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Original Research Paper

Responses of different okra (*Abelmoschus esculentus*) cultivars to water deficit conditions

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ABSTRACT

A pot experiment was conducted to evaluate the adverse effects of drought on different okra cultivars and to identify the most suitable okra cultivar for growing in drought conditions. Five okra cultivars namely Pusa Green, Clemson, Sabz Pari, Pusa Swani and Mehak Pari were subjected to three drought levels i.e., control (100% Field capacity),50% and 25% Field Capacity (FC). Physiological parameters like fresh and dry weight of plant and plant height were recorded along with biochemical attributes such as chlorophyll content (a, b, total) carotenoids, total protein, proline content, and Membrane stability index (MSI%). Results showed that drought significantly reduced all the studied parameters and at maximum drought (25% FC) lowest values of fresh weight (12.42g), dry weight (1.22g), plant height (7.86cm), chlorophyll a (9.02mg/g FW), chlorophyll b (18.69mg/g FW), total chlorophyll (27.71mg/g FW), carotenoids (11.80mg/g FW), total protein (2.73mg/g FW),whereas maximum Proline (21.36µg/g FW), and MSI (72%) were observed under the same drought. The results concerning responses of okra cultivars under drought conditions showed that maximum. Fresh weight (15.25g) and Dry weight (2.74g) was observed in Pusa green while maximum Plant height (13.77cm), Chlorophyll a (14.38mg/g FW), Chlorophyll b (24.41mg/g FW), Total Chlorophyll (38.80mg/g FW), Carotenoids (18.57mg/g FW), Total Protein (5.44mg/g FW), Proline (27.78µg/g FW), and MSI (56.33%) were produced by Sabz Pari. Hence it can be concluded that drought causes significant variation on physical and biochemical attributes of okra whereas Sabz Pari showed resistance towards the applied stress and produced better results.

***Keywords*: Drought, Okra, Oxidative Stress and Proline content**

INTRODUCTION

Okra (*Abelmoschus esculentus* L.), belongs to the family Malvaceae, is an important vegetable crop grown during summer season in Pakistan for its nutritious edible pods. It is favored for soft and tender green pods, which are commonly consumed as curries and boiled vegetables (Mounir *et al*., 2020). Despite their astonishing beautiful flowers, okra pods are rich source of nutrients and medicinal properties. The fresh okra fruit contains carbohydrates (9.6%), protein (2.25%), fiber (1.1%), fat (0.2%) and minerals such as magnesium iron, potassium, calcium, sodium, zinc, nickel and manganese (Khan and Rab 2019). Fiber found in okra pods reduces cholesterol and risk of cardiac diseases and promotes healthy digestive track. Okra helps in slow absorption of sugar, hence can be consumed as anti-diabetic food (Nawaz *et al*., 2020).

Many environmental conditions including droughts have much harmful effects on the growth and yield of agricultural crops (Ayub *et al*., 2018). During plants exposure to drought, many physiological and biochemical alterations occur inside plants on cellular level. These changes include accumulation of ABA, reduction in leaf area and closing of stomata (Meise *et al*., 2018). Drought also decreases the rate of leaf growth by making cell walls sclerotic and reduced plant biomass. Like any other abiotic stresses, under drought stress proline accumulates inside plant which helps plants to with stand under stress conditions (Lintunen *et al*., 2020). Plants which are exposed to drought stress also exhibits lower levels of carbohydrates and starch (Qu *et al*., 2019). During drought stress protein degradation starts and reduction in chlorophyll takes place (Dawood *et al*., 2019). Drought stress mostly causes accumulation of ROS (Reactive Oxygen Species) which leads to oxidative stress in chlorophyll and disrupts normal working of plants cells (Stanley and Yuan 2019). ROS also damages lipids, terpenoids, carbohydrates and nucleic acids (Guo *et al*., 2018).

Okra is one of the most important summer vegetables commonly cultivated in tropical and subtropical plans of Pakistan including Haripur due to its higher nutritional values, ease of cultivation and resistance to harsh environmental conditions. Most of the cultivated lands in Haripur region are rainfed, thus the farming relies mainly on rainfall for water. During the summer followed by low rainfall seasons, these regions face moderate to severe droughts during summer in case of low rainfall. Despite of huge potential of okra production low water availability to the crop causes a great reduction on yield per area and total area under cultivation. Hence this study was conducted to evaluate the adverse effects of drought on different okra cultivars and to identify the most suitable okra cultivar for growing in drought conditions.

MATERIALS AND METHODS

Current study was conducted at Horticulture nursery, Department of Horticulture, The University of Haripur during February-March 2020. For this experiment pots of 20 cm diameter and 15cm depth were used. Each pot was filled with 2kg potting media containing soil, sand and farmyard manure in equal ratio (1:1:1). These pots were kept inside the rainout shelters during night time and during rain to avoid the entry of water to plants. Seeds of five okra cultivars namely Pusa Green, Clemson, Sabz Pari, Pusa Swani and Mehak Pari were collected from National Agriculture Research Council, Islamabad. The experiment was laid out in a split-plot factorial arrangement with Completely Randomized Design with three replications. The drought stress was taken as main plot whereas factorial arrangements of verities were placed as a sub plot.

Imposing drought treatment

Eight seeds of okra were planted in each pot. 10 days after germination plants were thinned to 5 plants per pot. Plants were irrigated up to full field capacity (FC) during 14 days after germination to achieve maximum germination and equilibrium in plant growth, afterward okra plants were subjected to three levels of drought i.e.,100% FC (control/normal irrigation), 50% FC and 25% FC. Field capacity was calculated based on saturation percentage as described by Wilcox (1951).Uniform cultural practices were carried out throughout the research period. After 20 days of drought treatment, plants were uprooted and phenotypic characters viz. plant height, fresh weight, and dry weight were measured as per the standard procedures.

Biochemical analysis

Chlorophyll and carotenoids content was measured by the method explained by Lichtenther (1987). About 0.2 g of grounded leaf sample was extracted with 80% acetone till the residue becomes colourless. Absorbance of the acetone extract was measured at 470, 663 and 646 nm with the help of spectrophotometer (from Germany, Cary-50). Chlorophyll and carotenoids concentration was then measured by following formula.

$$\text{Chla} = (12.25A_{663.2} - 2.79A_{646.8})$$

$$\text{Chlb} = (21.21A_{646.8} - 5.1A_{663.2})$$

$$\text{ChlT} = \text{chla} + \text{chlb}$$

$$\text{Carotenoids} = \frac{1000A_{470}1.8\text{chla}85.02\text{chlb}}{198}$$

Soluble protein content in the okra leaf sample was measured by the method described by Lowry *et al.* (1951).

Method of Bates *et al.* (1973) was implemented to evaluate the proline content. 5g plant grounded plant sample was mixed in 3% sulfosalicylic acid (aqu) and the mixture was centrifuged at 10,000 rpm. The supernatant was mixed with 2 mL of ninhydrin) and 2 mL of glacial acetic acid, and the solution was boiled for 1h at 100 °C. The reaction is allowed to take place in ice bath and after the completion of reaction 4mL toluene to extract the mixture and absorbance at 520nm were read by using spectrophotometer.

MSI was measured as per Premachandra *et al.* (1991). Fresh leaf material (1.0 g) was cut into small discs, washed with deionized water and placed in glass test tubes along with blank. 10 mL of deionized water was added to each test tube so that leaf discs get submerged. The test tubes were kept in a water bath for 30 min at 45 °C. After cooling, the electrical conductivity of water (C1) was measured using the conductivity meter. Water was again poured back to the same leaf discs and kept in the water bath at 100 °C for 10 min. The final electrical conductivity was measured. Percent conductivity was used to calculate membrane stability index using the following formula.

MSI (%) = [1 – (C1/C2)] *100

where,

C1 = Initial electrical conductivity
C2 = Final electrical conductivity

The experimental data were subjected to analysis of variance (ANOVA) using windows software Statistix 8.1 with two-factor factorial arrangements. Each treatment was replicated three times. The effects of drought on okra varieties were determined by the Least Significant Difference test (LSD) at pd"0.05, where the F test was significant (Steel and Torrie 1960).

RESULTS

Study was conducted to evaluate the adverse effects of a drought on different okra cultivars and to identify the most suitable okra cultivar for growing in drought conditions. The results obtained for various plant phenotypical and biochemical parameters studied are given in the Table 1.

Table 1: Comparison of okra varieties and drought stress on growth and biochemical attributes

Okra Cultivars	Plant Height	Fresh Weight	Dry Weight	Chlorophyll a	Chlorophyll b	Chlorophyll total	carotenoids	Protein	Proline	MSI
Pusa Green	11.66c	15.25a	2.74a	12.26b	23.30b	35.56b	16.31b	5.44a	23.58b	51.88b
Clemson	12.22bc	14.82b	2.65a	9.33c	20.50c	29.88c	13.30c	5.44a	20.34c	55.22a
Sabz Pari	13.77a	14.23c	2.47c	14.38a	24.41a	38.80a	18.57a	5.44a	27.78a	56.33a
Pusa Swani	13.33a	14.00c	2.41b	8.51d	16.52d	25.03d	10.20d	5.33a	15.78d	55.88a
Mehak Pari	12.88ab	13.93c	2.45b	5.43e	13.51e	18.94e	6.91e	4.55a	11.57e	55.77a
LSD	1.0448	0.3645	0.1166	0.2278	0.4419	0.2790	0.2371	0.7861	0.3912	0.9740
Drought										
Control	17.73a	16.63a	3.70a	10.98a	20.39a	31.37a	14.28a	8.06a	18.47c	35.93c
50% FC	12.73b	14.28b	2.72b	9.99b	19.60b	29.85b	13.09b	5.00b	19.61b	56.86b
25% FC	7.86c	12.42c	1.22c	9.02c	18.69c	27.71c	11.80c	2.73c	21.36a	72.26a
LSD	0.8093	0.2823	0.0903	0.1765	0.1976	0.2161	0.1837	0.6089	0.3030	0.7545
LSD (C×D)	1.8097	0.6313	0.2019	0.3946	0.2551	0.4833	0.4107	1.3615	0.6776	1.6871

The results are presented as mean based on n=3, LSD Least significant differences at ($p<0.05$). Different letters within column indicate significant differences between okra varieties and drought stress ($p<0.05$)

Plant height (cm)

Plant height is the major character significantly affected due to drought. In the present study, maximum plant height (17.73cm) was observed in control whereas lowest plant height (7.86cm) was recorded in plants subject to 25% FC. Okra cultivar Sabz Pari exhibits highest height (13.77cm) whereas lowest height (11.66 cm) was recorded in Pusa green (Table 1). The combined effects of drought and variety showed that Sabz Pari exhibited highest plant height among all other cultivars under all droughts. Maximum plant height 18, 15 and 8.33cm was recorded in Sabz Pari at 100%, 50% and 25% drought stress respectively,

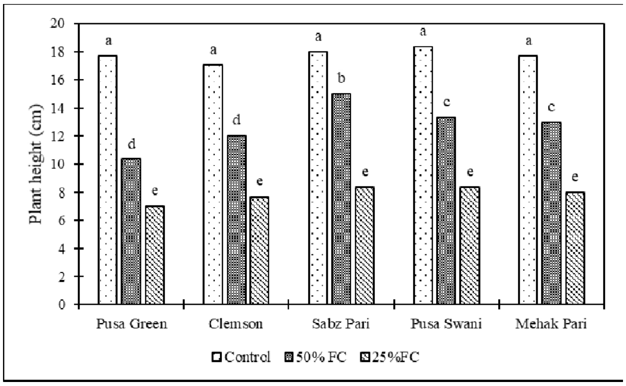

Fig. 1: Effect of drought stress on plant height of okra cultivars

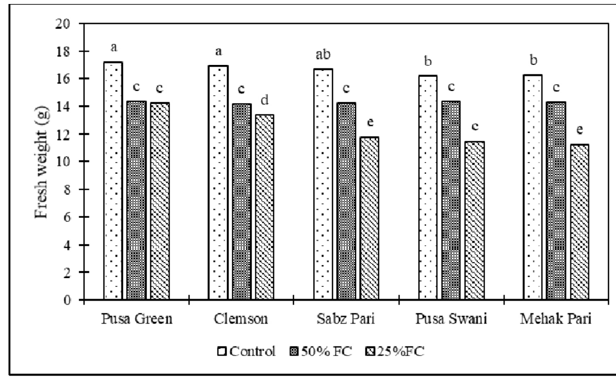

Fig. 2: Effect of drought stress on fresh weight of okra cultivars

whereas lowest plant height 17.66, 13 and 8 cm was observed in Mehak Pari under 100%, 50% and 25% drought. (Fig. 1).

Fresh weight (g)

Highest plant fresh weight (16.63g) was recorded at control (100%FC) whereas, lowest values (12.42g) were observed in plants subjected to water stress of 25% FC. Analysis of variance showed highly statistical difference ($p<0.01$) among okra cultivars for fresh weight and applied drought. Okra cultivar Pusa green showed maximum fresh weight (15.25g) whereas minimum fresh weight (13.93g) was obtained by Mehak Pari (Table 1). Results regarding interaction of drought and okra cultivars indicates that all okra cultivars showed reduction in their fresh weight as drought stress is elevated. Highest fresh weight (17.20g) was recorded in okra cultivar Pusa Green and Clemson under control condition (100% FC) whereas 25% FC drought stress significantly reduced the fresh weight and lowest values of fresh weight (11.26g) were observed in okra cultivar Mehak Pari, meanwhile under same drought level okra cultivars Pusa Green while Clemson retained maximum biomass and showed maximum fresh weight of 14.20g and 13.3g, respectively (Fig. 2). Results of our experiment correspond with findings of Idrees *et al*. (2010), Singh and Usha (2003) and Munir *et al*. (2016) who observed similar reduction in fresh weight of lemon grass, wheat and okra, respectively, when exposed to elevating drought.

Dry Weight of Plants (g)

Results regarding plant dry weight indicate that highest plant dry weight (3.70g) was recorded at control (100% FC) whereas lowest dry weight (1.22g) was observed in plants subjected to maximum water stress of 25% FC. Okra cultivar Pusa green showed maximum dry weight (2.74g) whereas minimum dry weight (2.41g) was obtained for Pusa Swani (Table 1). The interaction effect between drought and okra cultivars suggested a prominent reduction in dry weight for all cultivars. At 100% FC (normal irrigation) and maximum dry weight (3.86g) was recorded in Pusa Green while under same condition minimum dry weight (3.5g) were recorded in Pusa Swani. Meanwhile at highest drought stress (25%FC) least dry weight (0.76g) was recorded by Mehak Pari while under same drought Pusa green produced highest dry weight (1.6g) (Fig. 3). Similar results were observed by Idrees *et al.* (2010),Singh and Usha (2003) and Munir *et al.* (2016)in lemon grass, wheat and okra respectively.

Chlorophyll a (mg/g FW)

It was noted that maximum Chlorophyll-a content (10.98 mg/g FW) were recorded in 100% FC whereas minimum Chlorophyll-a content (9.0 mg/g FW) were observed in 25% FC. Okra cultivar Sabz Pari had highest Chlorophyll-a content (14.38 mg/g FW) while lowest values (5.43 mg/g FW) were recorded in Mehak Pari (Table-1). The combined results of drought and okra varieties revealed that there is a gradual reduction in chlorophyll content with increase in drought stress. At 100% FC (normal irrigation), okra cultivars Sabz Pari had maximum chlorophyll (15.23mg/g) while Mehak Pari had lowest chlorophyll content (6.46mg/g) ,. At 25% FC, Sabz Pari maintained highest chlorophyll content (13.76mg/g) while Mehak Pari produced lowest values of chlorophyll (4.56mg/g) (Fig. 4). A reduction in chlorophyll content was also reported in drought stressed cotton (Massacci *et al.*, 2008) and *Catharanthus roseus* (Jaleel *et al.*, 2009).

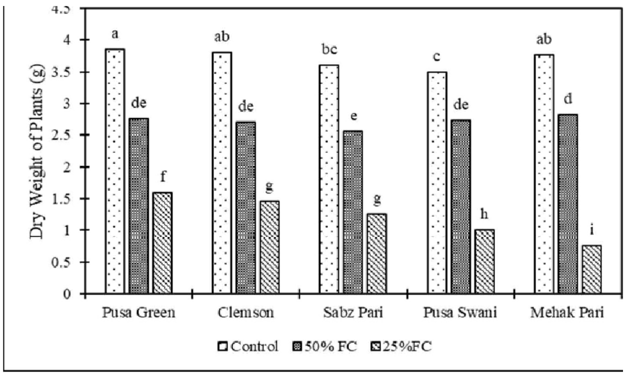

Fig. 3: Effect of drought stress on Dry weight of okra cultivars

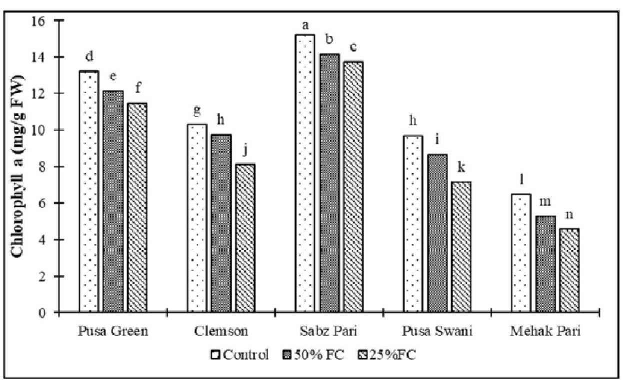

Fig. 4: Effect of drought stress on Chlorophyll a content of okra cultivars

Chlorophyll b (mg/g FW)

Maximum Chlorophyll b content (20.39 mg/g FW) was recorded in 100% FC (normal irrigation) whereas minimum Chlorophyll b content (18.6 mg/g FW) were observed in 25% FC drought. Okra cultivar Sabz Pari had highest Chlorophyll b content (24.41 mg/g FW) while lowest values (13.51 mg/g FW) was recorded in Mehak Pari (Table 1). The combined results of drought and okra varieties revealed that there was a gradual reduction in chlorophyll content with increase in drought stress. At 100% FC (normal irrigation) okra cultivars Sabz Pari showed maximum chlorophyll b (25.7mg/g) while a same irrigation lowest chlorophyll b content (14.56mg/g) were observed in Mehak Pari, on the other hand at highest drought (25% FC) Sabz Pari maintained highest chlorophyll b content (13.76mg/g) while Mehak Pari produced lowest values of chlorophyll b (4.56mg/g) (Fig. 5). The chlorophyll content decreased to a significant level at higher water deficits sunflower plants (Kiani *et al.*, 2008) and *Vaccinium myrtillus* (Tahkokorpi *et al.*, 2007).

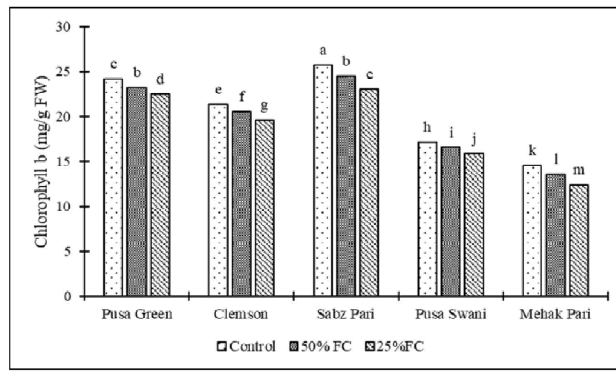

Fig. 5: Effect of drought stress on Chlorophyll-b content of okra cultivars

Total chlorophyll content (mg/g FW)

Effects of drought on total chlorophyll content indicate that maximum Total chlorophyll content (31.37 mg/g FW) was noted under no drought stress (normal irrigation) whereas minimum total chlorophyll (27.71 mg/g FW) was recorded under 25% FC drought (Table 1). Results concerning total chlorophyll content of okra cultivars reveled that Sabz Pari produced highest total chlorophyll content (38.80 mg/g FW) while lowest values (18.94 mg/g FW) were recorded in Mehak Pari (Table 1). The combined results of okra and drought stress revealed that significant reduction was observed with increase in drought stress. Highest total chlorophyll of 40.93, 38.66 and 36.6 mg/g was recorded in Sabz at 100%, 50% and 25% FC conditions, while lowest chlorophyll content 21.03, 18.83 and 16.96 mg/g was obtained by Mehak Pari at 100%, 50% and 25% FC (Fig. 6). Ram *et al.* (2014) and Amin *et al.* (2009) also observed that under drought conditions, reduction in chlorophyll content was noted in watermelon and okra respectively.

Carotenoids (mg/g FW)

Results regarding carotenoids (mg/g FW) of okra plant depicts highly significant statistical difference (*$p<0.01$*) among okra cultivars, applied drought and their interaction (Table 1; Fig. 7). It was noted that maximum carotenoids (14.28mg/g FW) were recorded in 100% FC (control) whereas minimum carotenoids values (11.08 mg/g FW) were observed in 25% FC drought stress. Among the okra cultivars studied maximum carotenoids (18.57 mg/g FW) were observed in Sabz Pari while lowest concentration of carotenoids (6.91 mg/g FW) was recorded in Mehak Pari (Table 1). The combined effect of drought stress and okra cultivars for carotenoids suggested that okra cultivar Sabz Pari showed highest carotenoids (20.43, 18.4 and 16.9 mg/g at 100%, 50% and 25% FC drought, respectively), while lowest carotenoids (5.26,7.23 and 5.26 mg/g at 100%, 50% and 25% FC respectively) were observed in Mehak Pari (Fig. 7). Similar findings were previously obtained by Altaf *et al.* (2015) in okra, Idrees *et al.* (2010) in lemon grass and by Ram *et al.* (2014) in water melon.

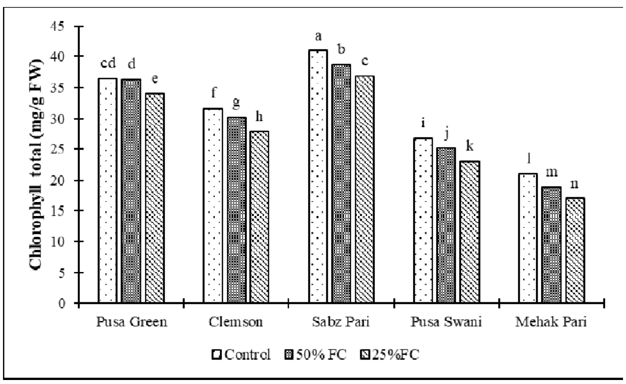

Fig. 6: Effect of drought stress on total Chlorophyll content of okra cultivars

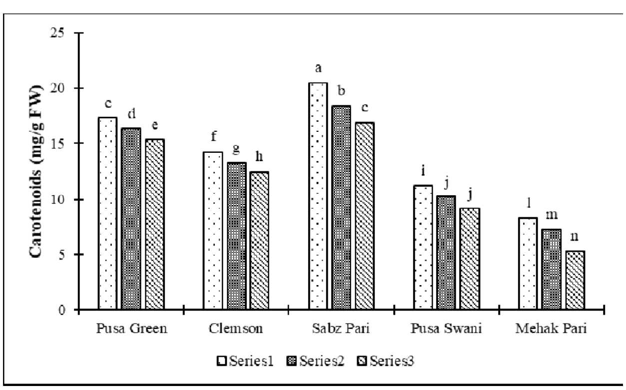

Fig. 7: Effect of drought stress on Carotenoids of okra cultivars

Total Protein (mg/g FW)

It was noted that maximum proteins (8.06 mg/g FW) were recorded in 100% FC whereas minimum protein (2.73 mg/g FW) were observed in 25% FC drought. Results regarding okra cultivars suggested non-significant variation for protein content, maximum protein (5.44 mg/g FW) were observed in Pusa green, Clemson, Sabz Pari and in Mehak Pari while lowest concentration of protein (4.66 mg/g FW) was recorded in Pusa Swani. The combined results of drought stress and okra cultivars for protein showed that okra cultivar Pusa green showed highest protein (9.0 mg/g FW) at control condition, while lowest protein (2.33 mg/g FW) was observed in Pusa Swani at highest drought stress i.e., 25% FC (Fig. 8). Amin *et al.* (2009) obtained similar results in okra and Kabiri *et al.* (2014) in *Nigella sativa.*

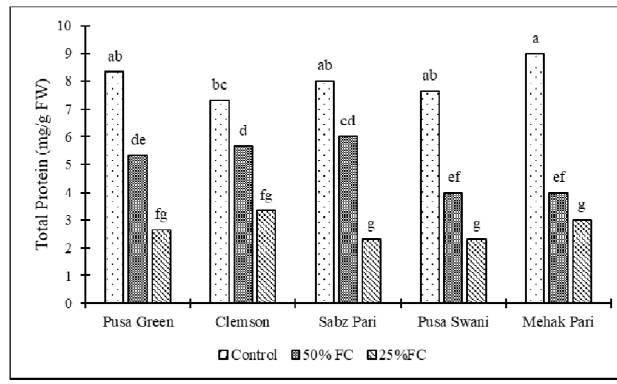

Fig. 8: Effect of drought stress on total protein of okra cultivars

Proline content (µg/g FW)

Maximum proline content (21.36µg/g) was noted in those okra plants which were exposed to 25% FC drought whereas minimum proline content (18.47µg/g) was recorded in control plants (100% FC). Okra cultivars showed significant variations in respect to proline content, okra cultivar Sabz Pari had highest proline content (27.78µg/g) while lowest proline value (11.57µg/g) was recorded in Mehak Pari (Table 1). The combined results of drought stress and okra cultivars suggested an increase in proline content of all okra cultivar with increase in drought stress and among all okra cultivar Sabz Pari showed highest proline content of 29.5, 27.63 and 26.23µg/g at 25%, 50% and 100% FC drought respectively, while okra cultivar Mehak Pari showed lowest proline content of 13.1, 11.4 and10.23µg/g were observed in Mehak Pari at 125%, 50% and 100% FC drought respectively (Fig. 9). Similar observation was recorded by Rokhzadi (2014) in chick pea, Amin *et al.* (2009) in okra and Idrees *et al.* (2010) in lemon grass.

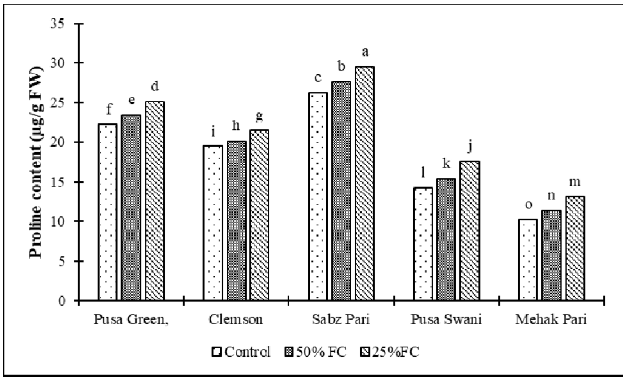

Fig. 9: Effect of drought stress on proline content of okra cultivars

Membrane stability index (%)

Effects of drought on membrane stability index (MSI) indicated that maximum MSI (72.26%) was noted at 25% drought whereas minimum MSI (35.93%) was recorded in control plants. Okra cultivars showed non-significant variations in respect to MSI, okra cultivar Sabz Pari produced highest MSI(56.33%) while lowest MSI values (51.88%) were recorded in Pusa green. The interaction of drought and okra varieties on MSI showed that okra cultivar Mehak Pari produced maximum MSI (73.33%) when grown in 25% FC drought, while least MSI (31.66%) were produced by Pusa green when grown at normal irrigation (Fig. 10). The results of the present study agree with Idress *et al.* (2010) for lemon grass and Sakhabutdinova *et al.* (2006) for wheat.

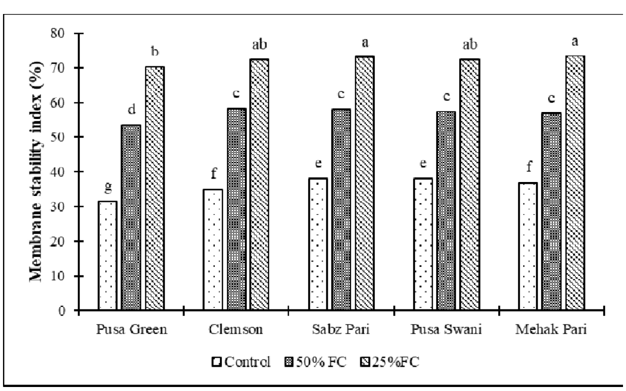

Fig. 10: Effect of drought stress on Membrane Stability index of okra cultivars

DISCUSSION

Reduction in plant biomass and other morphological parameter is clear indication of drought stress on plants and indicates sensitivity towards water deficiency. Our study also confirms that at higher water stress the decrease in plant growth parameters like plant height, fresh weight, and dry weight was observed. Wilting, closing of stomata to prevent transpiration and reduction in cell growth are some key unique responses of plants under drought stress which are produce due to lesser water content, reduced turgor pressure and lower water potential which causes reduced dry and fresh weight and plant height (Guo *et al*., 2018). Water stress also affects cell division, cell differentiation and growth which might be the reason for a cause for reduced plant height, low dry and fresh weight of okra plants. Lesser availability of water under drought stress to cells might have reduced the photosynthesis due to which plants are unable to acquire desirable biomass and height as suggested by Tanveer *et al.* (2019).

In case of effects of drought on chlorophyll content of okra it was observed that an increase in drought significantly reduces the chlorophyll pigment concentration and at highest drought the lowest values were observed. Chlorophyll (a, b and total) pigments are responsible for collection and conversion of sunlight into food and energy. Structural and functional integrity of both pigments is directly related to water availability, which is also confirmed by this study that at higher drought a decrease in photosynthetic pigments were observed as suggested by Peiró *et al.* (2020) and Hussain *et al*. (2019). Decrease in photosynthetic pigments can be attributed to lesser relative water content of leaves and lower water potential (Trueba *et al.,* 2019). Similarly, stomatal impairment in water deficit plants is responsible for reduced chlorophyll pigment content (Dąbrowski *et al.,* 2019). Drought stress also destabilizes the integrity of protein complexes and increases the activity of chlorophyllase, an enzyme which is responsible for chlorophyll degrading, this eventually leads to reduced chlorophyll concentration. This decrease in chlorophyll content might have caused a reduction in photosynthesis rate, which can lead to lesser availability of food and energy required for development and growth of new tissues and organs, which lead to reduced fresh and dry weight and plant height of okra plants under drought conditions.

Drought stress causes a series of physical and bio-chemical changes in plant organs and tissues, carotenoids reduction is one of them. This reduction can be related to severity of drought, duration of exposure and phase of plant growth and genetic resistance capacity of plants towards drought stress (Plazas *et al.,* 2019). Khan *et al*. (2019) also proposed that the reduced carotenoids levels in plants under stress can be due to chloroplast degradation, photo oxidation of chloroplast, chlorophyll synthesis inhibition and increased chlorophyllase activity. Ahmad *et al*. (2019) suggested that activation of LOX and degradation of β-carotene caused the degradation of carotenoids under drought conditions.

Water deficiency under drought condition causes decrease in protein content of plants because water shortage seriously affects the nitrogen metabolism inside plants. The finding of our experiment regarding protein content showed a decrease in protein content with increase in drought stress; this can be attributed to the fact that under drought conditions reduction in polysomal complexes was noted in plant tissues because of lower tissue water content (Khan and Rab 2019). Also, the production of ROS (Reactive Oxygen Species) caused the collapses of protein structure, hence causing an oxidative stress which might be responsible for reduced protein content in stress affected okra plants.

During this study an increase in proline content was recorded in plants subjected to drought. Proline synthesis is greatly associated with the plants response towards stress. Production of osmolytes by plants is a common mechanism adopted to lower the stress; proline is one of these osmolytes which in case of drought stress act as organic reservoir (Zhang *et al*., 2014). It is reported that increase inproline can protect turgor pressure and prevents membrane damage on plants. So, proline accumulation is an adaptation of plants which amplify the tolerance toward drought stress (Singh *et al*., 2019).

Membrane stability index helps to assess the injury occurred to cell membrane due to a-biotic stress. The integrity of cell membrane allows plant to survive during the continuous or random water deficiencies (Oraee and Tehranifar 2020). Decrease of MSI percentage in plants indicates the tolerance of plants towards drought stress (Jafarnia *et al*., 2018). The increase in MSI of okra plants can be due to production of ROS, and oxidation of cell membrane which caused damage to membrane stability and integrity (Meena *et al*., 2017).

CONCLUSION

From this experiment it was observed that drought have significant effect on the overall growth and caused serious reduction in biochemical characters of okra cultivars and at higher drought levels maximum reductions in all studied parameters was observed. On the other hand, okra cultivars subjected to different drought levels exhibits prominent variations in all parameters but okra cultivar Sabz Pari showed promising results and showed increased chlorophyll concentration, lower Membrane stability index and higher protein content as compared to other cultivars, Mehak Pari failed to withstand the applied stress and is more sanative to the drought stress.

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