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ENHANCEMENT IN BIOMASS AND NUTRIENTS UPTAKE IN CUCUMBER THROUGH METHIONINE AND PHENYLALANINE UNDER SALINE SOILS

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Cucumber is one of the important vegetable for nourishing human being due to the presence of nutrients and vitamins throughout the world. However, its production is decreasing due to several environmental stresses. Amongst the abiotic stresses, salinity is the foremost problems for agricultural crops which cause a great loss in crop production in the world. A number of management approaches have been executed to cope with salinity problem. However, the foliar application of amino acids to enhance plant tolerance under salt stress is a cost-effective technology being utilized in all over the world. For this purpose, the experiments were conducted to evaluate the foliar application of two amino acids i.e., phenylalanine (75 and 100 ppm) and methionine (25 and 50 ppm) separately and in combinations on four cucumber genotypes (HC-999, Valley, NSC-CM1 and Akbar). Results showed that 25 ppm methionine showed better behavior towards the enhancement of biomass production as compared to 50 ppm methionine and 75 and 100 ppm phenylalanine separately under saline and non-saline conditions. However in combinations, the 25 ppm methionine with 100 ppm phenylalanine showed better performance in non-saline and saline conditions in biomass production as compared to all other treatments of both amino acids separately and also in combined foliar sprays. The foliar application of 100 ppm phenylalanine showed better results in nutrients uptake as compared to other treatments of both amino acids separately under saline and non-saline conditions. Therefore the application of 25 ppm methionine with 100 ppm phenylalanine may be used to improve the quantity and quality of maize to grow in saline soils.
Keywords: Shoot and root fresh and dry weights, Ions analysis, Genotypes HC-999, Valley, NSC-CM1.

INTRODUCTION

Salinization is a great ecological problem across the globe because of increased soluble salt content in soil and water (Kausar *et al.*, 2019; Sadak *et al.*, 2020) and it affects approximately 800 Mha that is 6 % of the total area of world land (Kheyrodin, 2014). Saline soil lower the plant water potential which ultimately affects plant physiological and biochemical parameters and as a consequences reduction in plant growth and its productivity (Rohman *et al*., 2016).
Among abiotic factors drought and salinity influence adversely on growth, productivity and yield of the crop (Tian *et al.*, 2020; Trabelsi *et al*., 2019). Salinity is a foremost risk to the development and productivity of crops, due to high soluble salts levels in soil and water and sodium (Na^+) is the major factor which causes salinization in many soils and crops (Zhan *et al*., 2019). Sodium ions because of its small size are frequently absorbed in root cells by passive movement and leading to osmotic stress and nutrient imbalance (Hameed *et al.*, 2014). Plant membranous system is also severely damaged by specific ions toxicity, plants as stress tolerance response, compartmentalize Na^+ and chloride (Cl^-) ions in vacuole but when there is the high concentration of soluble salts, vacuole becomes saturated then these soluble ions start to accumulate in cytoplasm leading to the enzyme inhibition, cell dehydration and decreased seed germination (Butt *et al*., 20). It is therefore necessary to adapt some salinity management practices such as to renovate such saline soils into useable land, use of plant growth regulators or use of salt tolerant crops in salt-hit areas for better results (Shahbaz and Ashraf, 2013). Several studies emphasized the use of foliar application of plant growth regulators which increase plant growth, productivity and nutrients uptake (Sarwar *et al*., 2013).
Amino acids are the main constituents of proteins which are significant for incentive growth and development of plant cell and reduce the impacts of abiotic stress in plants (Bakhoum *et al.*, 2019). Methionine and Phenylalanine are well known amino acids which exert positive impact on crop yield and mitigate the stress mediated effect on plants by exerting effect on oxidative metabolism, hormonal interactions, enzymatic and non-enzymatic activities (Maxwell and Kieber, 2010).
Methionine significantly enhanced the growth and quality parameters as well as increased plant biomass, increase the

biochemical constituents, total protein, flavonoids, free amino acids, indoles and phenolic content of green onion and okra (El-Awadi *et al*., 2012; Zulqadar *et al*., 2015). . Phenylalanine increases salt tolerance in various crops like maize and broad bean plants. Foliar application of phenylalanine deteriorates the negative effects of salinity with the increase of saccharides as well as proteins progressively increased as well as concentration of proline significantly dropped in maize. Amino acids treatments markedly reduced the increased Na^+ contents in shoot and roots and increase the concentration of K^+, Ca^{2+}, Mg^{2+} and P under salt stress (Abd El-Samad *et al.*, 2010).

Cucumber is the important vegetable crop for nourishment of human beings mostly grown in the semi-tropical region of the world (Jiménez-Guerrero *et al.,* 2012) and it is moderately sensitive to salinity however salinity deteriorated the vegetative growth of cucumber as it reduce plant height significantly total leaf area and plant biomass (Folegatti and Blanco, 2000) but the effect of salinity at fruit setting stage was less severe however salinity highly deteriorated the yield of cucumber leading to severe economic loss to farmers (Stepien and Klobus, 2006). Salinity also causes negative impact on many physiological mechanisms as well as ionic uptake in cucumber (Savvas *et al*., 2005). In the current experiment, the objective was the assessment of antagonistic effects of salinity on biomass and uptake of nutrients in cucumber through foliar application of methionine and phenylalanine.

MATERIALS AND METHODS

The experiments were performed using four genotypes of cucumber (HC-999, Valley, NSC-CM1 and Akbar) to study the mechanism of salt tolerance using two amino acids methionine (0, 25 and 50 ppm) and phenylalanine (0, 75 and 100 ppm) under 100 mM NaCl stress.

The experiment was carried out at Government College Women University Faisalabad and Soil Biology Division, NIAB Faisalabad, Pakistan under natural wire house conditions. Fifteen seeds from each of the genotype were sown in plastic pots, were filled with sandy soil under 0 and 100 mM NaCl solution and three optimized levels (through screening experiments, data not published) of methionine (0, 25 and 50 ppm) and phenylalanine (0, 75 and 100 ppm with three replicates of each treatment were maintained. After fifteen days of seeds germination, the numbers of plants per pot were maintained four and irrigated according to plant's need. Salinity was applied at four leave stage and maintained at 100 mM gradually. After seven days of salinity application, three doses of foliar spray with four days difference of phenylalanine and methionine was applied. The pots were arranged in a completely randomized design.

After 120 days of sowing different growth and nutrients uptake were calculated. Three plants from each treatment were removed at harvest and were washed with tap water (gentle stream). Water was blotted off from the surface of all plants for recording data. Then plants were finally oven-dried at 70 ^{0}C for 72 h and their dry weights were recorded.

Treatments were as follow;

T1: control; T2: S (Saline); T3: M1 (Methionine 25 ppm); T4: M2 (Methionine 50 ppm); T5: P1 (Phenylalanine 75 ppm); T6: P2 (Phenylalanine 100 ppm); T7: M1 S (Methionine 25 ppm + Saline); T8: M2 S (Methionine 50 ppm + Saline); T9: P1 S (Phenylalanine 75 ppm + Saline); T10: P2 S (Phenylalanine 100 ppm +Saline); T11: M1P1 (Methionine 25 ppm + phenylalanine 75 ppm); T12: M1P2 (Methionine 25 ppm + phenylalanine 100 ppm); T13: M2P1 (Methionine 50 ppm + phenylalanine 75 ppm); T14: M2P2 (Methionine 50 ppm + phenylalanine 100 ppm); T15: M1P1 S (Methionine 25 ppm + phenylalanine 75 ppm + Saline); T16: M1P2 S (Methionine 25 ppm + phenylalanine 100 ppm + Saline); T17: M2P1 S (Methionine 50 ppm + phenylalanine 75 ppm + Saline); T18: M2P2 S (Methionine 50 ppm + phenylalanine 100 ppm + Saline)

Data regarding shoot and root fresh and dry weights (g) were recorded. Uptake of nutrients (Na^+, K^+, Mg^{2+}, Ca^{2+} and Cl^-) by cucumber plant was determined by using the method of Jackson (1962). The plant material has been digested for different nutrients estimation, according to Wolf (1982). In digestion tubes and 5mL of individual roots and stems, dry crouched plant material of 0.5 g was taken. Each tube was fitted with H_2SO_4. All mixed tubes were allowed to incubate at room temperature overnight. Then 0.5 mL of H_2SO_4 (35 percent) was added along the sides of the digestion tubes and placed in a digestion block until the fumes were produced and heated at 350 *°C*. After fumes were formed, digestion tubes continued to heat for another 30 minutes, the digestion tubes were separated from the hot plate and allowed to cool for 5 minutes by placing them back into the digestion block. The above step was sporadically repeated until colorless became the digested material. The material was filtered to extract and the extract in volumetric flasks was raised to a volume of 50 mL. This extract has been filtered and used for sodium, potassium, and calcium and magnesium determination. For the estimation of potassium (K^+), sodium (Na^+) digested root and shoot of cucumber genotypes were analyzed with the help of flame-photometer (Jenway PFP 7). Calcium and magnesium shoot and root content were examined through the method in Hand book-60 by US Salinity Laboratory Staff, 1962.

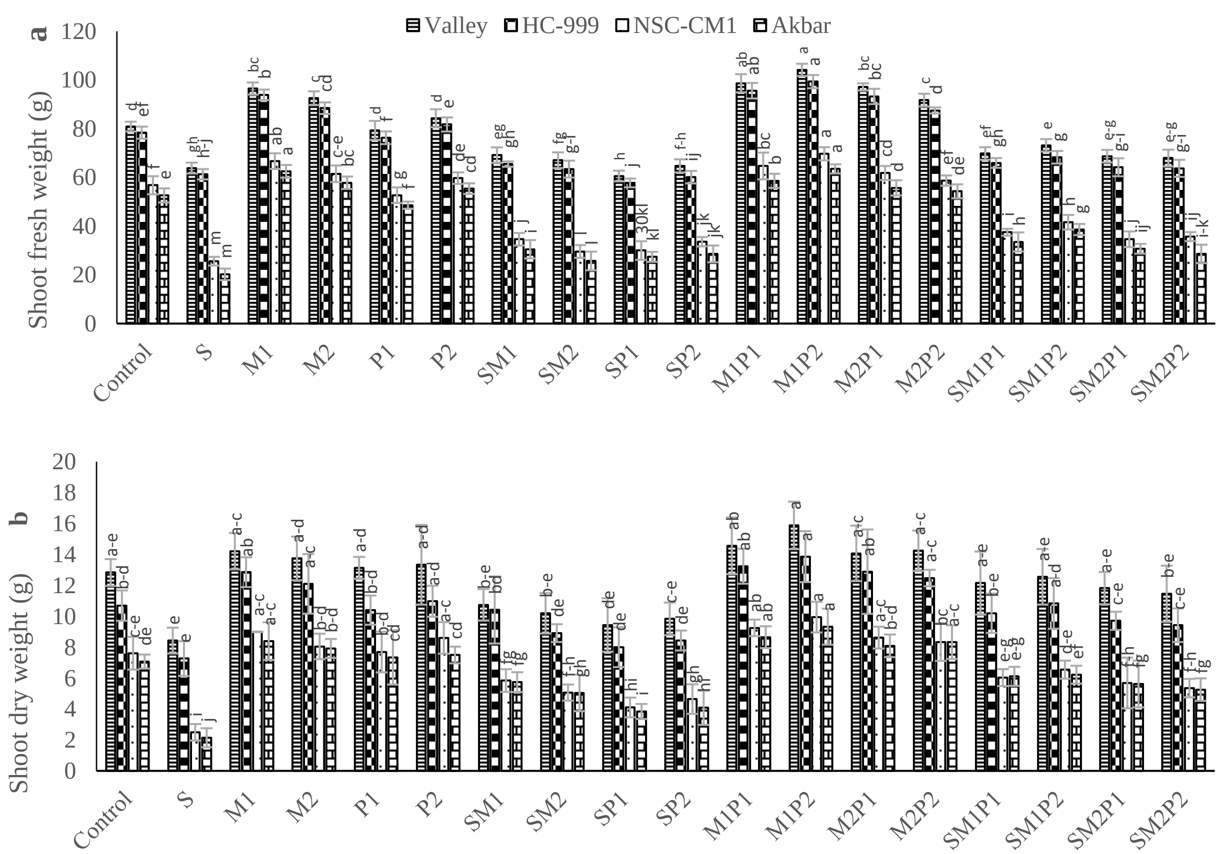
Statistically, data were analyzed by the technique of analysis of variance by using co-stat computer program. The LSD (Least Significant Difference) test at 5% probability was used to calculate the differences among the mean values (Steel *et al.,* 1997).

RESULTS

Maximum shoot fresh weight was calculated by Valley (79.4 g) followed by HC-999 (75 g) whereas Akbar showed minimum shoot fresh weight (42 g) followed by NSC-CM1 (47 g). The overall decrease in shoot fresh weights was 34.9% in saline environments in all genotypes of cucumber. The foliar application of amino acids showed a positive impact on plant shoot fresh weight (Fig.1 a). The highest plant shoot fresh weight was calculated by Valley grown under non-saline condition with the treatment of methionine 25 with phenylalanine 100 ppm (104 g) followed by HC-999 under same condition with treatment of methionine 25 + phenylalanine 100 ppm (99 g) while the lowest value (20 g) was recorded in plant of Akbar under saline condition, treated with 100 mM salinity which is closely followed by the plants of NSC-CM1, grown under saline environment 100 mM NaCl (25.5 g).

The highest shoot dry weight was observed by Valley (12.3g) followed by HC-999 (10 g) whereas the minimum shoot dry weight was calculated by Akbar (6.4 g) followed by NSC-CM1 (6.8 g). A significant decrease in shoot dry weight was 30.1% in saline environments in all genotypes of cucumber (Table 1). Exogenous application of amino acids enhanced shoot dry weight of plant (Fig. 1b). The maximum value for shoot dry weight was observed by Valley grown in control condition under the treatment of methionine 25 + phenylalanine 100 ppm (15.8 g) whereas the lowest value was recorded in plant of Akbar and NSC-CM1 under saline condition treated with 100mM salinity (2.1 g) and (2.4 g) respectively.

The overall increase in Na^+ content in shoots was 34.5% in saline environments in all genotypes of cucumber however Akbar maintained the highest value of Na^+ level in shoots (6.2 mg g^{-1}) which significantly differed from all other verities while the Valley and HC-999 have minimum value of Na^+ (2.8 mg g^{-}) and (3 mg g^{-}) respectively (Table 1). The treatment of amino acids significantly influenced the Na^+ level. The highest level of Na^+ was maintained by Akbar treated with



S = Salinity (100mM), M1 = Methionine (25 ppm), M2 = Methionine (50 ppm),P1 = Phenylalanine (75ppm),P2=Phenylalanine (75ppm)

Figure 1. Effect of methionine (25 and 50 ppm) and phenylalanine (75 and 100 ppm) on shoot fresh and dry weights of four cucumber genotypes under 100 mM NaCl

Table 1. Mean square values from analysis of variance of data for shoot and root fresh, dry, K^+ and Na^+ content of four cucumber genotypes at different levels of methionine and phenylalanine under 100 mM NaCl

Source	DF	Shoot fresh weight	Shoot dry weight	Shoot K^+	Root K^+	Shoot Na^+	Root Na^+
Genotypes (G)	3	72912.7***	1710.51***	863.19***	230.97***	142.98***	614.68***
Salinity (S)	1	3555.1***	76.45***	1863.02***	1060.20***	202.18***	1425.66***
Amino acids (A.A)	8	114.0***	3.63**	95.10***	39.91***	15.010***	74.64***
G × S	3	1603.6***	25.71***	5.53ns	11.56*	2.147ns	24.66***
G × A.A	24	41.9***	1.43ns	2.71ns	1.03ns	0.765ns	3.46ns
S × A.A	8	12.6***	0.18ns	21.99*	6.14ns	0.471ns	43.36***
G×S×A.A	24	8.9***	0.19ns	1.97ns	0.93ns	0.096ns	2.10ns
Error	144	4.6	1.71	8.72	4.92	2.161	5.68
Total	215						

* = significance levels at 0.05, ns = non-significant

methionine 50 ppm (8.7 mg g^{-1}) and 100 mM NaCl (8 mg g^{-1}) while the lowest value was in plant of Valley in non-saline condition treated with methionine 25 + phenylalanine 100 ppm (1.3 mg g^{-1}). Overall the results represented the adverse effects of salinity on imbalance of nutrients level Na^+ in plant shoot and amino acid insert positive effects on all genotypes of cucumber under both saline and non-saline conditions (Fig. 2 a).

The overall increase in Na^+ in the roots was 33.3% in saline environments in all genotypes of cucumber. However, Akbar maintained the highest value of Na^+ level in roots (16 mg g^{-1}). Valley and HC-999 have minimum value of Na^+ (8 mg g^{-1}) and (9 mg g^{-1}). The treatment of amino acids significantly influenced the Na^+ level. The highest level of Na^+ was maintained by Akbar and NSC-CM1 treated with 100 mM NaCl (26 mg g^{-1}) and (25 mg g^{-1}) respectively while the lowest value was observed in plant of Valley under non-saline condition treated with methionine 25 + phenylalanine 100 ppm (3 mg g^{-1}) followed by same verity under same condition with the treatment of phenylalanine 100 ppm (4 mg g^{-1}) and methionine 50 + phenylalanine100 (5 mg g^{-1}). The overall results represented the adverse effects of salinity causes imbalance of nutrients level Na^+ while the amino acid effects positively on all genotypes (Fig. 2 b).

The overall increase in Cl^- in roots was 56% in saline environments in all genotypes of cucumber however, Akbar maintained the highest value of Cl^- level in roots (12 mg g^{-1}) which significantly differ from all other verities (Table) while the Valley and HC-999 have minimum value of Cl^- (5.2 mg g^{-1}) and (6 mg g^{-1}) respectively. The treatment of amino acids significantly influenced the Cl^- level. The highest level of Cl^- was maintained by Akbar and NSC-CM1, treated with 100 mM NaCl (20 mg g^{-1}) and (18 mg g^{-1}) respectively while the lowest value was in plant of Valley in non-saline condition treated with methionine 25 + phenylalanine 100 ppm (2 mg g^{-1}) and phenylalanine 75 ppm (2.3 mg g^{-1}) (Table 2). Overall results represented the adverse effects of salinity, causes imbalance of nutrients level Cl^- while amino acid effects positively on all genotypes and deteriorated the impacts of salt stress (Fig. 2 d).

The increase in Cl^- content in shoots was 59.8% in saline environments in all genotypes of cucumber however Akbar maintained the highest value of Cl^- level in shoots (11 mg g^{-1}) followed by NSC-CM1 (9 mg g^{-1}) while the Valley have minimum value of Cl^- (4 mg/g). The treatment of amino acids significantly influenced the Cl^- level in plant shoots. . The highest level of Cl^- was maintained by Akbar treated with methionine 50 ppm (17.3 mg g^{-1}) followed by phenylalanine

Table 2. Mean square values from analysis of variance of data for shoot and root Cs^{2+} Cl^- and Mg^{2+} content of four cucumber genotypes at different levels of methionine and phenylalanine under 100 mM NaCl

Source	DF	Shoot Ca^{2+}	Root Ca^{2+}	Shoot Cl^-	Root Cl^-	Shoot Mg^{2+}	Root Mg^{2+}
Genotypes (G)	3	203.330***	276.680***	647.38***	802.71***	114.988***	98.640***
Salinity (S)	1	496.730***	560.310***	2220.74***	2570.18***	355.278***	247.149***
Amino acids (A.A)	8	27.570***	32.362***	31.12***	39.76***	18.212***	9.768***
G × S	3	0.239ns	3.861ns	112.28***	95.03***	1.393ns	1.902***
G × A.A	24	0.794ns	0.881ns	1.66ns	1.22ns	0.121ns	0.423ns
S × A.A	8	2.228ns	5.788ns	3.79ns	5.56ns	1.864ns	0.641ns
G × S × A.A	24	0.422ns	0.772ns	2.25ns	4.27ns	0.090ns	0.312ns
Error	144	5.065	3.787	5.20	4.20	3.325	0.381
Total	215						

* = significance levels at 0.05, ns = non-significant

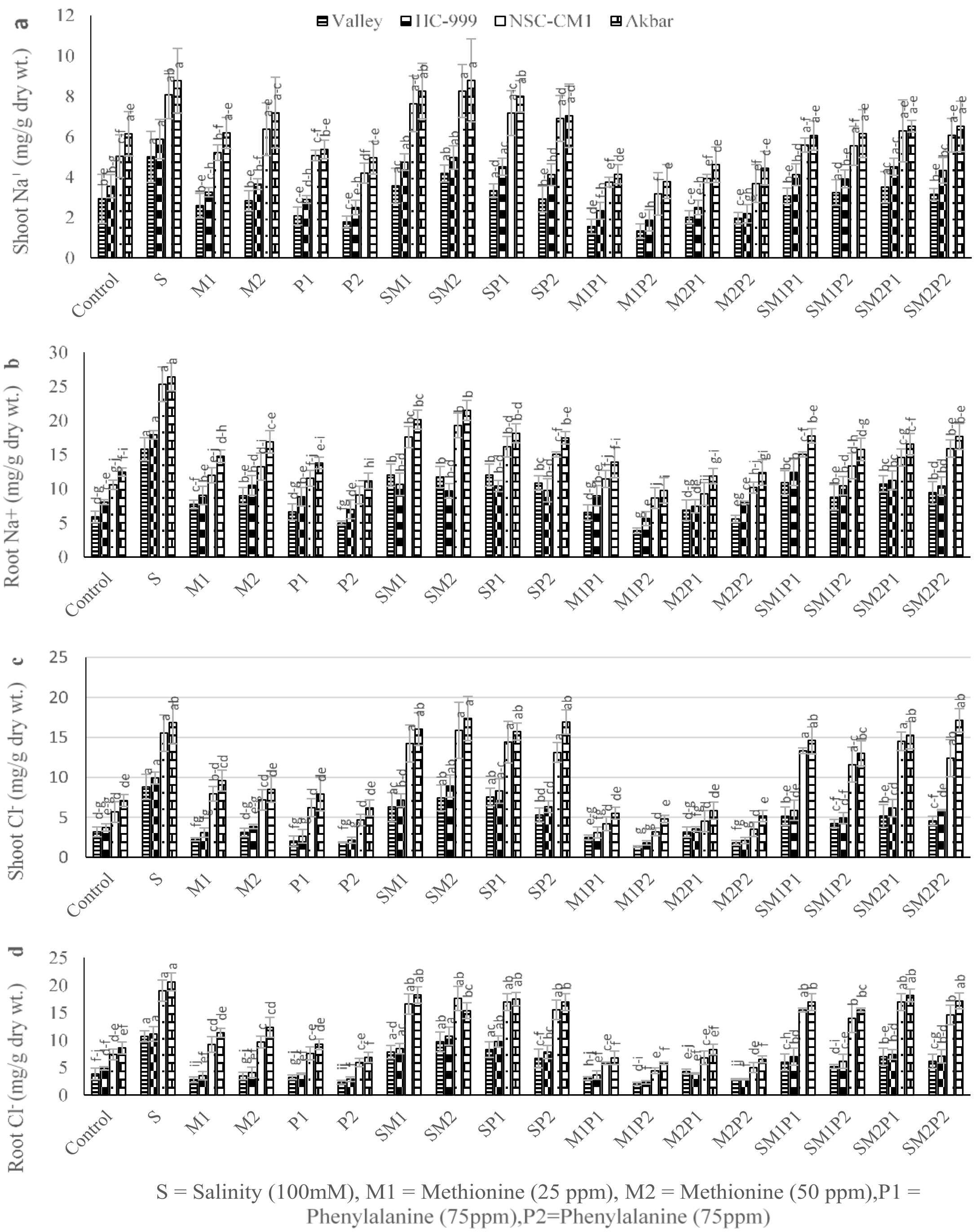


Figure 2. Effect of methionine (25 and 50 ppm) and phenylalanine (75 and 100 ppm) on shoot and root Na^+ and Cl^- of four cucumber genotypes under 100 mM NaCl

100 ppm (17 mg g^{-1}) while the lowest value was in plant of Valley and HC-999 in non-saline condition treated with methionine 25 + phenylalanine 100 ppm (1.3 mg g^{-1}) and (1.8 mg g^{-1}) respectively (Fig. 2 c).

Shoot K^+ was significantly decreased in all genotypes of cucumber under the influence of salinity. A significant decrease in shoot K^+ content was 30.6% in saline environments in all genotypes of cucumber (Table 1). The maximum reduction of shoot K^+ was observed in Akbar (13 mg g^{-1}) and NSC-CM1 (11 mg g^{-1}) while highest value of K^+ was maintained by Valley (20 mg g^{-1}) which is closely followed by HC-999 (18 mg g^{-1}). All the genotypes have significant difference. Exogenous application of amino acids showed positive impact by enhancing the K^+ level in plant shoot. Valley grown in non-saline condition under the treatment of methionine 25 + phenylalanine 100 ppm (28 mg g^{-1}) and methionine 50 + phenylalanine 100 ppm (27 mg g^{-1}) showed maximum values after that genotype HC-999 under non-saline condition with the foliar application of methionine 25 + phenylalanine 100 ppm (26 mg g^{-1}) showed good results (Fig. 3 a).. The maximum reduction (6 mg g^{-1}) of K^+ was noted in plant of Akbar under saline condition treated with 100mM NaCl.

The maximum reduction of K in roots of plants was noted under the influence of salinity and a significant decrease in root K^+ content was 36% in saline environments in all

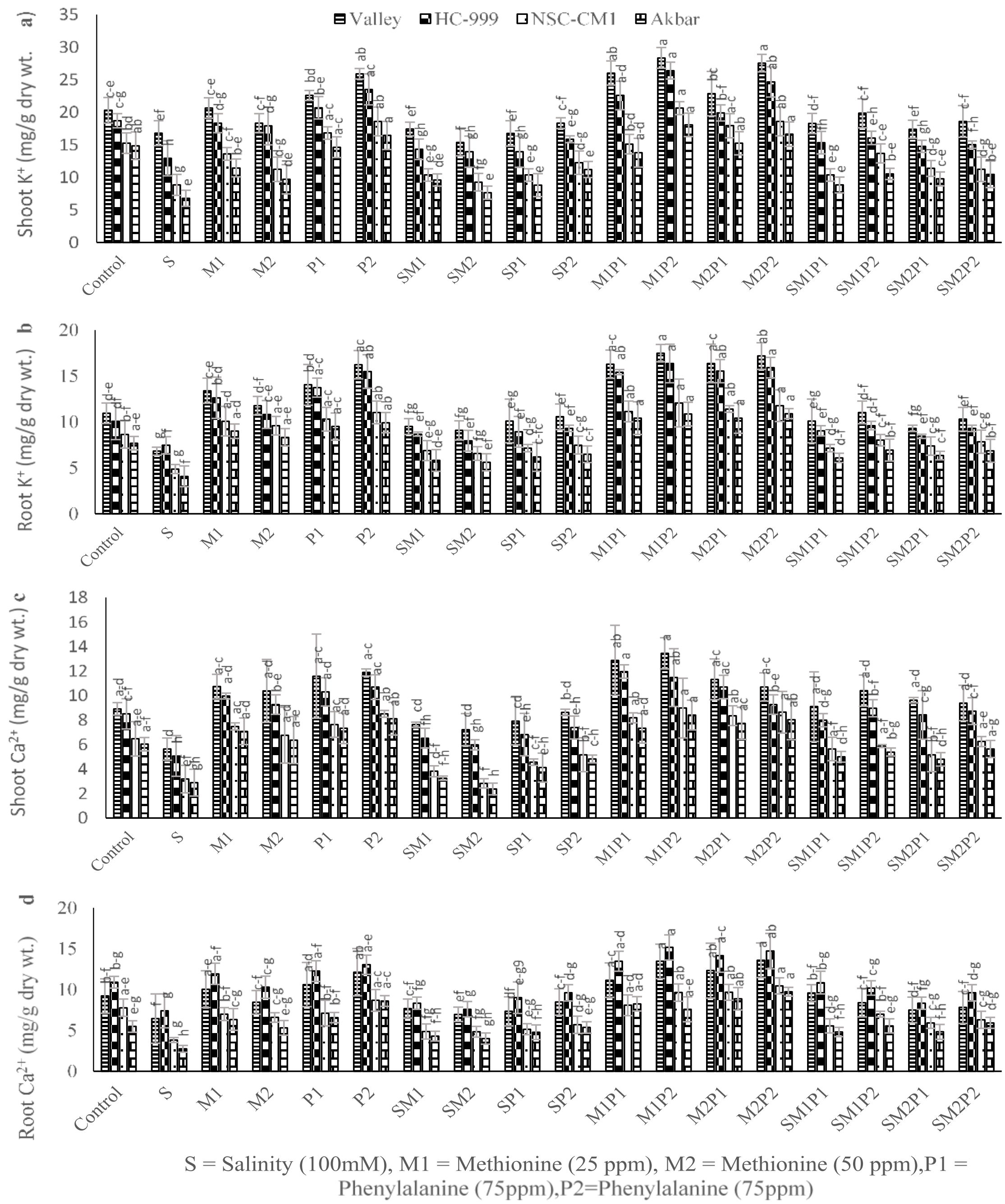


Figure 3. Effect of methionine (25 and 50 ppm) and phenylalanine (75 and 100 ppm) on shoot and root K^+ and Ca^{2+} of four cucumber genotypes under 100 M NaCl

genotypes of cucumber. Valley maintained the highest value of K^+ (12 mg g^{-1}) and maximum reduction of root K^+ was observed in Akbar (7mg/g) and HC-999 (8 mg g^{-1}). Amino acids application showed positive impact to enhance the K^+ level in plant roots (Fig. 3 b). Valley grown in non-saline condition under the treatment of methionine 25 + phenylalanine 100 ppm (17.4 mg g^{-1}) and methionine 50 + phenylalanine 100 ppm (17 mg g^{-1}) showed maximum values however maximum reduction of K^+ in roots was noted in plant of Akbar (4 mg g^{-1}) and NSC-CM1 (4.8 mg g^{-1}) under saline condition treated with 100mM NaCl (4 mg g^{-1}) followed by methionine 50 ppm (5.5 mg g^{-1}).

Significant reduction of shoot Ca^{2+} was noted in genotype of cucumber Akbar (5 mg g^{-1}) which is closely followed by NSC-CM1 (6 mg g^{-1}) however maximum value of Ca $^{2+}$was recorded in Valley (9 mg g^{-1}) and after that HC-999 (8 mg g^{-1}). Salinity deteriorate the level of Ca^{2+} in plant shoot and the overall decrease in Ca^{2+} content in shoot was 33.6% in saline environments in all genotypes of cucumber. Exogenous application of amino acids showed positive impact by enhancing the Ca^{2+} level in plant shoot. Valley grown in non-saline condition under the treatment of methionine 25 + phenylalanine 100 ppm (13 mg g^{-1}) showed maximum value (Fig. 3 c). The maximum reduction of $Ca^{2+}$was noted in plant of Akbar and NSC-CM1 under saline condition treated with methionine 50 ppm (2.3 mg g^{-1}) and 2.8mg/g).·Calcium content in roots was decreased under saline condition and the overall decrease in Ca^{2+} content in root was 32.3% in saline environments in all genotypes of cucumber however in genotype Akbar Ca^{2+} was reduced (6 mg g^{-1}) which is closely followed by NSC-CM1 (6.8 mg g^{-1}) and maximum value of Ca^{2+} was recorded in HC-999 (11 mg g^{-1}) followed by Valley (9 mg g^{-1}) and after that HC-999 (8 mg g^{-1}). All values have significant difference with each other. Amino acids showed positive impact by enhancing the Ca^{2+} level in plant root (Table 2). HC-999 grown in non-saline condition under the treatment of methionine 25 + phenylalanine 100 ppm (15 mg g^{-1}) showed maximum value which was closely followed by methionine 50 + phenylalanine 100 ppm (14.6 mg g^{-1}). The maximum reduction of Ca^{2+} was noted in plant of Akbar (2.7 mg g^{-1}) and NSC-CM1 (3.8 mg g^{-1}) under control condition (Fig. 3 d).

Shoot Mg^{2+} was significantly decreased in all genotypes of cucumber under the influence of salinity. The overall decrease in Mg^{2+} content in shoots was 34.2% in saline environments in all genotypes of cucumber. The maximum reduction of shoot Mg^{2+} was observed in Akbar (4 mg g^{-1}) and NSC-CM1 (5 mg g^{-1}) while the highest value of Mg^{2+} was maintained by Valley (8 mg g^{-1}) which is closely followed by HC-999 (7 mg g^{-1}). All the genotypes have a significant difference.

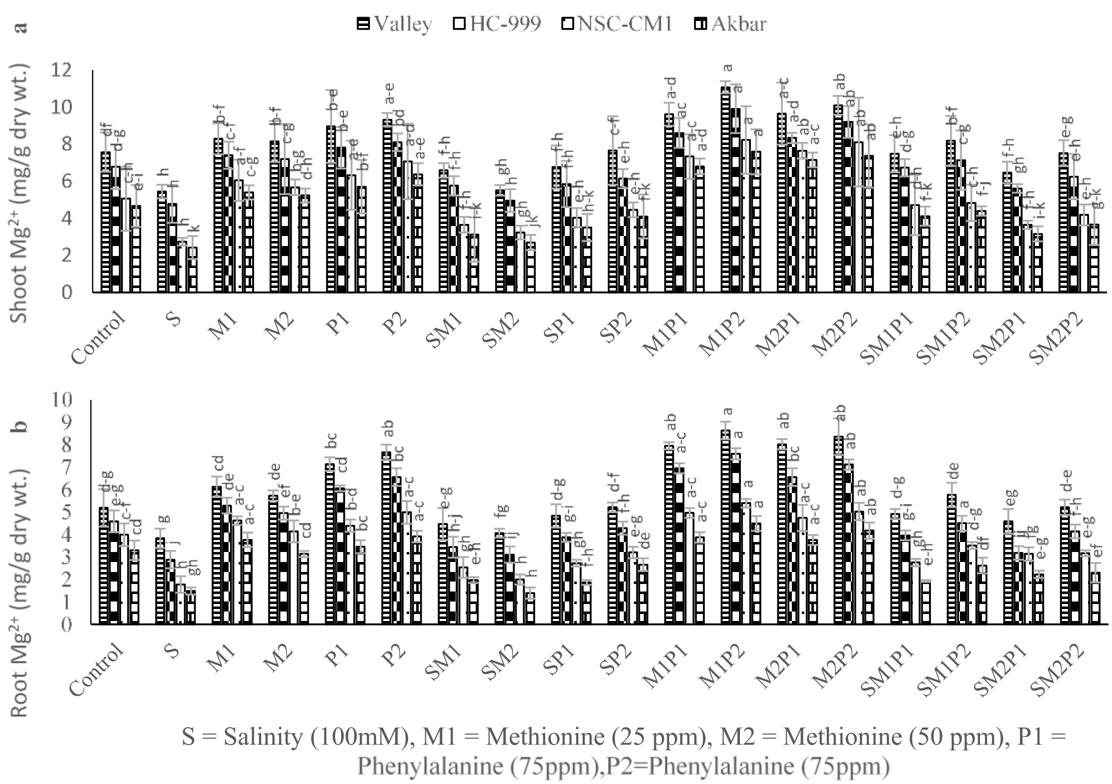


Figure 4. Effect of methionine (25 and 50 ppm) and phenylalanine (75 and 100 ppm) on shoot and root Mg^{2+} of four cucumber genotypes under 100 mM NaCl

Application of amino acids impact positively by enhancing the Mg^{2+} level in plant shoot (Fig. 4 a). Valley grown in non-saline condition under the treatment of methionine 25 + phenylalanine 100 ppm (11 mg g^{-1}) which is closely followed by methionine 50 + phenylalanine 100 ppm (10 mg g^{-1}), showed maximum values and minimum value of Mg^{2+} was noted in plant of Akbar under saline condition treated with 100mM NaCl (2.4 mg g^{-1}) followed by methionine 50 ppm (2.6 mg g^{-1}).

Root Mg^{2+} was significantly decreased in all genotypes of cucumber under salt stress and the overall decrease in Mg^{2+} content in root was 38.8% in the saline environments in all genotypes of cucumber. The maximum reduction of Mg^{2+} in roots was observed in Akbar (2 mg g^{-1}) and NSC-CM1 (3 mg g^{-1}) while the highest value of Mg^{2+} was maintained by Valley (6 mg/g) which is closely followed by HC-999 (5 mg g^{-1}). Application of amino acids impact positively by enhancing the Mg^{+} level in plant root (Fig. 4 b). The maximum value of Mg^{2+} was observed in Valley grown in non-saline condition under the treatment of methionine 25 + phenylalanine 100 ppm (8.6 mg g^{-1}) which is closely followed by methionine 50 + phenylalanine 100 ppm (8 mg g^{-1}) and Mg^{2+} level was highly reduced in plants of Akbar under saline condition treated with 100mM NaCl (1.3 mg g^{-1}) followed by methionine 50 ppm (1.4 mg g^{-1}).

DISCUSSION

Salinization is a serious threat to agriculture in arid and semi-arid regions of the world and ultimately leading to the reduced biomass, physiological and biochemical disorders, imbalance in nutrients uptake and causes food shortage in all over the world (Khorasaninejad *et al*., 2020).

The finding of present studies depicted that salinity reduced the plant biomass in all cucumber genotypes however the exogenous application of methionine and phenylalanine and their combinations significantly improved the growth attributes and nutrients uptake in plants under both salinity and in normal condition. It is well documented (Ashraf and Sarwar, 2002) that abiotic stresses including salinity deteriorate the plant biomass production which is because of the photosynthetic disturbance (Zheng *et al*., 2012).

Plant biomass is highly affected by the application of salinity stress and imbalance in nutrients uptake caused because of increased concentration of Na^{+} and Cl^{-} which significantly reduced the plant biomass and this is supported by the previous experiments which showed that different plant species had differential response to salt stress (Nawaz *et al*., 2010). Major findings from this experiment indicated that salinity influenced negative effects on the cucumber shoot and root length however varietal difference are there too however amino acids treatment significantly influenced the shoot and root length. The results are verified by the study of El-Awadi *et al*. (2012) who suggested that methionine significantly enhanced the growth and quality parameters in accordance with increased plant biomass which is because of the increase of biochemical constituents such as total protein, indoles, free amino acids, flavonoids and phenolic content of green onion.

Observations of this experiment showed that excessive concentration of Na^{+} ions decreased the uptake of nutrients whereas methionine and phenylalanine and their combinations reduced the negative impact of salinity by improving the uptake of essential ions (K^{+}, Ca^{2+}, Mg^{2+}) in all cucumber genotypes. Several reports indicated that increased amount of Na^{+} and Cl^{-} accumulates in the vegetative parts of the plants causing specific ion toxicity (Abd-Allah *et al*., 2015). It has been documented by Tavakkoli *et al*. (2011) that high Na^{+} competes with K^{+} and Ca^{2+} ions, disturb regulation of stomata where as high level of Cl^{-} in soil degrade photosynthetic process and chlorophyll pigment resulting the leaf necrosis . Plant membranous system is also severely damaged by specific ions toxicity, plants as stress tolerance response, compartmentalize Na^{+} and Cl^{-} ions in vacuole but when there is the high concentration of Na^{+} and Cl^{-} ions, vacuole becomes saturated then these ions start to accumulate in cytoplasm leading to the enzyme inhibition, cell dehydration and decreased seed germination (Butt *et al*., 2016). Several reports demonstrated that amino acids decreased the Na^{+} ion content and reduce the ion toxicity by increasing the Ca^{2+} contents in the cytoplasm and depolarize the membrane (Stephens *et al*., 2008).

Conclusion: Genotypes Valley and HC-999 are salt tolerant and NSC-CM1 and Akbar are salt sensitive genotypes. Phenylalanine and methionine enhanced plant biomass and nutrients uptake of all cucumber genotypes both under salinity and normal conditions. In conclusion, a management practice that may be promising is the exogenous application 25 ppm of methionine and 100ppm of phenylalanine recommended alone and in combination to increase growth and yield of cucumber genotypes in salt hit areas of the world. Farmers may also use the technology to enhance the growth and yield of other crops in saline soils.

Conflict of interest statement: The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Significance of work: The foliar application of 25ppm methionine along with 100ppm phenylalanine showed significance results and we are pioneer in these combinations on cucumber. Therefore, it become possible the use of saline areas with profitably by the foliar application of 25ppm methionine with 100ppm phenylalanine to get maximum yield of cucumber genotypes.

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