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Genotypic variability in physiological response to deficit water condition in bell pepper (*Capsicum annuum* L.)

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Abstract

Deficit or excess water conditions are the most important factors constraining vegetable crop production all over the world under the scenario of climate change. The present study was conducted to evaluate the physiological response of bell pepper (*Capsicum annuum* L.) genotypes i.e. Arka Mohini, Arka Gaurav, PBC-848, CHT 3-1 and CHT 3-2 to deficit water stress. Genotypic variability was observed for gas exchange characteristics, chlorophyll (Chl) a fluorescence, water use efficiency and plant water relation (relative water content (RWC), leaf water potential and osmotic potential. Genotypes, Arka Mohini and Arka Gaurav showed higher photosynthetic rate and better plant water relations during stress as compared to other genotypes. A positive relationship between Chl a fluorescence and RWC indicated the involvement of non-stomatal factors towards reduction in P_N during deficit water stress. The genotypic differences were observed in pollen germination and root characteristics (root length, root volume and root fresh and dry weights) during stress. The genotypes, Arka Mohini and Arka Gaurav showed better root growth under stress conditions. Deficit water stress resulted in reduction of IAA, DHZR and ZR coupled with ABA accumulation. High levels of auxins and cytokinin- zeatinriboside were recorded in stressed plants of Arka Gaurav, Arka Mohini and CHT 3-2 implying better tolerance to water deficit stress by maintaining higher photosynthesis rate and root development through modulations in phytohormones.

Key words: Bell pepper, deficit water, photosynthesis, water use efficiency, phytohormones.

Introduction

Many vegetable crops seldom reach their total potential for high productivity mainly because the limitations imposed by the environmental factors on various physiological and biochemical processes involved in growth and yield. Climate change, one of the most significant problems faced by humanity, is resulting in erratic rainfall, occurrence of high and low temperature spells and incidence of new diseases and pests. The successful cultivation of horticultural crops in general and vegetable crops in particular is impeded by the occurrence of these environmental vagaries. Limited water conditions affect the physiological and biochemical processes such as photosynthesis, respiration, translocation of photo-assimilates, phytohormone production as well as the nutrients mobilization and thereby, limiting plant growth and production (Farooq et al. 2009). It is indisputable that for high yields, an adequate water supply and relatively moist soils are required during the entire crop growing season for production of vegetable crops. Among solanaceous vegetables, bell-pepper (*Capsicum annuum* L.) is found to be relatively sensitive to environmental extremes such as the prevailing high and low temperatures and limited and excess soil moisture (Fernandez et al. 2005). Earlier studies have indicated high stomatal conductance, wide transpiring leaf surface area, pollen germination and fertilization are vital for bell pepper's susceptibility to low moisture (González-Dugo et al. 2007, Barnabas et al. 2008). However, a prolific root system can confer advantage to support plant growth during adverse water deficit conditions (Yordanova et al. 2003). Although the genetic enhancement under various breeding programmes is going on in different laboratories for developing resilient varieties to deficit water conditions, there is a need to adopt strategies to minimize the effect of water stress on bell-pepper and improve crop production. In recent studies, improving plant resilience to abiotic stresses by adopting efficient rootstocks and grafting found to be an ideal approach (Bhatt et al. 2014 & 2015, Bahadur et al. 2015). The present study, therefore, was conducted to evaluate the physiological responses of bell pepper genotypes to identify suitable water deficit tolerant rootstocks for grafting.

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Materials and Methods

Plant material and growth conditions: The study was conducted on five bell pepper (*Capsicum annuum* L.) genotypes, Arka Mohini, Arka Gaurav, PBC-848, CHT 3-1 and CHT 3-2. Seeds were sown in pro-trays filled with coco peat as the growing medium. After 25 days of seedlings emergence, these were transplanted into 20-liter capacity plastic containers filled with growth media consisting of soil, FYM and sand (2:1:1 w/w). The experiment was conducted in poly house conditions. During the study, day temperature was around 26-28 °C and relative humidity varied between 38-40%.

Stress imposition: Water stress was imposed at flowering stage by withholding irrigation for 4 and 8 days. Soil moisture content was determined gravimetrically. There was a gradual decrease in soil moisture which reached 15.0% by 4th day and 9.0% by 8th day of stress indicating 40.0% and 65.0% reduction, respectively over field capacity. The average soil moisture in control plants at day 4 and 8 was 25%.

Plant water relations: Leaf samples were collected from both water stressed and control plants and leaf water potential ($Ø_L$) was determined using pressure bomb apparatus (ARIMAD-3000 MRC). The leaf relative water content (RWC) was estimated (Turner 1981). A portion of leaf used for the photosynthetic determination was frozen for a week, thawed and the sap was used for determination of osmotic potential ($Ø_S$) using vapor pressure osmometer (Wescor: VAPRO-Vapor Pressure Osmometer, Germany).

In vitro pollen germination: In order to measure pollen germination, about 5-10 fully opened flowers with dehiscent anthers were collected randomly during stress period. The collected pollen was transferred on a drop of growth media and placed on a petri-dish. The growth media was prepared according to Niles and Quesenberry (1992). The slides were incubated for 3 h in dark at room temperature. After incubation, a drop of Alexander's strain was placed on top and covered with cover slips. The samples were then assessed for pollen germination under a light microscope. Pollen containing pollen tube at least half a length of diameter of a pollen grain was considered as germinated (Kakani et al. 2005).

Leaf gas exchange characteristics: Gas exchange parameters like net photosynthesis (P_N), transpiration rate (AE) and stomatal conductance (g_s) were recorded on fully expanded leaf (4th from top) between 9300 h and 1100 h using portable photosynthetic system (model LCpro+, ADC Bioscientific limited, UK). The ambient CO_2 concentration during the measurement ranged between 380-390 ppm, irradiance between 1300-1500 µmol m^{-2} s^{-1} (PAR) and average leaf temperature around 27-29 ÚC. Water use efficiency (WUE) calculated from CO_2 exchange rate and transpiration rate was expressed as ìmol CO_2/mol H_2O.

Chlorophyll (Chl a) fluorescence kinetics: Chlorophyll (Chl a) fluorescence parameters were measured using modulated chlorophyll fluorometer (OPT1-SCIENCES, OSIp, USA). The minimal fluorescence (F_0), maximal fluorescence (F_m) and maximal photochemical efficiency of PSII (F_v/F_m) were recorded after 30 minutes of dark-adaptation of leaves. Light response curves of the relative electron transport rate (ETR_{PSII}) and the effective photo chemical quantum yield of PSII ($Ö_{PSII}$) measurements were also obtained through application of a series saturation pulses on the fourth leaf from shoot apex.

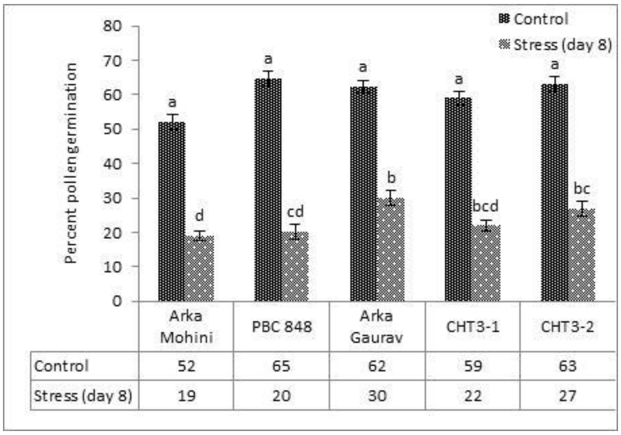
Root morphological parameters: Plants were gently uprooted ensuring intactness of root system and adhering soil particles were removed by washing roots in running tap water. Roots were dried by keeping between pads of filter papers and root length and fresh weight were measured immediately. Root volume was measured by water displacement method. For root dry weight, roots were kept for drying in an oven maintained at 80ÚC until constant weight is attained.

Phytohormones estimation: Leaf and root samples were collected before releasing stress and immediately frozen in liquid nitrogen for measuring contents of phytohormones, indole acetic acid (IAA) and abscisic acid (ABA) in leaves, and cytokinins [Zeatin (Z) zeatinriboside (ZR) and dihydrozeatinriboside (DHZR)] in roots using HPLC (Prominance, Shimadzu, Japan) equipped with pump (LC-20AD, Shimadzu, Japan) and a PDA detector (SPD-M20A). The sample extract for analysis of phytohormones were prepared according to kelen *et al.* (2004) and Chen *et al.* (2010) with some modification. All quantification of the above phytohormones was carried out using IAA, ABA and cytokinins external standards (Sigma-Aldrich, USA).

Statistical analysis: Statistical analysis was done by computing the standard deviation and analysis of variance (ANOVA) at 0.05 levels of probability and mean discrimination was done according to the Duncan's multiple range test using MSTATC 2.0.

Results and Discussion

Plant water relations and pollen germination: Bell pepper growth is closely linked to the amount of water applied during growing period (González-Dugo et al. 2007) and it becomes critical during the flowering phase (Ferrara *et al.,* 2011). There was considerable decrease



	Arka Mohini	PBC 848	Arka Gaurav	CHT3-1	CHT3-2
Control	52	65	62	59	63
Stress (day 8)	19	20	30	22	27

Fig. 1: Germination of pollens under deficit water condition in bell pepper genotypes

in leaf turgidity under water stress conditions as indicated by drastic reduction in RWC, Ø$_{L}$ and Ø$_{S}$. Leaf relative water content (RWC) varied from 84.0 to 88.0% in control plants. However, in water deficit plants, the RWC decreased from 76.0 to 64.0% with least reduction in Arka Mohini (Table 1). The leaf water potential (Ø$_{L}$) ranged from -0.5 to -0.6 MPa in control and -1.2 to -2.9 MPa in water deficit plants. There was considerable decrease in osmotic potential (Ø$_{S}$), which varied from 1.3 to 2.8 (-MPa) in water deficit plants with the maximum being in PBC-848 and least in Arka Mohini (Table 1). The RWC and Ø$_{S}$ are important characteristics that influence plant water relations under water stress. The maintenance of turgidity in Arka Mohini and CHT 3-2 may be due to the accumulation of the osmolytes as indicated by a negative relationship between Ø$_{S}$ and RWC (Fig 2). Genotypic variability was observed for

Table 1: Relative water content (RWC), osmotic potential (Ø$_{S}$) and leaf water potential (Ø$_{L}$) as affected by deficit water stress in bell pepper

		RWC (%)		Osmotic potential (Ø$_{S}$, -MPa)		Leaf Water potential (Ψ_L, -MPa)	
		Day 4	Day 8	Day 4	Day 8	Day 4	Day 8
Arka Mohini	C	88.2^{a}	88.3^{a}	1.35^{a}	1.41^{ab}	0.57^{d}	0.57^{d}
	S	81.4^{bcd}	76.5^{bc}	1.39^{abc}	1.69^{b}	1.26^{bc}	2.10^{bc}
PBC 848	C	84.2^{abc}	85.2^{a}	1.36^{abc}	1.36^{a}	0.63^{d}	0.63^{d}
	S	73.9^{e}	64.8^{e}	1.53^{d}	2.82^{d}	1.83^{a}	2.96^{a}
Arka Gaurav	C	86.0^{ab}	84.7^{a}	1.38^{abc}	1.42^{ab}	0.60^{d}	0.60^{d}
	S	78.9^{cde}	70.3^{cd}	1.41^{abc}	2.62^{cd}	1.30^{bc}	2.40^{b}
CHT 3-1	C	88.6^{a}	84.1^{ab}	1.36^{ab}	1.35^{a}	0.60^{d}	0.60^{d}
	S	75.8^{de}	68.2^{de}	1.46^{cd}	2.37^{c}	1.50^{b}	2.26^{bc}
CHT 3-2	C	86.2^{ab}	85.4^{a}	1.35^{a}	1.35^{a}	0.63^{d}	0.63^{d}
	S	81.9^{bc}	73.3^{cd}	1.45^{bcd}	2.70^{d}	1.23^{c}	2.04^{c}
SEM		12.46	21.97	0.003	0.031	0.02	0.035
CD@0.05%		6.05	8.04	0.09	0.302	0.24	0.32

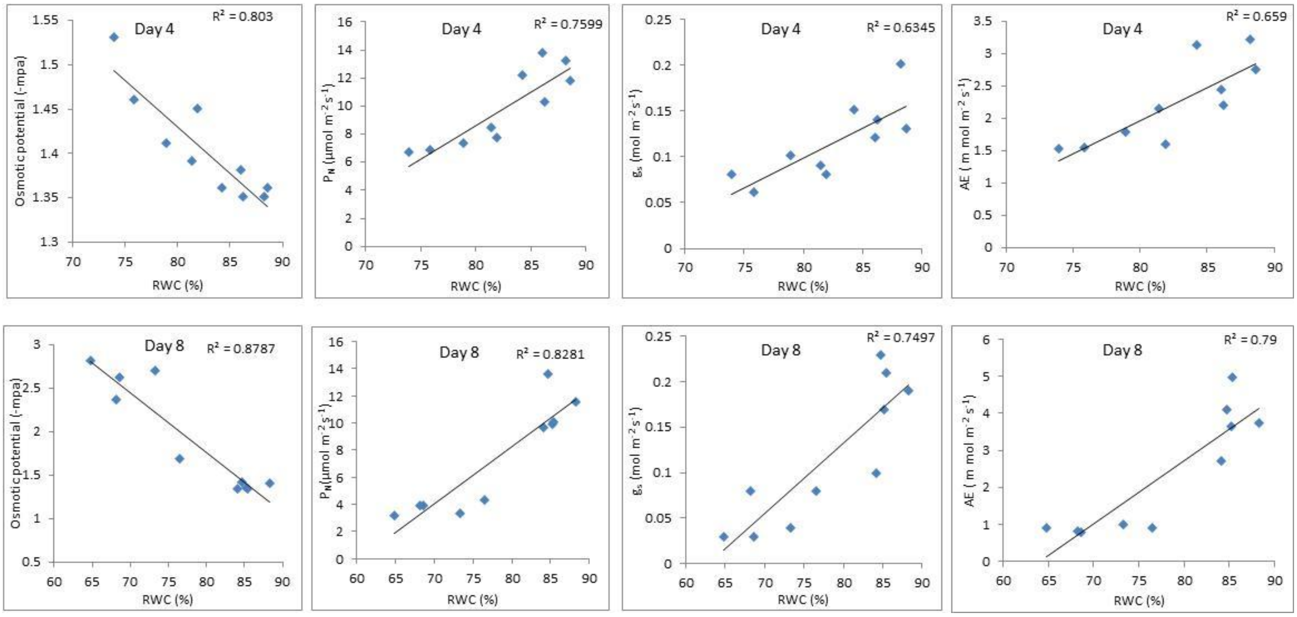


Fig.2: Relationship between relative water content (RWC), osmotic potential and gas exchange parameter under deficit water condition in bell pepper

pollen germination during water deficit stress in bell pepper (Fig 1). Among the cultivars studied Arka Gaurav (30.0%) and CHT 3-2 (27.0%) had maximum pollen germination. However, Arka Mohini had the least pollen germination in control (52.0%) as well as in deficit water stress (19.0%) conditions. The reduction in pollen germination in the stressed plants was attributed to dehydration as a result of moisture loss due to stress induced drying of pollens (Aylor 2004). Deficit water stress reduced accumulation of starch during pollen development which rendered them unviable for germination (Schoper et al. 1985). The reduced pollen germination was attributed to an increase in ABA content and reduced invertase activity during water stress (De Storme and Geelen 2014).

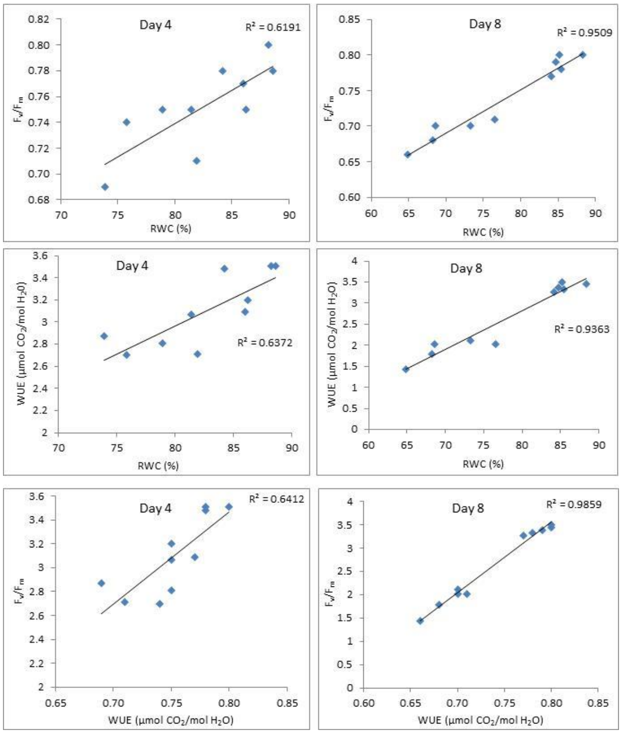


Fig.3: Relationship between maximum fluorescence efficiency (F_v/F_m), WUE (µmol CO_2/mol H_2O) and RWC under deficit water condition in bell pepper

Gas exchange characteristics and chlorophyll fluorescence kinetics: The results indicated that water deficit conditions have negatively affected the gas exchange characteristics in all genotypes. Under control conditions, the highest P_N was observed in Arka Gaurav and Arka Mohini (13.1 to 13.7 µmol m^{-2} s^{-1}) and the lowest was noticed in PBC-848 (10.0 µmol m^{-2} s^{-1}). There was a gradual decrease in P_N up to day 4 in all the genotypes (24.0 to 47.0%). However, after day 4, there was a significant decrease in P_N (59.0 to 71.0%) indicating the photosynthetic sensitivity in these cultivars to water stress (Table 2). Maintenance of higher P_N rate by Arka Mohini indicated the photosynthetic resilience of this genotype to water stress as compared to other genotypes. A considerable decrease in g_s was found with increase in stress. There was 16.0 to 55.0% and 78.0 to 82.0% decrease in g_s by days 4 and 8, respectively, under stress in all the genotypes (Table 2). The higher P_N rate in Arka Mohini during stress was attributed to the higher stomatal conductance. A sharp reduction in AE was observed in all the genotypes during stress. Further, it was shown that reduction in RWC and leaf osmotic potential influences photosynthetic rate in bell pepper (Fig 2). The higher WUE (2.02 to 2.11µmol CO_2/mol H_2O) was found in CHT 3-2, Arka Gaurav and Arka Mohini (Table 2) and that was positively correlated with RWC (Fig 3).

Apart from a reduction in P_N and g_s the photochemistry of photosynthesis was also influenced during deficit water conditions as indicated by a reduction in Chl a fluorescence kinetics such as F_0, F_m, fluorescence efficiency (F_v/F_m) and electron transport rate (ETR) and also yield (PSII) (Table 3). The decrease in P_N is,

Table 2: Net photosynthetic rate (P_N), stomatal conductance (g_s), transpiration rate (AE) and instant water use efficiency (WUE) of bell pepper under deficit water condition

		P_N (µmol m^{-2} s^{-1})		g_s (mol m^{-2} s^{-1})		AE (m mol m^{-2} s^{-1})		WUE (µmol $C0_2$/mol H_20)	
		Day 4	Day 8	Day 4	Day 8	Day 4	Day 8	Day 4	Day 8
Arka Mohini	C	13.17^{a}	11.55^{ab}	0.20^{a}	0.19^{bc}	3.20^{a}	3.75^{bc}	3.51^{a}	3.45^{ab}
	S	8.40^{cd}	4.32^{c}	0.09^{bc}	0.04^{d}	3.19^{a}	0.92^{d}	3.07^{c}	2.11^{c}
PBC 848	C	12.11^{ab}	9.95^{b}	0.15^{ab}	0.17^{bc}	3.11^{ab}	3.66^{bc}	3.48^{a}	3.51^{a}
	S	6.68^{d}	3.17^{c}	0.08^{bc}	0.03^{d}	2.81^{ab}	0.90^{d}	2.87^{d}	1.43^{e}
Arka Gaurav	C	13.75^{a}	13.63^{a}	0.12^{bc}	0.23^{ab}	2.43^{ab}	$4 .48^{b}$	3.09^{c}	3.38^{ab}
	S	7.27^{d}	3.89^{c}	0.10^{bc}	0.03^{d}	1.77^{ab}	0.79^{d}	2.81^{d}	2.02^{c}
CHT 3-1	C	11.74^{ab}	9.69^{b}	0.13^{abc}	0.10^{cd}	2.74^{ab}	2.73^{c}	3.51^{a}	3.27^{b}
	S	6.78^{d}	3.88^{c}	0.06^{c}	0.03^{d}	1.53^{b}	0.81^{d}	2.70^{e}	1.79^{d}
CHT 3-2	C	10.22^{bc}	10.11^{b}	0.14^{ab}	0.31^{a}	2.18^{ab}	5.23^{a}	3.20^{b}	3.33^{ab}
	S	7.71^{d}	3.37^{c}	0.08^{bc}	0.04^{d}	1.59^{ab}	1.00^{d}	2.71^{e}	2.02^{c}
SEM		2.03	1.93	0.002	0.003	0.87	0.54	0.003	0.012
CD@0.05%		2.44	2.83	0.076	0.09	1.60	1.26	0.09	0.18

Table 3: Chlorophyll fluorescence kinetics (dark adapted fluorescence, F_O ;maximal fluorescence during saturation flash, F_m; maximum potential quantum efficiency of PSII, F_v/F_m; effective quantum photosynthetic yield, Yield II and electron transport rate, ETR) as affected by deficit water stress in bell pepper

		F_O		F_m		F_v/F_m		Y(II)		ETR	
		Day 4	Day 8	Day 4	Day 8	Day 4	Day 8	Day 4	Day 8	Day 4	Day 8
Arka Mohini	C	220^{bcd}	218^{abcd}	0.80^{a}	0.85^{a}	0.80^{a}	0.80^{a}	0.63^{ab}	0.54^{ab}	171^{a}	170^{a}
	S	171^{d}	169^{d}	0.50^{b}	0.38^{cd}	0.75^{ab}	0.71^{bc}	0.46^{de}	0.29^{c}	147^{b}	111^{b}
PBC 848	C	264^{abc}	254^{a}	0.82^{a}	0.72^{b}	0.80^{a}	0.80^{a}	0.72^{a}	0.59^{a}	177^{a}	158^{a}
	S	149^{d}	169^{d}	0.46^{b}	$0.30d^{e}$	0.67^{c}	0.66^{c}	0.42^{e}	0.21^{d}	122^{c}	75^{c}
Arka Gaurav	C	275^{ab}	252^{ab}	0.87^{a}	0.80^{ab}	0.77^{ab}	0.79^{a}	0.71^{a}	0.60^{a}	191^{a}	172^{a}
	S	199^{cd}	198^{bcd}	0.53^{b}	0.46^{c}	0.71^{bc}	0.70^{c}	0.49^{bcde}	0.26^{cd}	147^{b}	99^{b}
CHT 3-1	C	283^{ab}	230^{abc}	0.80^{a}	0.75^{b}	0.78^{a}	0.77^{ab}	0.63^{abc}	0.49^{b}	172^{a}	170^{a}
	S	182^{d}	169^{d}	0.41^{b}	0.27^{e}	0.74^{abc}	0.68^{c}	0.49^{bcde}	0.24^{cd}	138^{bc}	81^{c}
CHT 3-2	C	318^{a}	241^{abc}	0.85^{a}	0.71^{b}	0.80^{a}	0.78^{a}	0.61^{abcd}	0.59^{a}	179^{a}	160^{a}
	S	198^{cd}	195^{cd}	0.52^{b}	0.33^{de}	0.75^{ab}	0.70^{c}	0.47^{cde}	0.28^{cd}	147^{b}	101^{b}
SEM		1013	621	0.012	0.002	0.001	0.001	0.005	0.001	98.49	42.44
CD@0.05%		72.01	56.39	0.24	0.10	0.07	0.07	0.160	0.071	21.87	14.74

therefore, a result of both stomatal and non-stomatal limitations under water stress (Yordanov *et al.,* 2003). A positive relationship between Chl a fluorescence and RWC (Fig 3) further showed the involvement of non-stomatal factors towards the reduction in P_N during water stress. Decrease in F_v/F_m indicated damage to thylakoid membranes and/or photosynthetic electron transport system. The maintenance of higher Chl a fluorescence efficiency (F_v/F_m) (0.75) in Arka Mohini and CHT 3-2 compared to other genotypes is indicative of better photosynthetic performance and thus avoiding damage owing to photo inhibition under deficit water conditions. These genotypes also maintained higher electron transport rate (101-111) and quantum yield (0.28 -0.29) at 8-day stress (Table 3). Maintenance of higher Chl a fluorescence efficiency of photosystem II (F_v/F_m) is a parameter used to evaluate photosynthetic performance (Bresson et al. 2015). Furthermore, WUE was also positively correlated with Chl a fluorescence (Fig 3). In the present study the differential response of genotypes indicated significant influence of water stress on the physiological functioning of bell pepper.

Root characteristics and Phytohormone changes: A genotypic difference was found in root response to water stress in bell pepper as shown by a substantial reduction in root characteristics viz., root length (27.0 to 71.0%), root volume (37.0 to 68.0%), root fresh weights (36.0 to 62.0%) and dry weights (52.0 to 72.0%) under deficit water conditions (Table 4). Maintenance of root system has been recognized as a crucial aspect to cope with water stress conditions (Kulkarni and Phalke 2009, Arun Kumar et al. 2017). Arka Mohini and Arka Gaurav showed lesser reduction in these characteristics as compared to other genotypes by 8-day stress (8-9% soil moisture) (Table 4 and Plate 1). Water stress differentially affected the production of phytohormones (IAA, ABA, cytokinins-Z, ZR and DHZR) in bell pepper genotypes (Table 5). A significant increase in ABA content was observed in all the genotypes (41.0 to 48.0%) under water deficit condition, with maximum increase in PBC-848 and minimum in Arka Gaurav. ABA tends to increases in plants during water deficit conditions (Li et al. 2016) suggesting its

Table 4: Influence of deficit water stress on root characteristics in bell pepper

		Root length (cm)	Root Volume (cubic cm)	Root FW (g)	Root DW (g)
Arka Mohini	C	62.3^{a}	290.0^{a}	100.7^{a}	51.7^{ab}
	S	35.3^{c}	160.0^{bc}	59.0^{c}	25.7^{d}
PBC 848	C	60.3^{a}	196.7^{b}	89.3^{b}	50.7^{abc}
	S	17.3^{e}	96.0^{d}	33.7^{e}	14.0^{f}
Arka Gaurav	C	62.7^{a}	296.7^{a}	100.3^{a}	54.0^{a}
	S	45.3^{b}	186.7^{b}	63.7^{c}	25.7^{d}
CHT 3-1	C	62.0^{a}	286.7^{a}	95.7^{ab}	47.3^{c}
	S	31.3^{d}	90.0^{d}	42.0^{d}	18.7^{e}
CHT 3-2	C	60.7^{a}	280.0^{a}	97.0^{a}	49.7^{bc}
	S	34.0^{cd}	120.0^{cd}	40.3^{de}	23.3^{d}
SEM		3.75	998.4	18.32	4.47
CD@0.05%		3.32	54.20	7.34	3.62

Plate 1: Response of bell pepper root growth under irrigated (control) and deficit water condition (8 days)

role in maintaining stomatal regulation. In the present study, though there was a significant increase in the ABA content in PBC-848, it did not show expected resilience to stress as reflected in a substantial decline of all other physiological parameters under stress. The ABA increase coincided with decrease in IAA and cytokinin content (Table 5). However, the decrease in root cytokinin was less in CHT 3-2 (18.5%) followed by Arka Gaurav (21.0%) and Arka Mohini (23.0%) during water stress. Least reduction in IAA was found in Arka Gaurav (14.0%) followed by CHT 3-2 (21.0%) and Arka Mohini (23.0%). Parallel increase in ABA and decline in IAA and cytokinins in roots under water stress contributed to change in other physiological parameters in shoots. Similar response was reported in French bean under deficit water conditions (Upreti et al. 2000). Phytohormonal imbalance caused by deficit water conditions lead to reductions of IAA, DHZR and ZR contents coupled with increase in ABA in bell pepper genotypes. The higher level of auxins and cytokinin-zeatinriboside in stressed plants of Arka Gaurav, Arka Mohini and CHT 3-2 possibly contributed for their resilience under stress conditions.

The present study shows great sensitiveness of bell pepper crop to water deficit conditions. The ability of different genotypes to acclimatize to deficit water conditions is directly and indirectly associated with their ability to acclimate at the level of photosynthetic characteristics and chlorophyll fluorescence kinetics. Among the genotypes, Arka Mohini and Arka Gaurav maintained better plant water relation and thus recorded higher photosynthetic rate under stress. The study further indicates that the response of root characteristics and hormonal homoeostasis plays a pivotal role in bell pepper for better resilience during deficit water stress. The results suggest the significance of root characteristics to improve resilience under deficit water conditions in bell pepper. The findings would go a long way in recommending water stress resilient bell pepper genotypes for use as rootstocks.

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Table 5. Hormonal (leaf ABA and IAA content and root cytokinins- zeatin, Z; zeatinriboside, ZR and dihydrozeatinriboside, DHZR) response of bell pepper genotypes under deficit water conditions.

		ABA (ng g-1)	IAA (ng g-1)	ZR (ng g-1)	DHZR (ng g-1)	Z (ng g-1)
Arka Mohini	C	145.4±15.2	78.8±3.2	436.9±12.4	497.2±10.2	200.8±10.8
	S	251.5±10.2	60.2±5.4	390.1±13.4	315.5±9.8	165.7±9.8
PVC 846	C	176.8±9.5	86.7±3.9	512.6±13.4	563.4±12.4	363.7±11.2
	S	342.2±14.2	59.8±5.4	302.3±10.2	348.8±12.7	205.2±10.5
Arka Gaurav	C	163.8±9.8	122.7±9.8	465.8±14.2	411.7±13.4	152.1±9.8
	S	281.4±11.2	104.7±8.5	365.8±13.8	324.7±14.5	103.6±9.4
CHT 3-1	C	156.7±9.51	65.8±3.4	296.8±12.4	347.4±13.8	214.2±10.2
	S	283.9±11.2	42.3±2.1	219.4±10.5	236.3±9.8	155.2±9.4
CHT 3-2	C	165.1±10.4	100.7±6.5	462.6±13.4	408.5±14.5	302.3±9.7
	S	299.7±9.8	79.2±3.2	363.9±10.8	349.8±11.2	242.9±8.4

lkjka'k

विश्वभर में जलवायु–परिवर्तन के परिदृश्य में पानी की कमी या अधिकता सब्जी फसलों के उत्पादन को प्रभावित करने वाले प्रमुख कारकों में एक है। वर्तमान अध्ययन जल–प्रतिबल की कमी के प्रति शिमला मिर्च (*कैप्सिकम एनम* एल.) के अर्का मोहिनी, अर्का गौरव, पीबीसी–848, सीएचटी 3–1 और सीएचटी 3–2 जीनप्ररूपों की कार्यिकीय अनुक्रिया के मूल्यांकन के लिए किया गया। गैस विनिमय लक्षणों क्लोरोफिल प्रतिदीप्ति, जल–उपयोग–दक्षता एवं पौध–जल–संबंध (आनुपातिक जल की मात्रा) (आरडब्ल्यूसी), पर्ण–जल–क्षमता और ऑस्मोटिक क्षमता के संबंध में आनुवंशिक विविधता पाया गया। प्रजाति अर्का मोहिनी एवं अर्का गौरव जीनप्ररूपों ने अन्य जीनप्ररूपों की तुलना में प्रतिबल के दौरान अधिक प्रकाश संश्लेषित दर और बेहतर पौध–जल–संबंध दर्शाया। क्लोरोफिल प्रतिदीप्ति और आनुपातिक जल की मात्रा के बीच एक सकारात्मक संबंध ने जल प्रतिबल की कमी के दौरान पीएन की कमी में गैर–रंध्रीय कारकों के सम्मिलित होने का संकेत दिया। प्रतिबल के दौरान परागकणों के अंकुरण और जड़ संबंधी लक्षणों (जड़ की लंबाई, जड़ का आयतन और जड़ का ताजा व शुष्क वजन) में जीनप्ररूपीय अंतर पाया गया। अर्का मोहिनी और अर्का गौरव जीनप्ररूपों में प्रतिबल–परिस्थितियों के तहत बेहतर जड़–विकास पाया गया। जल–प्रतिबल की कमी के परिणामस्वरूप एबीसिसिक अम्ल के संचयन के साथ आईएए, डीएचजेडआर और जेडआर में कमी हुई। अर्का गौरव, अर्का मोहिनी और सीएचटी 3–2 के प्रतिबलित पौधों में ऑक्सिन और साइटोकिनिन–जीटिनराइबोसाइड की अधिक स्तर पाए गए, जिसने पादप हॉर्मोन में उतार–चढ़ाव के माध्यम से उच्च प्रकाश–संश्लेषण दर और जड़–विकास के अनुरक्षण के द्वारा जल–प्रतिबल के प्रति बेहतर सहनशीलता का संकेत दिया।

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