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Biochemical and yield evaluation of onion (*Allium cepa* L.) genotypes under waterlogging condition

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Abstract

The present investigation entitled “Biochemical and yield evaluation of onion (*Allium cepa* L.) genotypes under waterlogging condition” was carried out at ICAR-Directorate of Onion and Garlic Research, Rajgurunagar, Pune (Maharashtra). Onion crop is extremely sensitive to waterlogging or soil flooding stress due to its shallow root growth habit. The climate change and rainfall distribution pattern most of the onion growing belt might be subjected to heavy rainfall leading to soil flooding condition and cope up with such situation need to identify the improved onion genotypes with better adaptive traits and tolerance for waterlogging condition. Therefore, the main objective of the present study was screening of elite genotypes for water logging tolerance under pot condition. The experiment was laid out in *factorial* CRD for pot condition during *kharif*, 2018. The pot experiment was conducted in rainout shelter using plastic pot and plants were treated with creating artificial waterlogging condition with the help of tank pit and another set were kept outside in rainout shelter as control. The experimental materials comprises of 17 onion entries including red and white onion entries. The seedlings of each entry were raised from seeds in nursery for 45 days with recommended cultural practices and transplanted in pot. The biochemical traits leaf antioxidant, leaf flavonoids and phenol content exhibited maximum in genotype RGP 5 under waterlogging condition. The waterlogging condition was increased quality traits which producing more secondary metabolites for defense strategy of the plant. Further, the yield attribute like bulb yield percent was minimum decreased in genotype RGP 5 with the percent reduction of 18.59% and the genotype W 344 recorded maximum percent reduction with decline by 83.49% under water logging treatment. It may due the water logging condition inhibits the translocation of assimilates from source organs to sink organ. Therefore, on the basis of overall yield reduction percentage and other important traits, genotype RGP 5 can be categorized as water logging tolerant genotypes, whereas genotype W 344 and W 448 recognized as water logging sensitive genotypes among all the tested onion genotypes.

Keywords: *Allium cepa*, waterlogging, leaf antioxidant, phenol content, leaf flavonoids

Introduction

Onion (*Allium cepa* L.) is one of the economically important *Allium* crops belonging to the family *Alliaceae*, which is highly recognized for its distinct flavours and nutritive values throughout the world. It is widely consumed as spices and vegetable crop in the form of salad and cooked in various ways in curries, fried, boiled, baked and used in soup making and pickles. Besides fresh consumption, onion provides very good raw material for processing industry as it is processed in the form of dehydrated powder, rings, shreds and onion in vinegar or brine. The pungency and distinct flavor of onion is due to the presence of sulphur containing compounds like allicin, ajoene, allixin thio sulfinates and sulphites etc. which impart distinctive medicinal properties making it as a potential herb (Robinowitch and Currah, 2002) [10]. The volatile oil present in onion known as ally-propyldisulphide act as an source of dietary Flavanoids and S-alk(en)yl cysteine sulfoxide (Suleria *et al.*, 2015) [13]. Globally, the changing climatic scenario leading to the extreme temperature events like gradual increase in temperatures, freezing stress, water stress like drought, floods, soil salinity, atmospheric and soil pollutants limits productivity of major crops. The recent decades increasing frequent and severe flooding events due to erratic and unseasonal rainfall pattern negatively impact the overall agriculture productivity (Sasidharan *et al.*, 2018) [11]. Plants, being sessile organisms are prone to various environmental stresses. In tropical and subtropical regions, prolonged seasonal rainfall causes severe crop yield losses by subjecting the plant

roots consequently, to suffer hypoxia or anoxia due to soil flooding within a few hours of rainfall. It often gets more detrimental in soil with poor drainage and texture. The visual symptom revealed by crop plant subjected to waterlogging is premature leaf senescence that led to yellowing and wilting, reduction in leaf area and chlorophyll due to which entire plant get collapsed (Kreuzwieser and Rennenberg, 2014). The flooding, risk the crop life by depleting the oxygen and light supply to the developing roots thereby affecting the gas exchange process and inducing anaerobic fermentation pathways ultimately affecting plants normal metabolic pathways in waterlogged soil. (Sauter, 2013) [12]. However, the severity of damage due to waterlogging or soil flooding varies from crop to crop grown under different agro climatic zones. These harsh weather conditions advances the tolerance and adaptive mechanisms in plants helping them to survive. Plant adaptive phenotypic traits such as increased shoot-root elongation and enhanced metabolic pathways are correlated with flooding tolerance that might be play a significant role in determining the ability of a particular crop to sustain the severity of waterlogging. The most impeding consequence of waterlogging on plant growth is the arrested oxygen supply to the root system. In flood-tolerant plants, the formation of these gaseous spaces between cells known as aerenchyma facilitate the increased oxygen uptake in roots under waterlogging conditions as an adaptive mechanisms (Arora *et al.*, 2017) [2]. Onion crop is extremely sensitive to waterlogging or soil flooding stress due to its shallow root growth habit. The maximum root penetration is about 75cm in onion crop with high root density occurring in top soil layer of 18cm (Drinkwater and Janes, 1955) [5]. This root architecture makes the onion crop highly susceptible to excess moisture stress particularly during *khariif* season. The extent of damage due to flooding depends on the season, soil property, variety, crop growth stage, intensity and duration of rainfall that overall predict the bulb yield and survival potential of a particular onion variety. The climate change and rainfall distribution pattern most of the onion growing belt might be subjected to heavy rainfall leading to soil flooding condition and cope up with such situation need to identify the improved onion genotypes with better adaptive traits and tolerance for waterlogging condition in flood prone areas.

Materials and methods

An investigation was carried out at was carried out at Directorate of Onion and Garlic Research, Rajgurunagar, Pune (M.H) during *khariif*, 2018. The experiment was laid out in *factorial* CRD with three replication. The pot experiment was conducted in rainout shelter using plastic pot. One set of plant treated with creating artificial waterlogging condition with the help of tank pit and another set were kept outside in rainout shelter as control (**Plate.1**). The experimental materials comprises of 17 onion entries including red and white onion entries. The seedlings of each entry were raised from seeds in nursery for 45 days with recommended cultural practices and transplanted in pot condition and total 408 plants for each entry in each replication were used for evaluation. The plants were harvested from waterlogged and control pot, when leaves turned yellow and uniform neck fall occurred. The single bulb weight was measured in gram per plant.

Biochemical analysis

The biochemical analysis was done at ICAR, Directorate of Onion and Garlic Research, Rajgurunagar, Pune (M.H)

laboratory. The leaf samples were collected in the bags after the end of the treatment and stored in deep freezer for further analysis.

Determination of Leaf antioxidant (mg/g)

The antioxidant activity is determined by Ferric Reducing Antioxidant Power (FRAP) Assay method described by Benzie and Strain (1996) [3]. The ability to reduce ferric ions was measured using the method. One g of sample was grind in 10ml of 80% methanol and kept it at 4°C for 24 hours. Then centrifuged it at 10000 rpm for 20 minutes and the clear supernatant was collected. FRAP reagent was prepared freshly by mixing 25 ml of 300 mM solution. Above solution was mixed well and incubated at 38°C by kept it in water bath at 37°C temperature for 10 minute. Then the reaction mixture was made of 3 ml by mixing, 150 µL extracted in 2850 µL FRAP reagent and allowed it to stand in dark for 30 minutes. The absorbance was read at 593 nm. The working standard was prepared of ascorbic acid concentrations (20 µg/ml). The antioxidant capacity based on the ability to reduce ferric ions of sample was calculated from the linear calibration curve.

Determination of Total flavonoids content (mg/g)

The total flavonoids content was determined by Olivera (2008) [8] with little modifications. 1 g of sample was extracted with 80% methanol. The extract was centrifuged at 10000 rpm for 10 min and supernatant was collected. One ml of extract was added in 4 ml of water and mixed well. Then 0.3 ml of 5% NaNO₂ was added to the above mixture and incubated for 5 min. Further 0.3 ml of 10% ALCL₃ was added and kept it on stand for 6 minute. Then 2 ml of 1M NaOH was added to the above mixture and finally 2.4 ml of distilled water was added. Mixed the mixture properly and incubated at 18±1°C in dark for 20 min. The absorbance was read at 510 nm on spectrophotometer. A standard curve was constructed based on a range of quercetin concentration (50 µg/ml to 500 µg/ml).

Determination of Phenol content (mg/g)

Total phenols were measured by the method given by Bray *et al.* (1954) [4]. One mg leaf sample was weighed and homogenate with 10ml 80% methanol. It was centrifuged at 10000rpm for 10 minutes. Supernatant was collected and 10 ml of 80% methanol was added again to the residue/pellet, centrifuge it and supernatant 2 was mixed with supernatant 1 and used for estimation. Residue was discarded. Then take 200µl of extract and add 1ml FCR and incubate it for 5 minutes at room temperature. Then add 800µl of 20% Na₂CO₃ and incubate for 2 hours in dark and read the absorbance at 765nm using spectrophotometer.

Results and discussion

Biochemical analysis

The data pertaining to the leaf antioxidant (mg/g), total flavonoids content (mg/g) and Phenol content (mg/g) in onion (*Allium cepa* L.) are presented in Table.1.

The effect of water logging stress on leaf antioxidant was significantly differed in onion genotypes. The highest leaf antioxidant was recorded in genotype Bhima Raj (2.70 mg/gm) followed by W 208 (6.52 mg/gm) while, minimum leaf antioxidant was observed in Bhima Shubhra (1.68 mg/gm) at bulb development stage. It may be due to the genetic make-up of onion genotypes. The leaf antioxidant was differed significantly under control and water logging condition. The maximum percent was increased in genotype

RGP 5 (2.39 mg/gm) with highest incline by 50.33% and the genotype W 344 (2.11 mg/gm) recorded minimum percent increase with incline by 1.68% under water logging treatment. While, the genotype Bhima Dark Red (2.62 mg/gm) recorded maximum antioxidant content and genotype RGP 5 (1.19 mg/gm) recorded lowest antioxidant content under control condition. The waterlogging was pronounced effect and increased leaf antioxidant which may be due to the fact that plant confer tolerance to various abiotic stresses by enhancing both enzymatic and non-enzymatic antioxidant defense systems. Similar results were also reported by Ahmed *et al.* (2016) [1].

The leaf flavonoids were differed significantly in all the genotypes as well as under control and water logging condition. The maximum percent increase was recorded in genotype RGP 5 (2.95 mg/gm) with highest incline by 46.69% and the genotype W 344 (1.85 mg/gm) recorded minimum percent increase with incline by 1.08% under water logging treatment. While, the genotype W 208 (3.78 mg/gm) recorded maximum flavonoids content and genotype Bhima Super (1.08 mg/gm) recorded lowest flavonoids content under control condition.

The plant starts secreting secondary metabolites like flavonoids under stress condition. The genotypes which produce showed higher flavanoid content adapt the waterlogging more efficiently as compared to rest of the genotypes. Similar results were also reported by Khang *et al.* (2016) [7]. The leaf phenol was significantly differed under water logging stress condition in onion genotypes. The highest leaf phenol was recorded in genotype W 355 (12.60 mg/gm) followed by KH-M 2 (12.57 mg/gm) while, minimum leaf phenol was observed in W 208 (8.31 mg/gm) at bulb development stage. The leaf phenol was also differed significantly under control and water logging condition. The

maximum percent increase was recorded in genotype RGP 5 (14.80 mg/gm) with highest incline by 43.76% and the genotype W 344 (9.47 mg/gm) recorded minimum percent increase with incline by 1.80% under water logging treatment. While, the genotype W 355 (12.21 mg/gm) recorded maximum phenol content and genotype Bhima Shweta (8.53 mg/gm) recorded the lowest phenol content under control condition. The waterlogging was pronounced effect and increased leaf phenol which may be defense strategy of the plant by producing more secondary metabolites. Similar results were also reported by Elavarthi and Martin (2010) [6].

Bulb yield (gm/plant)

The effect of water logging stress on single bulb weight (g/plant) in onion (*Allium cepa* L.) genotypes at harvesting stage is presented in Table.2 and Plate.2.

The effect of water logging stress on bulb yield was significantly differed in onion genotypes. The maximum bulb yield was recorded in genotype W 344 (7.22 gm/plant) followed by Bhima Dark Red (7.22 gm/plant) while, minimum bulb yield was observed in Acc. 1630 (2.18 gm/plant) at harvesting stage. The bulb yield was differed significantly under control and water logging condition. The minimum percent decrease was recorded in genotype RGP 5 (4.88 gm/plant) with the percent reduction of 1.47% and the genotype W 344 (3.14 gm/plant) recorded maximum percent reduction with decline by 76.94% under water logging treatment.

While the genotype W 344 (13.62 gm/plant) recorded maximum yield content and genotype Acc. 1630 (3.09 gm/plant) recorded the lowest yield content under control condition. The bulb yield was decreased which may be due to the water logging condition inhibits the translocation of assimilates from source organs to sink organ (onion). Similar results were also reported by Prasanna and Rao (2014) [9].

Table 1: Effect of water logging stress on leaf antioxidant, leaf flavonoid and leaf phenol in onion (*Allium cepa* L.) genotypes at bulb development stage

Genotypes	leaf antioxidant			leaf flavonoid			leaf phenol		
	Control	Water logging	Percent Increase	Control	Water logging	Percent Increase	Control	Water logging	Percent Increase
W 344	1.19	1.21	1.66	1.08	1.10	1.81	7.27	7.44	2.29
W 448	1.68	1.81	7.02	1.09	1.11	1.81	7.65	7.90	3.17
Bhima Shubhra	2.14	2.52	14.98	1.87	2.01	7.10	10.10	13.05	22.61
Bhima Safed	1.49	1.56	4.48	1.86	1.99	6.52	8.73	9.03	3.32
Acc 1630	2.04	2.30	11.32	1.90	2.06	7.63	9.39	11.48	18.21
KH-M2	2.08	2.40	13.57	2.51	2.87	12.63	9.44	11.57	18.41
Acc 1664	2.45	3.00	18.51	2.70	3.07	12.24	12.21	15.96	23.50
Bhima Dark Red	1.60	1.68	4.58	1.70	1.75	2.52	8.53	8.83	3.40
Bhima Raj	2.02	2.25	10.24	1.81	1.86	2.69	9.27	10.05	7.76
W 361	1.40	1.43	1.89	1.57	1.60	1.87	8.97	9.40	4.57
RGP 5	2.64	3.84	31.33	3.78	5.16	26.70	14.50	20.45	29.10
W 208	1.85	2.00	7.49	1.83	1.92	4.54	9.30	10.60	12.26
W 355	1.85	2.06	10.05	1.78	1.82	2.36	9.02	9.49	4.95
DOGR HY 7	2.03	2.27	10.32	2.18	2.38	8.28	9.30	11.12	16.37
Bhima Super	2.21	2.62	15.65	3.71	4.67	20.57	11.51	14.98	23.17
Bhima Shweta	2.42	2.83	14.58	2.77	3.49	20.54	11.74	15.30	23.26
Bhima Red	2.29	2.68	14.44	2.50	2.71	7.54	10.10	13.39	24.57

Factors	C.D.			SE(d)			SE(m)		
Genotypes	0.215	0.38	1.128	0.107	0.19	0.564	0.076	0.134	0.399
Treatment	0.074	0.13	0.387	0.037	0.065	0.193	0.026	0.046	0.137
Interaction (V X T)	0.304	0.538	1.595	0.152	0.269	0.798	0.107	0.19	0.564

Table 2: Effect of water logging stress on single bulb weight (g/plant) in onion genotypes at harvesting stage

Genotypes	Control	Water logging	Genotypic mean
W 344	13.62	3.14	8.38
W 448	8.63	2.97	5.80
Bhima Shubhra	4.35	2.70	3.53
Bhima Safed	6.90	2.54	4.72
Acc. 1630	3.09	1.27	2.18
KH-M 2	5.46	3.81	4.63
Acc. 1664	4.12	3.33	3.73
Bhima Dark Red	10.96	3.48	7.22
Bhima Raj	7.65	2.65	5.15
W 361	8.46	2.24	5.35
RGP 5	4.95	4.88	4.91
W 208	3.92	2.23	3.07
W 355	6.07	2.39	4.23
DOGR HY. 7	5.34	3.05	4.20
Bhima Super	4.99	3.90	4.45
Bhima Shweta	3.91	2.35	3.13
Bhima Red	5.36	4.19	4.78
Treatment mean	6.34	3.01	4.67
Factors	C.D.	SE(d)	SE(m)
Genotypes	0.803	0.401	0.284
Treatment	0.275	0.138	0.097
Interaction (V X T)	1.135	0.568	0.401

**Plate 1:** Creating artificial waterlogging condition with the help of tank pit**Plate 2:** Bulb yield of onion (*Allium cepa* L.) genotypes

Conclusion

The biochemical traits leaf antioxidant, leaf flavonoids and leaf phenol content exhibited maximum in genotype RGP 5 under waterlogging condition. The waterlogging condition was increased quality traits which producing more secondary metabolites for defense strategy of the plant. Further, the bulb yield percent was minimum decreased in genotype RGP 5 with the percent reduction of 18.59% and the genotype W 344 recorded maximum percent reduction with decline by 83.49% under water logging treatment at harvesting stage. It may due the water logging condition inhibits the translocation of assimilates from source organs to sink organ.

Therefore, on the basis of overall yield reduction percentage and other important traits, genotype RGP 5 can be categorized as water logging tolerant genotypes, whereas genotype W 344 and W 448 recognized as water logging sensitive genotypes among all the tested onion genotypes.

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