM), which also increases the nutrition of phosphate (P) and zinc (Zn) (Wellings et al., 1991).

Pigeonpea has the advantage of enhancing long-term soil quality and fertility when utilized as green manure, a cover crop, or an alley crop (Bodner et al., 2007).When applied as green manure, the legume can also lower the amount of root-knot nematodes in the subsequent crop. By utilizing pigeonpea as a cover crop, maize yields in West Africa have risen by 32.1%. (Sogbedji et al., 2006). Pigeonpeas' initial slow development lessens competition for light, water, and soil nutrients, reducing any adverse effects on the primary crop when intercropped, (Musokwa and Mafongoya, 2021). Pigeonpea N fixation during rotation farming can have a residual effect of up to 40 kg N/ha on a subsequent cereal crop (Mugi et al., 2022).

Pigeonpea is subjected to a variety of abiotic stresses, including moisture (waterlogging/drought), temperature, photoperiod, and mineral (salinity/acidity) stress throughout its life cycle (Megha & Singh, 2023). Because pigeonpea is typically grown as a rain-fed crop, moisture stress is one of these challenges that is frequently encountered. Extreme temperature stress (too low/too high) during the reproductive stage is a common cause of crop failure in the Eastern areas of Kenya. The effect of moisture stress is imposed at pre-flowering stage. The impact of drought stress on the growth and yield of particular pigeonpea types in Kenya is explained in this research. Since the turn of the century, production trends appear to be on the rise, possibly as a result of the area's declining rainfall levels.
The maximum production (1087 Kg/ha) and average output (718 Kg/ha) over the past 16 years are much lower than the crop's potential yield, which is still being studied (Ojwang et al., 2021). The legume is grown exclusively in rainfed environments at various latitudes, elevations, and temperatures (Kaoneka et al., 2016). Although it is mostly grown in parts of Africa that receive between 500 and 1000 mm of rain in two seasons, it is said to be highly adaptable to all temperatures and soil types (Upadhyaya et al., 2012). The present study provides comprehensive information on effect of water stress on growth and yield of selected pigeonpea genotypes to aid in identification of potential genotypes that can be utilized as source of breeding materials for drought tolerance.

Results and discussions

Variation in a hundred seed weight (g)

Genotypes responded to moisture level with a substantial difference. The relationship between genotypes and moisture level was quite significant at P≤0.05. The amount of moisture had a significant impact on the weight of one hundred seeds. The changes in genotypes were substantial despite the variations in stress intensity. At 100% FC, a high significant seed weight of 36.3 g was recorded, whereas at 40% FC, a substantially reduction of 26.7 g was recorded. The average weight of the seeds ranged from 24.3 g (ICEAP 86012) to 45.3 g (ICEAP 192023) as shown in Table 1. Similar results were discovered in pigeonpea by (Khan, 2017). Variation in seed weight may be due to reduced pod and seed number (Vanaja et al., 2015). During the late blooming and early pod development periods, when pigeon pea seed yield is particularly susceptible to dryness, total shoot dry matter (TDM), seed weight, and harvest index might all decrease(Nam et al.,2001).

Number of pods per plant variation

In response to moisture level, there is extremely significant variances among genotypes at P≤0.05. Number of pods per plant was significantly impacted by moisture stress. In response to moisture stress, there were no significant associations between moisture level and genotypes. The average pod count ranged from 33.3 pods (ICEAP 182070) to 68.7 pods (ICEAP 182022). At 40% field capacity, genotype ICEAP 182022 recorded the highest number of pods of 43.7 pods. Number of pods varied significantly from 28.7 pods (40% FC) to 78.7 pods (100% FC). Moisture stress reduced number of pods by 63.5 % from 100% FC to 40% FC (Table 1). The existence of a significant differential response among genotypes to drought stress treatment indicated the possibility of alleviating the adverse effects by appropriate selection of lines for different stress environments (Khan, 2017). In other legumes, it has been discovered that drought stress at this stage is more harmful than it is at other growth stages (Khan, 2017). Lack of source or reproductive sink capacity, competition from vegetative sinks and rigidity of other yield components may cause reduced pod density under water stress and rigidity of other yield components (Nisha Singh, 2023).A more focused strategy for increasing crop drought tolerance will be possible with a better understanding of plant characteristics impacting yield components under water stress (Farooq et al., 2017).

Variation in number of seeds per pod

The genotypes differed significantly in the number of seeds per pod at P≤0.05. The number of seeds per pod was not significantly impacted by moisture stress. The quantity of seeds per pod was considerably influenced by interactions between genotypes and moisture content. Between 3.2 (ICEAP 192023 and ICEAP 182022) and 4.4 (ICEAP 182274 and ICEAP 182016) seeds on average were found in each pod. Genotypes showed no difference in the typical number of seeds per pod at 100% FC, 80% FC, and 40% FC. The accessions recorded 3.9 seeds per pod at every moisture level (Table 2). This same number of seeds per pod seen regardless of moisture fluctuation may be explained by the partitioning of dry matter to roots, especially at an FC of 40%, which promotes the growth of deep roots. Through accelerated root growth, drought tolerant genotypes can prevent moisture stress (Toker & Mutlu, 2011).

Pod diameter(cm) variation

Significant differences in pod diameter were found between genotypes with a range from 0.4 cm (40% FC) to 1 cm (100 FC). While genotypes ICEAP 182014, ICEAP 182022, and ICEAP 192020 recorded the lowest pod diameters at 100 % FC, genotype ICEAP 182274 recorded the highest pod diameter of 1 cm. While at 40% FC, 41.7 % of the genotypes recorded a greater pod dimeter of 0.4 cm compared to 58.3 % of the genotypes that reported pod diameter of below 0.3 cm, ICEAP 182273 recorded the largest pod diameter at 80 percent FC genotypes, measuring 0.9 cm. At 40% FC, water stress decreased pod diameter by 62.5 % (Table 2). Girth reduction due to water stress have also been reported in spider plant (Mosenda et al., 2020). This may be attributed to shrinking of the pod diameter due to alteration in cell turgidity as a result of water stress (Mosenda et al., 2020). Moisture stress reduces cell growth rate and sizes of the stem hence resulting to thinner pods than when there is enough water supply (Beshir et al., 2016).

Pod length (cm) variation

Genotypes showed highly significant differences in pod length at P≤0.05 ranging from 4-7 cm for 100%FC. The amount of moisture had a substantial impact on pod length and significant interactions between genotypes and moisture level was also observed (Table 3). A range of the average pod length of 5.3 cm (40 % FC) to 5.4 cm (100 % FC) was shallow compared to the average pod length at 80 percent FC (5.7cm). Some possible characteristics that may improve drought resistance of pigeonpea include the ability to maintain total dry matter, low flowering synchronization, small pod size with a few seeds/pod and large 100-seed weight (Nam et al., 2001).

Pod weight (g) variation

Genotypes showed a considerable variance in pod weight P≤0.05 with significant effects by moisture stress. Pod weight fluctuated considerably, ranging from 14.9 g at 40% FC to 93.4

Table 1. Effects of water stress on a hundred seed weight and number of pods per plant on 15 selected pigeonpea genotypes.

	100 seed weight (g)				Number of pods			
Genotype	**100% FC**	**80% FC**	**40% FC**	**Mean**	**100% FC**	**80% FC**	**40% FC**	**Mean**
ICEAP 182002	35.0	27.0	26.0	29.3	80.3	55.3	30.3	55.3
ICEAP 182013	24.0	28.0	26.0	26.0	86.7	61.7	36.7	61.7
ICEAP 182014	28.0	31.0	33.0	30.7	91.3	66.3	41.3	66.3
ICEAP 182016	35.0	26.0	28.0	30.0	70.7	45.7	20.7	45.7
ICEAP 182022	25.0	26.0	27.0	26.0	93.7	68.7	43.7	68.7
ICEAP 182070	58.0	31.0	26.0	38.3	58.3	33.3	8.3	33.3
ICEAP 182272	47.0	28.0	25.0	33.3	81.0	56.0	31.0	56.0
ICEAP 182273	38.0	29.0	27.0	31.3	79.0	54.0	29.0	54.0
ICEAP 182274	34.0	30.0	34.0	32.7	75.7	50.7	25.7	50.7
ICEAP 182279	27.0	30.0	28.0	28.3	86.3	61.3	36.3	61.3
ICEAP 192020	37.0	32.0	24.0	31.0	73.0	48.0	23.0	48.0
ICEAP 192023	24.0	27.0	26.0	25.7	66.0	41.0	16.0	41.0
ICEAP 192025	84.0	29.0	23.0	45.3	80.0	55.0	30.0	55.0
ICEAP 192027	27.0	36.0	30.0	31.0	86.0	61.0	36.0	61.0
ICEAP 86012	22.0	33.0	18.0	24.3	72.0	47.0	22.0	47.0
Mean	**36.3**	**29.5**	**26.7**	**30.9**	**78.7**	**53.7**	**28.7**	**53.7**
P-Value (G)	<.001					<.001		
P-Value (ML)	<.001					<.001		
P-Value(G×ML)	<.001					<1		
LSD ≤0.05 (G)	2.5**					3.6**		
LSD ≤0.05 (ML)	1.1**					1.6**		
LSD ≤0.05 (G×ML)	4.3**					6.2ns		
CV %	8.50					7.10		

G-Genotype, ML-moisture level; Significant at **P≤0.01, ns-not significant.

Table 2. Effects of available water (% field capacity) on number of seeds per pod and pod diameter on the selected pigeonpea genotypes.

Number of seeds/pod					Pod diameter(cm)			
Genotype	**100% FC**	**80% FC**	**40% FC**	**Mean**	**100% FC**	**80% FC**	**40% FC**	**Mean**
ICEAP 182002	3.3	4.7	4.7	4.2	0.9	0.8	0.3	0.7
ICEAP 182013	4.7	4.0	4.0	4.2	0.8	0.7	0.3	0.6
ICEAP 182014	2.3	4.0	4.0	3.4	0.7	0.6	0.3	0.5
ICEAP 182016	4.3	4.7	4.3	4.4	0.8	0.7	0.2	0.6
ICEAP 182022	2.7	4.0	3.0	3.2	0.7	0.7	0.3	0.6
ICEAP 182070	4.0	4.0	4.7	4.2	0.9	0.7	0.4	0.7
ICEAP 182272	5.0	2.7	3.0	3.6	0.8	0.6	0.3	0.6
ICEAP 182273	4.7	4.7	2.3	3.9	0.9	0.9	0.3	0.7
ICEAP 182274	4.3	5.0	4.0	4.4	1.0	0.8	0.3	0.7
ICEAP 182279	6.0	2.3	4.7	4.3	0.8	0.7	0.3	0.6
ICEAP 192020	3.3	4.7	3.3	3.8	0.7	0.7	0.4	0.6
ICEAP 192023	3.7	2.3	3.7	3.2	0.9	0.8	0.4	0.7
ICEAP 192025	4.7	3.7	3.7	4.0	0.9	0.8	0.3	0.7
ICEAP 192027	3.0	3.0	4.7	3.6	0.9	0.7	0.4	0.7
ICEAP 86012	2.0	4.7	4.3	3.7	0.9	0.8	0.4	0.7
Mean	**3.9**	**3.9**	**3.9**	**3.9**	**0.8**	**0.7**	**0.3**	**0.6**
P-Value (G)		<.001				0.001		
P-Value (ML)		<1				<.001		
P-Value (G×ML)		<.001				<.0.468		
LSD ≤0.05 (G)		0.6**				0.1*		
LSD ≤0.05 (ML)		0.3ns				0.04**		
LSD ≤0.05 (G×ML)		1.1**				0.16ns		
CV %		17.10				15.90		

G-Genotype, ML-moisture level; * P≤0.05, **P≤0.01, ns-not significant.

g at 100% FC. The largest pod weight was 22.3 g at 40% FC documented for genotype ICEAP 182273. With moisture falling to 40% FC, there was a considerable reduction in pod weight of 84.05% (Table 3). Water stress lowers development and yield indices, in this case pod weight, according to earlier studies (Mosenda et al., 2020).

SPAD Value variation

Water stress significantly affected chlorophyll content of the selected genotypes. Genotypes and moisture level recorded significant interactions at P≤0.05 (Table 4). Moisture stress reduced SPAD value by 35.7 % at 40 % FC while no reduction of SPAD value was recorded at 80% FC. 40% FC recorded the

Table 3. Effects of available water (% field capacity) on pod length and pod weight of the selected pigeonpea genotypes.

	Pod length(cm)				Pod weight(g)			
Genotype	**100% FC**	**80% FC**	**40% FC**	**Mean**	**100% FC**	**80% FC**	**40% FC**	**Mean**
ICEAP 182002	7.0	5.0	6.0	6.0	98.3	90.7	9.3	66.1
ICEAP 182013	5.0	7.0	4.0	5.3	95.3	101.0	7.7	68.0
ICEAP 182014	6.0	5.0	6.0	5.7	104.7	102.0	6.3	71.0
ICEAP 182016	4.0	6.0	5.0	5.0	81.3	96.7	10.0	62.7
ICEAP 182022	5.0	8.0	5.0	6.0	95.0	100.0	21.0	72.0
ICEAP 182070	6.0	7.0	6.0	6.3	99.7	103.7	14.7	72.7
ICEAP 182272	4.0	6.0	5.0	5.0	80.3	93.7	19.0	64.3
ICEAP 182273	5.0	4.0	5.0	4.7	80.7	106.0	22.3	69.7
ICEAP 182274	5.0	5.0	6.0	5.3	80.7	102.0	13.0	65.2
ICEAP 182279	6.0	6.0	4.0	5.3	94.0	95.0	6.0	65.0
ICEAP 192020	5.0	5.0	6.0	5.5	94.7	100.0	21.0	71.9
ICEAP 192023	6.0	5.0	5.0	5.3	103.3	78.3	24.3	68.7
ICEAP 192025	6.0	4.0	5.0	5.0	105.7	101.7	16.7	74.7
ICEAP 192027	4.0	6.0	5.0	5.0	90.3	88.3	16.0	64.9
ICEAP 86012	7.0	6.0	6.0	6.3	97.3	90.0	15.7	67.7
Mean	**5.4**	**5.7**	**5.3**	**5.5**	**93.4**	**96.6**	**14.9**	**68.3**
P-Value (G)		<.001				<.001		
P-Value (ML)		<.001				<.001		
P-Value (G×ML)		<.001				<.001		
LSD ≤0.05 (G)		0.08**				2.28**		
LSD ≤0.05 (ML)		0.04**				1.02**		
LSD ≤0.05 (G×ML)		0.14**				3.96**		
CV %		1.60				3.60		

G-Genotype, ML-moisture level; Significant at **P≤0.01.

Table 4. Effects of available water (% field capacity) on chlorophyll content (SPAD value) and shell weight (g) of the selected pigeonpea genotypes.

	SPAD Value							
Genotype	**100% FC**	**80% FC**	**40% FC**	**Mean**	**100% FC**	**80% FC**	**40% FC**	**Mean**
ICEAP 182002	54.4	53.7	34.4	47.5	8.7	10.3	7.7	8.9
ICEAP 182013	55.5	52.6	34.3	47.5	7.3	8.5	6.3	7.4
ICEAP 182014	54.1	55.7	36.5	48.8	10.7	8.3	7.0	8.7
ICEAP 182016	52.0	60.1	34.5	48.9	5.3	6.0	10.7	7.3
ICEAP 182022	53.0	52.0	37.1	47.4	8.3	10.2	11.0	9.8
ICEAP 182070	53.8	53.2	34.6	47.2	7.0	7.7	7.0	7.2
ICEAP 182272	55.7	53.0	33.5	47.4	7.0	8.2	8.3	7.8
ICEAP 182273	53.4	54.5	33.0	47.0	7.7	7.5	8.0	7.7
ICEAP 182274	57.7	51.0	35.7	48.1	10.7	8.3	7.0	8.7
ICEAP 182279	51.5	51.3	38.0	47.0	8.5	7.3	4.7	6.8
ICEAP 192020	51.6	52.5	33.8	46.0	7.0	6.3	9.2	7.5
ICEAP 192023	57.4	54.9	35.1	49.1	9.0	8.3	8.0	8.4
ICEAP 192025	54.4	54.0	35.9	48.1	8.0	8.8	7.7	8.2
ICEAP 192027	53.4	58.0	32.9	48.1	8.3	5.7	6.8	6.9
ICEAP 86012	52.7	53.1	31.0	45.6	9.3	9.3	8.7	9.1
Mean	**54.0**	**54.0**	**34.7**	**47.6**	**8.2**	**8.1**	**7.9**	**8.0**
P-Value(G)		0.186				<.001		
P-Value(ML)		<.001				0.607		
P-Value(G×ML)		0.002				<.001		
LSD ≤0.05 (G)		2.4ns				1.43**		
LSD ≤0.05 (ML)		1.07**				0.64ns		
LSD ≤0.05 (G×ML)		4.15*				2.47**		
CV%		5.40				18.90		

G-Genotype, ML-moisture level; * P≤0.05, **P≤0.01, ns-not significant.

lowest chlorophyll content of 34.7 %. Average chlorophyll content varied from 45.6 SPAD value (ICEAP 86012) to 49.1 SPAD Value (ICEAP 192023). In two cycles of water stress and recovery in pigeonpea genotypes, Vanaja documented genetic variation for chlorophyll content, vegetative development, leaf water potential, relative water content, photosynthesis, and stomatal conductance (Vanaja et al., 2015).

Shell Weight (g) variation

Highly significant variations in shell weight among the evaluated genotypes at P≤0.05 was recorded with a mean range from 6.8 g (ICEAP 182279) to 9.8 g (ICEAP 182022). Moisture stress did not have significant effect on the weight of the shell. The genotypes and moisture levels showed strong interactions, which had a major impact on the shell weight (Table 4). The weight of the shell decreased by 2.5 percent and 1.2 percent,

Table 5. Average performance characteristics at different treatment levels (percentage of field capacity) for the 15 pigeonpea genotypes evaluated.

Treatment	SPAD Value	Shell Weight (g)	Pod length (cm)	Pod weight (g)	No of seeds/ plant	Pod diameter (cm)	100 seed weight(g)	Number of pods/ plant
100% FC	54	8.2	5.4	93.4	3.9	0.8	36.3	78.7
80% FC	54	8.1	5.7	96.6	3.9	0.7	29.5	53.7
40% FC	34.7	7.9	5.3	14.9	3.9	0.3	26.7	28.7
Mean	47.6	8.0	5.5	68.3	3.9	0.6	30.9	53.7
P-value	<0.01	<0.01	<0.001	<0.001	< 1	<0.001	<0.001	<0.001
LSD	1.07**	0.64**	0.04***	1.02***	0.3ns	0.04***	1.1***	1.6***
CV%	5.4	18.9	1.6	3.6	17.1	15.9	8.5	7.1

FC-field capacity, * P≤0.05, **P≤0.01, ***P≤0.001 and ns-not significant.

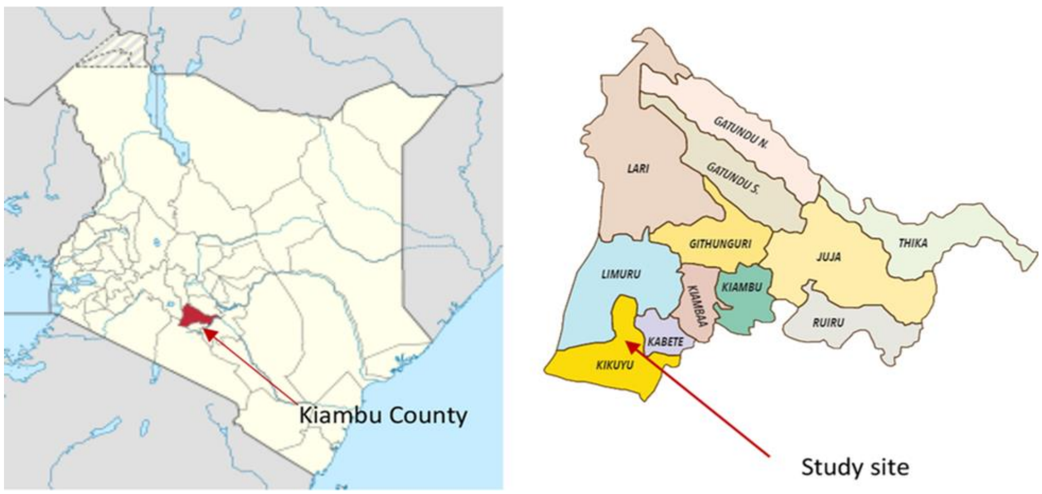

Fig. 1. Map of Kenya showing the experimental site.

respectively, when the moisture level dropped from 100% to 80% and 40%. Shell weight varied. Water stress affects crop phenology, yield parameters such as shell weight and finally results in low yield (Musokwa & Mafongoya, 2020).

Chlorophyll content (SPAD value), shell weight, pod length, pod weight, pod diameter, 100 seed weight, and number of pods were all considerably reduced by water stress. However, water stress had little impact on the quantity of seeds per pod (Table 5).

Materials and Methods

Study area description

Greenhouse experiment was carried out at the field station of the University of Nairobi, Upper Kabete campus, Kenya Fig. 1. The Kabete field station is located at an elevation of 1940 meters above sea level in a latitude of 00 14'45.00" S and a longitude of 360 44'19.51" E. The region is classified as upper midland zone three agro-ecologically (UM3). The experiment was carried out between April and September 2022. The ambient temperature ranged from 160 to 230 C with 1000 mm of precipitation on average per year. According to Jaetzold et al. (2007) the site has deep, well-drained dark reddish-brown clay humic nitisols with a pH range of 5.2 to 7.l.

Plant materials

Fifteen pigeonpea genotypes (ICEAP 182002, ICEAP 182013, ICEAP 182014, ICEAP 182016, ICEAP 182022, ICEAP 182070, ICEAP 182272, ICEAP 182273, ICEAP 182274, ICEAP 182279, ICEAP 192020, ICEAP 192023, ICEAP 192025, ICEAP 192027 and ICEAP 86012) were sourced from International Crops Research Institute for the Semi -Arid Tropics (ICRISAT) and evaluated in this study. The selection of the 15 genotypes was based on desirable traits pertinent to farmers' preferences on pod and seed production as per ICRISAT descriptors (ICRISAT, 1993).

Experimental treatments, design and crop husbandry

Experimental treatments comprised of 15 selected pigeonpea genotypes and three moisture levels. The moisture levels included 100% field capacity (FC) which served as the control, 80% FC and 40% FC. Field Capacity (100%) of the soil was determined through gravimetric analysis. The treatments were completely randomized in the greenhouse using a complete randomized design with a factorial arrangement of 15 pigeonpea genotypes by 3 field capacity levels (15×3) with three replications. Three seeds were initially sown in each pot, and after the plants grew to a height of 15 cm above the ground, the number of seeds per pot was reduced to one seedling. Each rounded pot was 18.3 cm in width and 36.3 cm in height. A 10 kg air-dried mixture of sterilized soil, sand, and composted animal manure in the proportions 1:2:2 was put into each pot. Just before planting, each pot received one teaspoon of 10 grams of calcium ammonium nitrate. The 15 genotypes were watered for 14 days to field capacity before beginning the drought stress treatments in order to promote root establishment and development. The plants were subjected to water stress for 8 months. A tensiometer ("Quick Draw" Soil moisture probe CAT. NO.2900F-Soilmoisture Equipment Corp. Santa Barbara, California, USA) placed at 13 cm depth was used to measure the soil's water potential. The pots' water levels were measured using tensiometers that were calibrated for that purpose. Plants were irrigated to 100%, 80% and 40% field capacity as soon as the water potential hit -8 kPa.

Data collection. Data on physiological, growth, and yield parameters was collected. Chlorophyll content, the relative water content of the leaf, and the distribution of dry matter between the root and shoot were among the physiological data. A SPAD 502 meter was used to measure the amount of chlorophyll (Loh et al., 2002). The number of pods per plant, the number of seeds per pod, the length, weight, and diameter of the pods were all included in the yield data. For each plant in each pot randomly chosen and tagged in the field, the quantity of pods per plant was counted and recorded. The calculation of pod weight involved selecting five pods at random from each genotype's harvest lot for each plot, weighing them, and then calculating the average weight for each genotype. Pod diameter was measured using a ruler from the tip of the pod petiole to the tip of the pod apex from the five tagged plants, and average length was recorded. Pod diameter was measured using a Vernier caliper of five mature pods from each tagged plant per plot. The average shell weight was determined by selecting five shells at random from lots in each genotype and plot, weighing them, and recording the results. The number of seeds in each shell was manually counted, and averages were calculated. For each plot and genotype, 100 seeds were counted and their weight was measured with a precision of 0.001g using a weighing scale.

Data analysis

Genstat 15th edition was used to do a variance analysis on the collected data at a 5% level of significance. To separate the mean for significant treatment effects, Fisher's protected least significant difference was applied (LSD). The degree of variation within each quantitative trait was calculated using the statistical metrics of mean, standard deviation, and coefficient of variation.

Conclusion

Drought stress decreased pod weight and pod length even at the lowest moisture content of 40 % field capacity. With increased drought, the amount of chlorophyll and shell weight decreased by 11.9 and 2.4 percent, respectively. Pod weight and length increased by 5.5 percent and 3.4 percent, respectively, when the moisture level was reduced to 80 percent FC, there was no discernible impact on the amount of chlorophyll or the number of seeds per pod. Increased pod density under drought circumstances should be the focus of efforts to improve pigeonpea drought tolerance.

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Author contributions

The authors have contributed significantly for this manuscript. **Juliana Cheboi:** Conceptualization, data curation, formal analysis, investigation and original draft preparation**. Paul Kimurto:** Project administration, Funding acquisition, writing- reviewing and editing**. George Chemining'wa:** Supervision, writing-review and editing. **Enock Mosenda:** Writing-review and editing. **Gangarao N.V.P.R:** Sourcing of seed materials**,** writing-review and editing.

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