Evaluation of Eggplant(*Solanumspp*)Genotypes for Proline Accumulation indroughtConditions of Ghana

ABSTRACT

Sixteen (16) genotypes of eggplant (*Solanum*spp) were grown over two years in the Coastal and Sudan Savannah areas of Ghanato identify proline accumulation response patterns of the genotypes under dry season and drought-stressed conditions of Ghana. The experiment was conducted at Savanna Agricultural Research Institute (SARI) experimental farm, Manga, Bawku (Sudan Savannah Agro-ecology), and University of Ghana, Legon, Accra, experimental farm (Coastal Savannah Agro-ecology). At each agro-ecology,leaf samples of the genotypes were collected at the flowering stages of growth, dried, milled and assayed for their proline levels. The prolinedata for each location and season for the two year period were separately analyzed by general analysis of variance (ANOVA), for the estimation of the variation among the genotypes in proline accumulation.Proline which confers tolerance of the crop to variable seasonal and drought-stressed conditions varied significantly, due to the genotype and genotype x environment interaction effects on its accumulation. The eggplantgenotypes were observed to develop internal complementary drought survival mechanisms, by lowering leaf relative water contents (LRWC) and increasing proline content, thereby enabling plants to withstand periodic drought better. Thegenotypes A3, A4, A8, A9F, A10 and Bawku1 accumulated higher levelsof prolineunder dry season and drought-stressed conditions of the Coastal and Sudan savannahs, with the associated high temperatures across locations. These genotypes could be selected on the basis of

prolineaccumulation, for improved drought tolerance of the crop,andshould be incorporated in eggplantdrought tolerant improvement programmes in Ghana.

Key Words: Eggplant, Drought, Growth Conditions, Proline Accumulation

1.0 INTRODUCTION

Eggplants(*Solanumspp*)arecultivated in Ghana as source of food and income, especially for the small scale farmers [1, 2]. Though widely cultivated ina small scale in Ghana, it is grownin the Coastal and Sudan savannah agro-ecologies under highly unstable conditions of high temperatures, erratic rainfall and intermittent drought. Drought stress, in particular, is very common in crop fields of these agro-ecologies, and it is a major crop developmental and yield-limiting factor[3, 4].

Few eggplant genotypes are predominantly cultivated in the Coastal and Sudan savannah agro-ecologies of Ghana, and may be considered as adaptive under those environmental conditions. The stable and adaptable genotypes that are considered superior in unfavorable environments similar to that of Coastal and Sudan savannah agro-ecologies of Ghanahave been identified with an ability to efficiently accumulate specific stressed-induced bio-active compounds [5-8].

In drought stress conditions, plants reduce and lose turgor, andaremost susceptible during the reproductive phase, when brief periods of water shortage could greatly reduce yield [9-11]. The reduction or loss of turgor in plants subjected to stress conditions triggersseveral physiological and/or chemical responsesin them [12,13]. The accumulation of proline is the primary physiological trigger in plants that activates a complex of a sequence of adaptive events correlated to the level of stress, plant tolerance and plant growth stage (14, 3]. In plants, the accumulation of cellular solutes, such as proline has been one possible means for overcoming osmotic stress caused by loss of water [15, 16].

However, the levels of prolinein plants are properly regulated, according to environmental conditions [17]. It is mainly accumulated under drought-stress conditions but can be accumulated under high temperature stresses [18].In drought stress conditions, most plants increase proline accumulation at flowering stages than at the vegetative stages [19, 20]. The proline accumulation in plants under stressed conditions, therefore, becomes a survival mechanism in plants, which greatly determine their adaptability to varying environments andlargely influence their desirable traits performance and stability over time and location [21].

Plants are able to adapt and resist stress because the accumulated proline regulates and reduces water loss from dehydrated cells [22, 23]. Its biosynthesis also enables plants to survive under stress conditions by assisting plants to maintain the photosynthetic efficiency and the overall survival and productivity [24]. In general, there is better survival and performance of plant species that accumulate proline under stress conditions. Proline, therefore, plays important role in adaptation and survival of plants under drought and temperature stresses [25,27].

The physiological responses of plantsin drought-stressed conditions such as increases or decreases inproline accumulationare useful indices of drought tolerance [28, 29]. Such physiochemical studies eggplant genotypes under varying environments in Ghana are vital to ascertain the physiological behavior of existing materials in the plant genetic pool [30]. In such studies, desirable genotypes could be identified and selected for farmers and for crop improvement purposes based on their physiological traits competencies across environments.

However,there is limitedstudy on the influence of varying soil moisture conditions onproline accumulation ineggplantsacross agro-ecologies in Ghana. It is in this light that a study was conducted to assesseggplant genotypes for proline accumulation under varying soil moisture conditions of two most drought-stressed agro-ecologies of Ghana.

2.0 MATERIALS AND METHODS

2.1 The Study Areas

The experiment was carried out at Savanna Agricultural Research Institute (SARI) experimental farm, Manga, Bawku in the Sudan savannahagro-ecology and University of Ghana, Legon, Accra experimental farm in the Coastal savannah agro-ecology. Manga, Bawku is located in the North-Eastern corner of the Upper East Region of Ghana, on Latitude 11°11'and 10°40'N and Longitude 0°18' W and 0°6'E, at an altitude of 249 meters above sea level, with atopography of gently sloping terrain of gradient 1-2%. The University of Ghana experimental farm is located in the north-east of the Greater Accra region of Ghana, on Latitude 5°38'45''N and Longitude 00°11'13''E at an altitude of approximately 300 meters above sea level.

2.2 Climatic Data Collection

Climatic data (Table 1) was collected during the respective rainy and dry seasons of 2012-2013 and 2013-2014 at each experimental site of Legon and Manga. Within the study period, Legon site recorded 5 months of dry season and 7 months of rainy season whereas Manga site was 7 months of dry season and 5 months of rainy season. Until flowering of the plants, temperature, relative humidity and sunshine data were collected daily at the University of Ghana, Legon-Accra on

Hobo Pro data loggers (Pocassett, ME, USA), whereas those of Manga-Bawku were taken from on-farm weather station. The rainfall data from both experimental sites was collected using on-farm rain gauges.

Table 1. Location and seasonal differences in monthly average climatic data per year from Manga-Bawku and Legon-Accra experimental farms during the 2012-2014 experimental period

Location	**Manga-Bawku Experimental Farm**							
Climatic Parameter	Rainfall (mm)		Temperature (°C)		Relative humidity (%)		Sunshine (Hours)	
Year / Month	2012-13	2013-14	2012-13	2013-14	2012-13	2013-14	2012-13	2013-14
Oct-April	0.2	0.2	29.8	30.7	50.4	50.2	8.5	8.4
May-Sept.	114.1(4)	102.9(3)	27.7	28.1	80.7	80.1	6.4	6.4
Yearly Mean	**47.6 (4)**	**43 (3)**	**28.3**	**29.4**	**63.1**	**62.6**	**7.5**	**7.4**

Location	**Legon-Accra Experimental Farm**							
Climatic Parameter	Rainfall (mm)		Temperature (°C)		Relative humidity (%)		Sunshine (Hours)	
Year / Month	2012-13	2013-14	2012-13	2013-14	2012-13	2013-14	2012-13	2013-14
Nov-March	25.4(2)	12.8(2)	27.6	28.4	75.1	73.4	5.8	6.4
April-Oct.	89.5(4)	56 (3)	27	27.2	78	76	5.7	5.8
Yearly Mean	**62.0 (3)**	**37.6 (3)**	**27.3**	**27.6**	**76.5**	**74.9**	**5.8**	**6.2**

( )* = Mean days of rainfall

2.3 Sampling and Analysis of Soil

Samples of soil were randomly collected at 0-30 cm depth from six (6) different locations of the experimental plots at Legon, Accra and SARI, Manga. The soil samplesof each experimental plotin the rainy and dry seasons were accordingly combined, air-dried and then sieved through a 5mm mesh.

The organic matter content of the soil was analyzed following [31]. The method for the determination of nitrogen was the Macro - kjeldhal [32] and that of phosphorus was the P-Bray

No. 1. The sieved soil samples were also used to determine particle sizes, exchangeable bases and pH.Soil bulk density was determined by collecting samples at six (6) different locations in each of the experimental sites using core samplers. The soil samples were analyzed in duplicates, and the results of the soils' physical and chemical analysis are shown in Table 2.

Table 2: **Soil characteristics at 0-30 cm depth from Manga-Bawku and Legon-Accra**

Locations	Manga-Bawku Experimental Farm			Legon-Accra Experimental Farm		
Soil Characteristics	Rainy Season	Dry Season	**Mean**	Rainy Season	Dry Season	**Mean**
Physical						
Sand (%)	84.1	75.3	**79.7**	58.7	70.3	**64.5**
Silt (%)	1.5	2.9	**2.2**	6.3	9.0	**7.7**
Clay (%)	14.4	21.8	**18.1**	34.9	20.7	**27.8**
Bulk Density (g/cm^3)	1.7	1.5	**1.6**	1.5	1.4	**1.5**
Chemical						
pH1:1 H2O	6.6	6.2	**6.4**	5.8	5.3	**5.5**
Nitrogen (%)	0.12	0.13	**0.12**	0.13	0.15	**0.14**
Organic Matter (%)	0.57	0.88	**0.73**	1.16	1.57	**1.37**
Available P. (ppm)	3.70	4.13	**4.13**	4.28	5.15	**4.72**

EC = Electrical Conductivity

The Coastal and Sudan agro-ecologies of Ghana differ in climatic and edaphic characteristics, and crop growth and performance are often influenced by those characteristics. The soils of both locationsare sandy, low in organic matter and water-holding capacities (Table 2). These characteristics influence the loss of soil nutrients and soil moisture as well as soil drying.

2.4 Soil moisture content determination

Soil moisture content at the Legon and Manga Experimental farms was determinedfollowing standard procedures and methods. The sampled soils were weighed and measured at different pressure plates of 0.3 bars and 15 bars, and oven-dried at 105 °C for 48 hours to constant weights before weighing [33, 34]. The soil moisture content values for Legon and Manga in the rainy season were 68% and 63%; dry season (irrigated) were 57% and 53% and under water-stressed were 26% and 24%.

2.5Planting Materials

Fourteen (14) eggplant (*Solanumaethiopicum*) genotypes were obtained from the Department of Crop Science, University of Ghana, Legon and Plant Genetic Resources Research Institute (PGRRI) of the Council for Scientific and Industrial Research (CSIR), Bunso and two popular local genotypes of bitter eggplant (*Solanumincanum*) commonly cultivated in Bawku area, were obtained from aneggplant producing farmer in Bawku. The sixteen (16) eggplantgenotypes were grown in two successive rainy and dry seasons' conditions of Coastal Savannah and Sudan Savannah agro-ecological zones in 2012 and 2013, and 2013 and 2014. Experimental procedure for the trials on the 16 genotypes was the same across seasons and locations.

2.6Treatments and experimental design

The genotype, rainy season, dry season, water-stressed and location (Legon and Manga) were the main treatments. There were sixteen (16) genotypes, three (3) soil moisture conditions and two (2) locations, giving ninety-six (96) treatment combinations. After ploughing and harrowing, the experimental fields were laid out in Randomized Complete Block Design (RCBD) with three (3) replications in both rainy and dry seasons.

Plant-to-plant spacing within a row was 80 cm and planting in both years was done in May-June, and November-December, coinciding with the onset of rainy season and dry season of 2012-2013 and 2013-2014. In both seasons, transplants at four weeks were applied with a compound fertilizer N: P: K (15-15-15) at the rate of 250kg\ha, till flower initiation.

2.7Leafsampling, drying and milling

Twelve (12) uppermost leaves were sampled from four recorded plants per genotype per replication at 50% flowering in both the rainy and dry season experimentsand were oven-dried at 50 ^{o}C for 72 hours. During the dry season, leaves were sampled at 50% flowering under well-watered and ten-days of water deprivation (stress) conditions.

Four (4) leaves from the sampled twelve (12) leaves for proline determination were picked immediately after excision from plants and cleaned well for leaf relative watercontent (LRWC) following [35] and [36]. Theremaining eight(8) of the sampled leaves per treatmentper location were oven-dried at 50 ^{o}C for 72hours.

The dried leaves from each location were bulked according to genotype and growth condition and ground into composite powders through a 1 mm mesh sieve fitted in the mill (Type: Fritsch, Schmeasal, AZ 15 ZVK-2005, Germany).

The composite leaf powders of the rainy season, dry season and stressed conditions were packaged in air-tight black polythene containers and stored in a freezer for analysis. The powdered leaf samples were used for determination of proline content.

2.8Determination of proline content in leaf samples

The proline content of leaves was estimated colorimetrically by the acid-ninhydrin method, following [37]. Samples of dry leaf powder were weighed 0.5g and homogenized in 10 ml of 3% aqueous sulfosalicylic acid. The homogenate was filtered through Whatman No. 1 paper and made up to 50 ml with distilled water. Prolinestandard concentrations of 5-100 µg/ml were prepared. One milliliter (1 ml) each of the filtrate (extract) and proline standards was pipetted into test tubes before adding 1ml acid ninhydrin and 1ml glacial acetic acid and mixed thoroughly. The mixtures were incubated for an hour at100 ^{o}C in water bath to develop colours. The test tubes were immediately cooled in an ice bath and vigorously vortex before adding 4 ml toluene reagent.

The chlomophore containing toluene was aspirated from the aqueous phase, and then warmed to room temperature (25 ^{o}C) and the absorbance read in a UV/Vis spectrophotometer at wavelength 520 nm, using toluene as blank. The proline concentration was calculated from a standard curve and computed on dry weight basis as µmole proline/g of dry leaf weight [37] asfollows:

$$\text{µmoleproline } g^{-1} \text{ dry weight} = \frac{(\text{µg proline/mL} - \text{Toluene/mL})\text{x Initial dilutionx } 5}{115.5 \text{ x Sample weight}}$$

2.9Analysis of proline content data

The proline concentration data was analyzed using GenStat Statistical Software (12thEdition). The data for each location and season for the two years were separately analyzed by general analysis of variance (ANOVA), for the estimation of the variation among the genotypes in the measured traits. Where ANOVA showed significant differences in proline, the mean values were separated by the Least Significant Difference (LSD) at probability level of 0.05.

The coefficient of variation (% CV) was calculated as $= \frac{\sqrt{\text{MSE}}}{\overline{\text{X}}}$x 100; where MSE = Error mean square;and $\overline{\text{X}}$ = Mean, from analysis of variance

3.0 RESULTS

Proline content in eggplant leaves at 50% flowering varied depending on the genotype, location and growth condition (Table 3). During rainy season conditions, location and genotype x location interaction effects onproline concentration were not significantly different (P = 0.05). The location and genotype x location interaction effects under dry-season conditions significantly (P = 0.05) affected the average proline levels of the genotypes.

Table 3: Proline accumulation in leaves ofeggplant genotypes at flowering in rainy, dry season and drought-stressed conditions of two locations for two years

Condition	Rainy Season			Dry Season			Drought-Stressed		
Location	Manga	Legon	**Mean**	Manga	Legon	**Mean**	Manga	Legon	**Mean**
Genotype	(µg/g dry weight)			(µg/g dry weight)			(µg/g dry weight)		
A1	0.44a	0.37ab	**0.41a**	0.78bc	0.55bc	**0.67c**	3.92bc	1.82d	**2.87d**
A2	0.40a	0.33b	**0.37ab**	0.83ab	0.65ab	**0.74ab**	4.22ab	3.65a	**3.93a**
A3	0.42a	0.40a	**0.41a**	0.82ab	0.72a	**0.77a**	4.30ab	3.64a	**3.98a**
A4	0.30b	0.38ab	**0.34bc**	0.88a	0.69a	**0.78a**	4.12b	3.85a	**3.99a**
A6B	0.43a	0.40a	**0.42a**	0.82ab	0.70a	**0.76a**	4.02b	3.90a	**3.96a**
A6F	0.37a	0.29bc	**0.39a**	0.84a	0.68a	**0.76a**	4.43a	2.94bc	**3.69bc**
A7	0.46a	0.42a	**0.44a**	0.80b	0.74a	**0.76a**	4.30ab	3.07bc	**3.68bc**
A8	0.42a	0.40a	**0.41a**	0.85a	0.66a	**0.76a**	4.22ab	3.78a	**4.00a**
A9A	0.45a	0.40a	**0.42a**	0.74c	0.65ab	**0.70bc**	3.96b	3.55a	**3.76a**
A9F	0.37a	0.29bc	**0.33bc**	0.83a	0.72a	**0.77a**	4.31ab	3.79a	**4.05a**
A10	0.44a	0.40a	**0.41a**	0.75c	0.70a	**0.73a**	4.41a	3.75a	**4.08a**
A11	0.22b	0.41a	**0.32bc**	0.81b	0.71a	**0.76a**	4.31ab	3.51a	**3.91a**
A12	0.31b	0.43a	**0.37ab**	0.87a	0.67a	**0.77a**	4.22ab	3.65a	**3.71b**
Legon1	0.42a	0.40a	**0.41a**	0.78bc	0.72a	**0.75a**	4.37a	3.52a	**3.95a**
Bawku1	0.45a	0.38a	**0.42a**	0.81b	0.71a	**0.76a**	4.42a	3.51a	**3.97a**
Bawku2	0.47a	0.40a	**0.43a**	0.84a	0.61bc	**0.72ab**	4.20b	2.46c	**3.33c**

Mean	**0.40**	**0.39**	**0.39**	**0.81**	**0.68**	**0.75**	**4.25**	**3.37**	**3.82**
%CV	15.3	11.6	14.4	4.7	9.2	7.6	4.3	18.2	12.4

*Means with different letters in a column are significantly different at P = 0.05. LSD (5%) (Proline):Location (Rain-fed = 0.03ns; Dry season = 0.02**; Drought-stressed = 0.12**) Genotype x Location (Rainy season = 0.11ns; Dry season = 0.09**; Drought-stressed = 0.48**). ns = Not significant; ** =Significant at 1% levels of probability.*

Under drought-stressed conditions, the location and genotype x location interaction effects on the proline contents of the genotypes were significant (Table 3). At each location, the rainy and dry season conditions did not have significant effects on genotype proline levels; whereas drought-stressed conditions at each location significantly (P < 0.001) affected genotypes' proline accumulation. Generally, the proline levels of the genotypes in the dry season of growth were higher than that of the rainy season, whereas the levels of proline in genotypes under drought-stressed were about ten-fold higher than those in the rainy season and about five-fold higher than those under dry season conditions. In general, the proline levels of the genotypes across the growth seasons and conditions were consistently higher at Manga than at Legon.

Under drought-stressed conditions (Table 3), the Manga site recorded proline levels ranging from 3.93 µg/gDW in A1 to 4.43 µg/gDW in A6F; the levels atLegon ranged from 1.72 µg/gDW in A1 to 3.91 µg/gDW in A6B. Across locations,the genotypes proline levels ranged from 2.87µg/gDW in A1 to 4.08 µg/gDW in A10. The site means ranged from 3.36 µg/gDW at Legon to 4.24 µg/gDW at Manga. The highest six proline accumulating genotypes in drought-stress conditions across the locations,in the order of highest was A10 (4.08 µg/gDW), A9F (4.05 µg/gDW), A8 (3.99 µg/gDW), A4 (3.98 µg/gDW), A3 (3.97 µg/gDW) and Bawku1 (3.96 µg/gDW).

There were significant genotype and genotype and environment interaction effects on proline synthesis in eggplants grown across seasons of the Coastal and Sudan savannah agro-ecologies.The drought-stressed conditions of both locations were also associated with low leaf relative water contents of the genotypes (Table 4) but with higher variability (CV = 13.3%) among genotypes than the dry season variability (CV = 8.5%). The proline content in the leaves of the genotypes also increased as leaf relative water contents decreased (Tables 3 & 4). This indicates an inverse relationship between leaf water content and proline levels in eggplants.

Table 4: Leaf relative water content (LRWC) of eggplant genotypes at flowering under rainy, dry season and drought-stressed conditions of two locations for two years

Condition	Rain season			Dry season			Water-stressed		
Location	Manga	Legon	**Mean**	Manga	Legon	**Mean**	Manga	Legon	**Mean**
Genotypes	%	%	**%**	%	%	**%**	%	%	**%**
A1	78.4d	82.7c	**80.5f**	63.4b	75.2b	**69.3b**	47.7b	51.0b	**49.3b**
A2	78.7d	80.4c	**79.5f**	63.3b	75.3b	**69.3b**	48.2b	50.7b	**49.5b**
A3	84.2b	84.8bc	**84.5c**	61.1c	73.7b	**67.4c**	52.6a	60.7a	**56.4ab**
A4	83.5b	77.2d	**80.4f**	63.2b	75.9a	**69.5b**	47.4b	51.7b	**49.6b**
A6B	80.1c	79.4d	**79.8f**	63.5b	75.0b	**69.2b**	48.9b	53.8b	**51.3b**
A6F	85.8a	78.0d	**81.9e**	67.3a	77.2a	**72.3a**	50.5b	58.7a	**54.6ab**
A7	81.0c	87.0ab	**84.0c**	65.7b	73.4b	**69.5b**	53.6a	60.5a	**57.0ab**
A8	77.1d	84.9b	**81.0e**	66.2b	75.4a	**70.8b**	54.0a	61.5a	**57.8a**
A9A	84.3b	85.8b	**85.1c**	64.5b	73.9b	**69.2b**	54.0a	61.8a	**57.9a**
A9F	77.3d	86.3b	**81.8e**	65.3b	73.2b	**69.3b**	53.4a	58.1a	**55.7ab**

A10	80.3c	86.5ab	**83.4d**	70.3a	75.2b	**72.7a**	53.8a	50.6b	**52.2b**
A11	81.5c	85.4b	**83.5d**	64.8b	76.8a	**70.8b**	51.5a	62.5a	**57.0ab**
A12	77.4d	86.5ab	**82.0e**	63.1b	75.0b	**69.1c**	51.8a	57.9a	**54.9ab**
Legon1	79.5c	84.9b	**82.2e**	69.0a	74.1b	**71.6a**	53.1a	52.4b	**52.7b**
Bawku1	87.4a	89.3a	**88.3a**	64.3b	76.1a	**70.2b**	54.4a	65.0a	**59.7a**
Bawku2	87.6a	86.5ab	**87.0b**	68.9a	78.0a	**73.5a**	56.0a	63.1a	**59.6a**
Mean	**81.5**	**84.1**	**82.8**	**65.3**	**75.2**	**70.2**	**51.9**	**57.5**	**54.7**
%CV	4.9	4.9	5.1	6.0	3.4	8.5	9.3	14.3	13.3

Means with different letters in a column are significantly different at P = 0.05. LSD(5%) (LRWC at flowering): Rainy season (Location= 0.4**;Genotype x Location = 1.7**); Dry season (Location = 0.9**; Genotype x Location = 3.4**); and, Drought-stressed(Location=1.69**; Genotype x Location = 6.8**). ** = Significant at 1% level of probability.

The reduction in moisture content of leaves in the dry season could also be due to the utilization of the moisture to build proline and other leaf constituents.The accumulation of proline enable plants to maintain low water potentials, and this condition in plants could trigger the accumulation of other compatible osmolytes as well as chlorophyll and allows additional water to be taken up from the environment, and hence help in buffering the immediate effect of water deficit within the leaf [38, 39].In dry conditions, the proline in garden egg remained active and so some amount of water retention was made possible (Table 3&4).

4.0 DISCUSSIONS

The concentration of proline in the leaves of eggplant genotypes depended on the soil moisture levels of the rainy season, dry season and drought-stressed conditions of Manga and Legon (Table 3). With the exception of the rainy season, the dry season and drought-stressed conditions significantly (P = 0.05) affected the proline levels in the genotypes. The growth conditions of Manga resulted in higher levels of proline in plants than Legon, indicating that environmental conditions of Manga triggered higher proline synthesis than Legon. Seasonally, the dry season conditions enhanced proline synthesis than rainy season, suggesting that the rainy season and for that matter, higher moisture conditions do not trigger proline synthesis in eggplants.

This is an indication thatproline accumulation may result from both induction of proline biosynthesis and/or inhibition of its oxidation [40, 41]. The induction of proline biosynthesis is activated by the enzyme pyrroline-5-carboxylate synthetase, and proline is inhibited from degeneration by the enzyme proline dehydrogenase [40, 22, 42].

Plants accumulate proline when exposed to abiotic stresses such as drought [43, 44], as well as varying temperatures [45]. The high proline accumulation in the eggplant genotypes during the dry season and drought-stressed conditions could be attributed to lack of adequate water supply or due to high sunshine and temperatures at that period. During the dry season, temperatures were generally high across ecologies (Table 1), and so temperature increases in addition to low soil moisture or drought stress trigger and significantly increasedproline synthesis through enhanced activities of the biosynthetic enzyme, pyrroline-5-carboxylate reductase.

High proline accumulation is part of physiological responses to intense stress, and has been indicative of higher capability to resist drought [46-49].This is an indication that during drought stress, eggplants generally have inherent ability to counteract or minimize the effects through proline accumulation. It is also suggestive that, the production of proline is probably a common response of eggplant under drought-stress.

The osmotic adjustment through the accumulation of cellular solutes, such as proline, has been suggested as one of the possible means for overcoming osmotic stress caused by loss of water [15, 16, 50]. In this study, proline content in the leaves of eggplant genotypes tended to increase as leaf relative water contents decreased (Tables 3 & 4), indicatingan inverse relationship between leaf water content and proline content in eggplants.

The proline levels enable plants to maintain low water potentials, and it is this condition that triggers the accumulation of other compatible osmolytes and allows additional water to be taken up from the environment, and hence help in buffering the immediate effect of water deficit within the leaf [38, 39]. The drought-stressed conditions of both locations were associated with low leaf relative water contents of the genotypes (Table 4) suggesting that the accumulation of proline is probably a mechanism to withhold water during periods of water stress[38].

Regardless of the growth conditions of the crop, there were significant differences (P = 0.05) among genotypes in proline accumulation, suggesting that garden egg genotypes differ in their abilities to synthesize proline. The variation in the genotypes proline levels across locations was higher under drought-stressed conditions (CV = 12.4%) than the dry season conditions (CV = 7.6%) (Tables 3), and this clearly indicates the influence of drought-stressed conditions on prolineaccumulation in eggplants.Though there were location specific genotypic differences, the highest six proline accumulating genotypes under drought-stressed conditions across locations, were A3, A4, A8, A9F, A10 and Bawku1, and this present great opportunity in drought tolerant improvement programmes in garden egg under Coastal and Sudan savannah agro-ecologies of Ghana.

5.0 Conclusion

Proline as a bioactive compound, confer tolerance of many plants genotypes to drought or moisture stressed conditions. Eggplant genotypes at reproductive phase varied in their proline accumulation ability under drought or moisture stressed conditions.Under drought conditions, the crop genotypes might have developed internal complementary drought survival mechanisms by lowering leaf relative water contents (LRWC) and increasingproline concentrations, thereby enabling genotypes to withstand periodic drought better.

The information on genotypic differences in proline accumulation is useful in the survival and productivity of eggplant, and could be useful in settingthe crop breeding objectives. Though there were location specific genotypic differences, the highest six proline accumulating genotypes under drought-stressed conditions across locations, were A10, A9F, A8, A4, A3and Bawku1. This may present a great opportunity in drought tolerance improvement programmes in eggplantfor improved performance in drought-prone agro-ecologies of Ghana.

COMPETING INTERESTS

Authors declared there are nocompeting interests

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