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ENHANCEMENT IN GROWTH, NUTRIENT UPTAKE AND YIELD IN SALT STRESSED MAIZE BY FOLIAR APPLICATION OF METHIONINE

SADIA SHAHID[1], ABIDA KAUSAR[1*], MUHAMMAD YASIN ASHRAF[2], NOREEN AKHTAR[1] AND ZILL-I-HUMA NAZLI[3]

[1]*Department of Botany, Government College Women University Faisalabad, 38000, Pakistan*
[2]*Institute of Molecular Biology and Biotechnology, The University of Lahore, Pakistan*
[3]*Department of Chemistry, Government College Women University Faisalabad, 38000, Pakistan*
**Corresponding author's email: abidakausar@gcwuf.edu.pk*

Abstract

Maize is leading cereal crop, having good quantity of vitamins, nutrients and minerals. It is cultivated all over the world for nourishment of human beings. Salinity is topmost problem of agricultural lands worldwide. Among numerous techniques being used in developing countries, use of organic compounds like amino acids is a cost effective technology. Amino acids have a valuable role in crop production and to reduce the changes produced due to abiotic stresses. In present experiment, four maize genotypes (FH1275, FH 936, FH 1231 and FH 1227) were used for two methionine levels (5 and 10 mg /L) under 80mM NaCl stress. After 120 days of propagating, four maize genotypes were evaluated for the measurements of various morphological and nutrient uptakes. Plants were uprooted and washed well. Yield parameters were examined at plant maturity, the methionine level 10 mg/ L showed better results as compared to 5 mg/ L both under saline and non-saline environments. Completely Randomized Design (CRD) with three factor factorial plan was used to assess the efficacy of amino acid on maize, under saline stress. Data was analyzed using suitable statistical analysis.

Key words: Nutrients uptake, Yield, Maize, Salinity, Methionine.

Introduction

Maize in spite of being sensitive to salinity is nutritionally and economically very important (Estrada *et al*., 2013). Maize (*Zea mays* L.) is a vital grain crop with 1053.8 million metric tons predictable global yield in 2019 (USDA, 2019). Due to high dietary values, global farming and low price, maize plays a key role for human and animal feedstuff (Tariq & Iqbal, 2010). Maize also contains a good quantity of sugar, proteins, fibers, fats as well as macro and micronutrients (Ali & Ashraf, 2011).

About one-third land area is affected by saline stress therefore adversely affecting the crop production in all over the world (United Nations, 2012). According to Panta *et al.*, (2014) salinity and sodicity ruins the agricultural land. Due to distortion of soil structure under salinity, plants cannot absorb nutrients accurately (Semida *et al*., 2016). Saline stress causes a reduction in internode growth and leaf area resulting in obstruction of leaf initiation in maize (Sirhindi *et al*., 2018). According to El Sayed (2011), initial growth of maize shoot is affected by salinity, whereas at later phases, growth is not affected harshly. It was also reported earlier that crop shoot and root growth as well as physiology are highly influenced under saline stress (Ashagre *et al.*, 2013).

Amino acids are very important as precursors of hormones, stress reducing mediators and nitrogen source (Maeda & Dudareva., 2012). In spite of the fact that amino acids are present in the soil naturally, but plants are not able to absorb them without the presence of any transporters in their roots (Khan *et al*., 2020). Methionine, present in plant tissues and seeds, is an important sulfur containing essential amino acid (Galili & Amir, 2013) and its quantity limits the nutritional value of crop as it is comparable to base for proteinaceous food of animals and human beings (Galili *et al*., 2016).

All the chemical processes occurring within the plants, are desperately affected by the existence of noxious ions in the soil (Ashraf & Tang, 2017) especially Na^+/K^+ ratio due to boosted quantity of Na^+ ions under salinity, as plants absorbs more Na^+ and K^+ in salinity (Shahid *et al*., 2011) which in turn results in enzymes inactivation (Sarwar & Shahbaz, 2020). Concentrations of ions in soil vary from each other under saline stress. For example, Ca^{2+}, Na^+ and Cl^- concentrations increase whereas Na^+ and K^+ concentrations exhibit a declining tendency in salinity (Akhtar *et al*., 2003). It has been recorded in wheat that saline stress on physical characters is owed to augmented Na^+ and trivial K^+ concentration (Shamsi & Kobraee, 2013).

Osmotic stress and Na^+ toxicity in maize, grown under saline environment leads to meagre seed production (Schubert *et al.*, 2009). Kaya *et al*., (2013) working on maize reported that total grain and ears production, weight of 1000 seed reduced under salinity.

Materials and Methods

The experiment was performed using four genotypes of maize (FH 1275, FH 936, FH 1231 and FH 1227) to study the potential of salt tolerance using amino acid methionine (5 and 10 mg/L) under 80 mM NaCl stress.

The experiment was carried out at Government College Women University Faisalabad, Pakistan under natural wire house conditions. Ten seeds from each of the genotype were sown in plastic pots filled with sandy canal soil under 0 and 80 mM NaCl solution and three levels of methionine (5 and 10 mg/L) with three replicates of each treatment were maintained. After fifteen days of germination, the numbers of plants per pot was adjusted to four and were irrigated according to plant's requirement. Salinity was applied at four leaves stage and maintained at 80 mM gradually. After seven days of salinity application, foliar spray of methionine with four days difference was applied. The pots were arranged in a Completely Randomized Design (CRD).

After 120 days of sowing, different growth and nutrients uptake parameters were recorded Three plants from each treatment were removed at each harvest and washed with tap water. Water was blotted off from the surface of all plants for recording data. Shoot and root lengths (cm) with help of scale while shoot and root fresh weight (g), were measured at electrical balance.

Uptake of nutrients, e.g., sodium (Na^+), potassium (K^+), calcium (Ca^{2+}) and chloride (Cl^-), were calculated by using the method of Jackson (1962). The magnesium Mg^{2+} contents of shoot and root was determined according to the method in Handbook-60 by US Salinity Laboratory Staff, 1962. Yield parameters like number of kernels/ears, weight/ear (g), 100 seed weight (g) and 1000 seed weight (g) were measured. Statistically, data were analyzed by the three-way technique of analysis of variance and completely randomized design with three factors (maize, salinity, and methionine). The Least Significant Difference (LSD) test at 5% probability was used to calculate the differences among the mean values.

Results

Growth parameters

Shoot and root lengths: Genotype FH 1275 of maize maintained the highest shoot length (60.3 cm) and least value was documented in FH 1227 (38.4 cm) in control. Peak value of plant height was noted under methionine 10 mg/L (72.3 cm), while minimum under non saline conditions (53.5 cm). The overall decrease in shoot lengths was 39.9% under salinity in FH 1275 in saline stress as compared to the normal environment. (Fig. 1, Table 1). Salinity has highly influenced the plant root length (23.2 cm) as compared to non-saline condition (36.5 cm) showing an overall decrease in root length, 36.4% in FH1275. Application of 10 mg/L methionine showed maximum (32 cm) value in FH1275 while lowermost value of root length was noted in FH 1227 (21.5 cm) under 80 mM NaCl. Overall increase in root length under 10mg/L methionine and 80Mm NaCl was 39.13% in FH 1275 (Fig. 1, Table 1).

Shoot and root fresh and dry weights: Highest shoot fresh weight (81.8 g) was observed in FH 1275 whereas minimum (50.4g) in FH 1227 in control plants. Whereas the value of 60.4 (g) in FH 1275 and 21.4 (g) in FH 1227 was measured in saline environments. Overall decrease in shoot fresh weight was 26.1 % under salinity in FH 1275. Spray of methionine 10 mg/L (105.0 g) on FH 1275, showed the highest whereas the lowest shoot fresh weight (64.3 g) reading was observed in FH 1227 under control conditions. Overall increase (22.5%) in shoot fresh weight under 10mg/L methionine in all maize genotypes was recorded. (Fig. 1, Table 1). Maximum root fresh weights was shown by FH 1275 (9.45 g), whereas FH 1227 performed poorly with minimum (4.8 g) root fresh weight in control medium. However, in saline medium the values 7.89 (g) in FH 1257 and lowest in FH1227 were 1.8 (g) were investigated. Overall decrease in root fresh weight was 17.4 % under salinity in all maize genotypes were recorded. Application of methionine 10 mg/L was depicted as most effective dose concentration with highest value of root fresh weight (13.8 g) in FH 1275 and lowest (6.95 g) was observed in FH 1227. Percent increase in root fresh weight in FH 1275 was 34.6 % under 10mg/L methionine and 80mM saline stress (Fig. 1, Table 1).

Analysis of Nutrients

Shoot and root Na^+: Amount of Na^+ was found elevated in shoot under salt stress (16.8 mg/g D. W.) (D.W = Dry weight) than control (6.8 mg/g D. W.) conditions (Fig. 1). Genotype FH 1227 maintained the highest (27.39 mg/g D. W.) while the FH 1275 showed minimum value of Na^+ (5.3 mg/g D. W.) in shoots suggesting overall rise in shoot Na^+ 36.6% in FH 1227 under salinity. Highest value of shoot Na^+ (7.1 mg/g D. W.) in FH 1227 (28.30% decrease) whereas lowest value of shoot Na^+ (3.8 mg/g D. W.) was recoded in FH 1275 (26.3% decrease) under 10mg/L methionine (Fig. 1). Highest value of root Na^+ (27.3 mg/g D. W.) (103.7% increase) was documented in FH 1227 under salinity while lowest value (16.8 mg/g D. W.) (147% increase) was measured in FH 1227 under saline stress. Highest value of root Na^+ (16. 77 mg/g D. W.) (62.7% increase) in FH 1227 while lowest value (9.7 mg/g D. W.) (73.19 % increase) in FH 1275 was observed by the foliar spray of 10mg/L methionine (Fig. 2, Table 1).

Shoot and root K^+: Saline stress minimized root K^+ to 17.7 mg/g D. W. compared to control (21.3 mg/g D. W.) in FH 1275 (16.9% decrease) while FH 1227 showed lowest value 7.7 mg/g D. under saline stress as compared to control (15.8 mg/g D. W.) (51.2% decrease). Genotype FH 1275 was observed to achieve high value (20.8 mg/g D. W.) (17.5% increase) of shoot K^+ by the spray of methionine 10 mg/L whereas the lowest value (11.5 mg/g D. W.) (49.3% increase) was noted by FH 1227 under saline stress (Fig. 3, Table 1). FH 1275 maintained the highest value of root K^+ (7.8 mg/g D. W.) (34.4% decrease) under saline stress of 80 mM whereas FH 1227 showed least value (5.06 mg/g D. W.) (41.8% decrease) as compared to control. Foliar spray of methionine 10 mg/L resulted in highest root K^+ (12.2 mg/g D. W.) (54.1% increase) by FH 1275 while lowest value was noted in FH 1227 (7.9 mg/g D. W.) (58% increase) under salt stress (Fig. 3, Table 1).

Shoot and root Ca^{2+}: Substantial drop (3.8 mg/g) (44.8% decrease) of shoot Ca^{2+} was noted in genotype FH 1227 however maximum value (6.29 mg/g) (37.4% decrease) of Ca^{2+} was documented in FH 1275 under saline stress of 80mM NaCl compared to control (Fig. 2, Table 2). Maximum (11.4 mg/g) (83.8% increase) plant root Ca^{2+} content was observed in FH 1275 and lowest value (6.39 mg/g) (65.7% increase) was noted in FH 1227 under saline condition by methionine 10 mg/L (Fig. 2, Table 2).

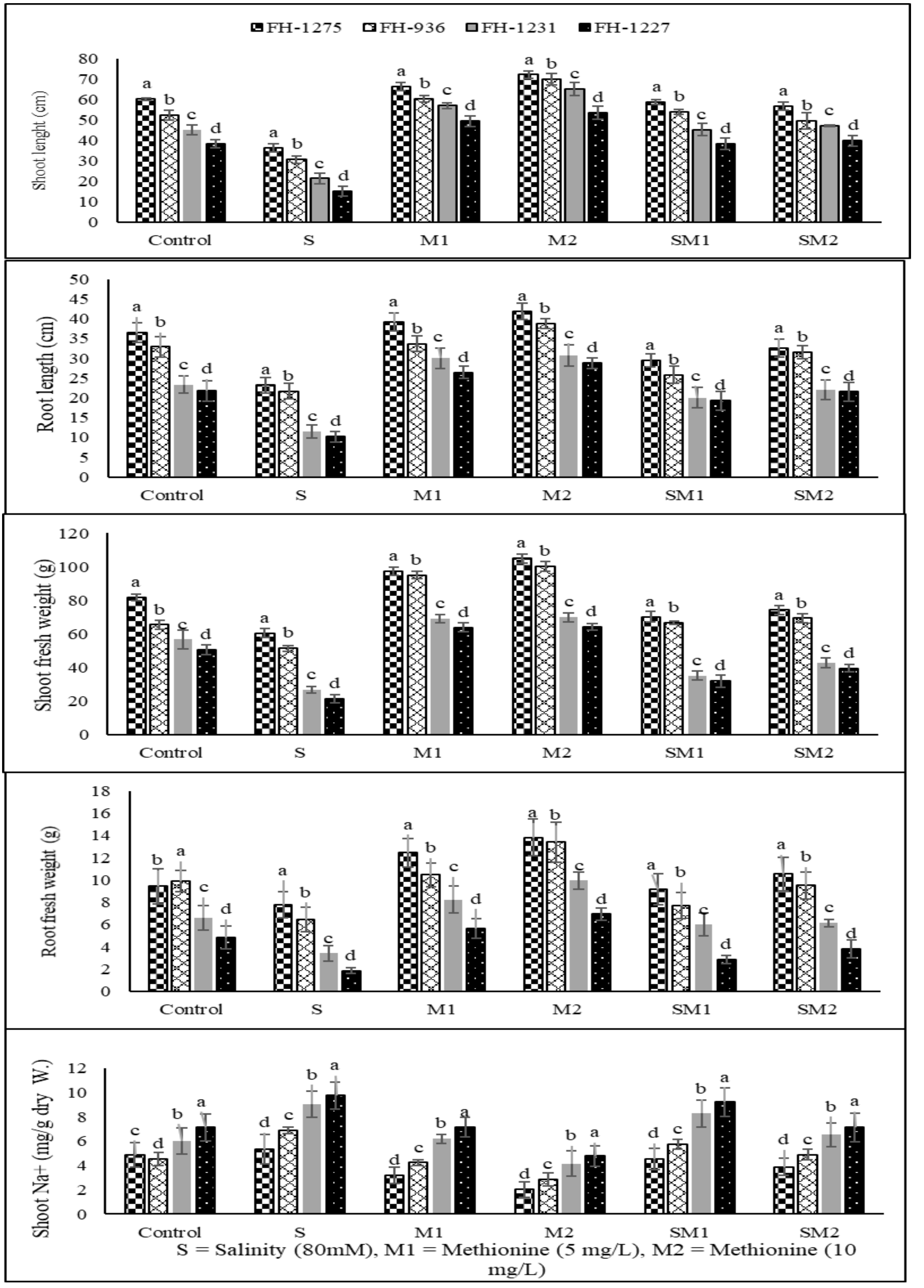

Fig. 1. Effect of methionine (5 and 10 mg/L) on shoot and root lengths (cm) and shoot and root fresh weights (g) and shoot Na^+ (mg/g D. W.) of four maize genotypes (FH 1275, FH 936, FH 1231 and FH 1227) under 80 m*M* NaCl stress.

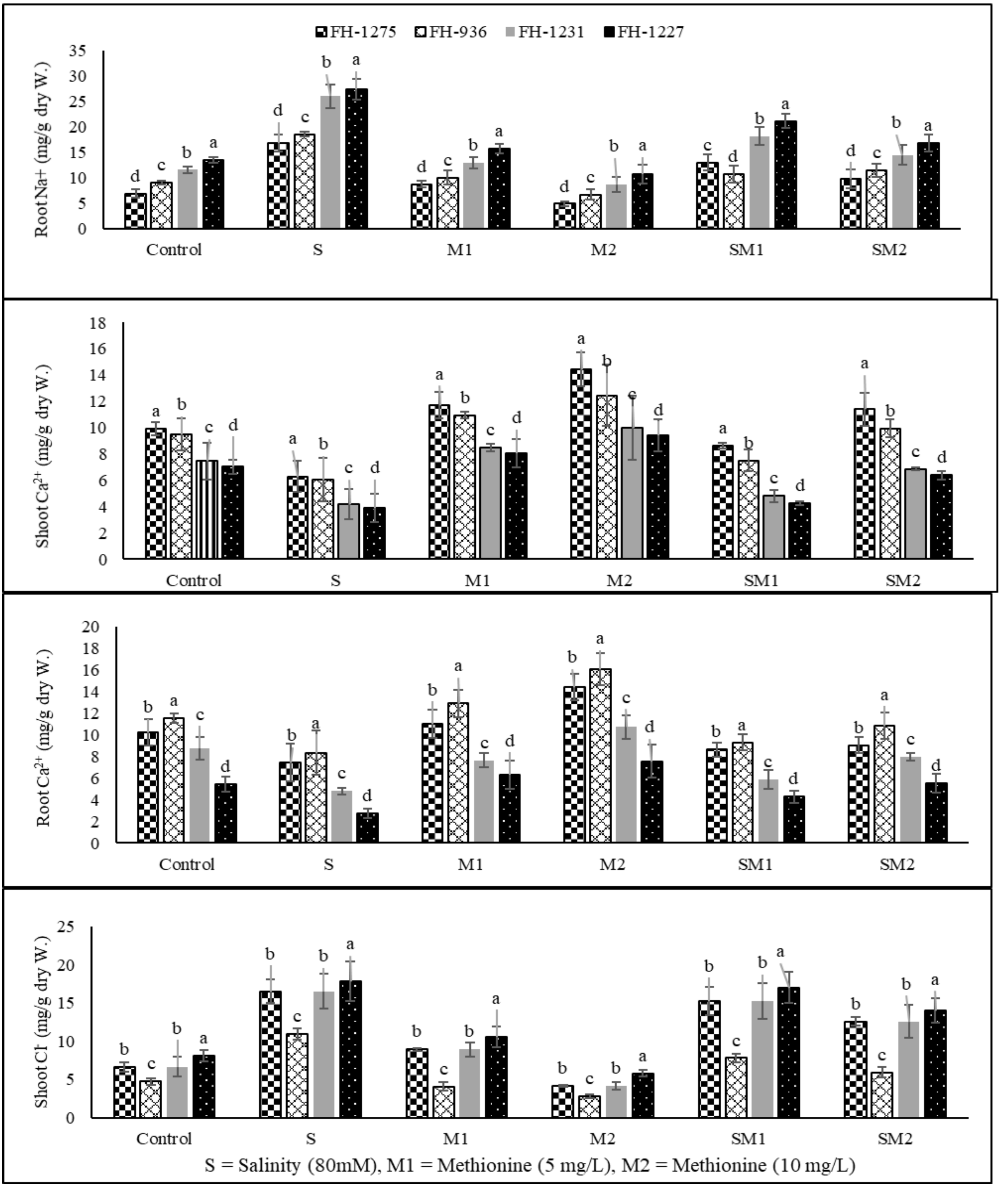

Fig. 2. Effect of methionine (5 and 10 mg/L) on root Na^+ (mg/g dry W.), shoot and root Ca^{2+} (mg/g D. W.) and shoot Cl^- (mg/g D. W.) of four maize genotypes (FH 1275, FH 936, FH 1231 and FH 1227) under 80 m*M* NaCl stress.

Shoot and root Cl^-: Salinity increased amount of Cl^- (16.5 mg/g) in shoots of FH 1275 compared to control condition (6.6 mg/g) (150% increase) by while value of shoot Cl^- (17.8 mg/g) was observed in FH 1227 under salinity of 80mM as compared to control (8.1 mg/g) (120% increase). FH 1227 maintained the highest value of shoot Cl^- (17.03 mg/g) (4.3% decrease) while lowest value was observed in FH 1275 (15.23 mg/g) (7.8% decrease) under 5mg/L methionine spray and 80Mm salinity (Fig. 2, Table 2). FH 1227 maintained the peak value (21.6 mg/g) (87.8% increase) of root Cl^- while lowest value was observed by FH 936 (12.1 mg/g) (108.6% increase) under saline stress of 80Mm. FH 1227 showed maximum value of root Cl^- (19.2 mg/g) (24.5% decrease) and FH 936 showed lowest value root Cl^- (7.4 mg/g) (41.3% decrease) under 10mg/L spray of methionine. (Fig. 3, Table 2).

Table 1. Mean squares values from analysis of variance of data for shoot and root lengths, fresh weights and shoot and root Na^+ and K^+ as affected by foliar application of methionine (5 and 10 mg/L) under 80 m*M* (NaCl) salt stress.

Source	Mean squares								
	df	Shoot length	Root length	Shoot fresh weight	Root fresh weight	Shoot Na^+	Root Na^+	Shoot K^+	Root K^+
Varieties (V)	3	1086.96***	570.80***	6474.5***	143.881***	47.6565***	231.716***	277.114***	66.850 ***
Salinity (S)	1	3074.59***	2134.00***	13750.9***	167.964***	72.4240***	872.506***	595.700***	298.901***
Treatment (T)	2	670.79**	502.00***	1373.6***	51.731***	28.5384***	191.797***	182.657***	98.845**
V × S	3	9.85^{ns}	1.16^{ns}	35.1ns	0.248^{ns}	1.2503ns	11.493ns	1.775ns	1.526ns
V × T	6	26.37^{ns}	12.82^{ns}	2.4ns	1.274^{ns}	0.6203ns	4.600ns	1.354ns	1.891ns
S × T	2	83.90**	22.38^{ns}	60.6*	0.938^{ns}	0.3327ns	114.990***	40.577**	5.877ns
V × S × T	6	12.12^{ns}	2.73^{ns}	46.3*	0.474^{ns}	0.2838ns	3.371ns	3.700ns	1.372ns
Error	48	16.12	13.61	20.0	3.701	2.6472	6.009	7.016	5.194
Total	**71**								

***= *p*<0.001; **= *p*<0.01; *= *p*<0.05; ns= Non-significant

Table 2. Mean squares values from analysis of variance of data for shoot and root Ca^{2+}, Cl^-, Mg^{2+} as affected by foliar application of methionine (5 and 10 mg/L) under 80 m*M* (NaCl) salt stress.

Source	Mean squares						
	Df	Shoot Ca^{2+} (mg/g D. W.)	Root Ca^{2+} (mg/g D. W.)	Shoot Cl^{1-} (mg/g D.W.)	Root Cl^{1-} (mg/g D.W.)	Shoot Mg^{2+} (mg/g D.W)	Root Mg^{2+} (mg/g D. W.)
Genotypes (G)	3	63.902***	134.800***	207.919***	283.110***	34.6474***	25.8914***
Salinity (S)	1	19.709*	21.725*	3.754^{ns}	5.917^{ns}	23.8856**	8.1541***
Treatment (T)	2	127.011***	104.978***	383.763***	503.233***	67.0926***	41.9845***
G × S	3	3.085^{ns}	0.042^{ns}	1.479^{ns}	0.211^{ns}	0.3946^{ns}	1.0926^{ns}
G × T	6	0.341^{ns}	1.417^{ns}	14.661*	18.907**	0.0427^{ns}	0.2147^{ns}
S × T	2	27.237**	28.257**	45.260***	76.230***	22.3094**	14.5723***
G × S × T	6	0.080^{ns}	2.378^{ns}	0.860^{ns}	1.015^{ns}	0.1006^{ns}	0.5209^{ns}
Error	48	3.840	3.567	5.302	4.508	3.2138	0.5235
Total	**71**						

***= *p*<0.001; **= *p*<0.01; *= *p*<0.05; ns= Non-significant

Table 3. Analysis of variance (mean squares) of data for weight of ear/plant, number of ears /plants, number of kernels/ cobs, 100 kernels weight (g) and 1000 kernels weight (g) as affected by foliar application of methionine (5 and 10 mg/L) under 80 m*M* (NaCl) salt stress.

Source	Mean squares					
	Df	Weight of ear/ plant	Number of ears/ plants	Number of kernels/ cobs	100 kernels weight (g)	1000 kernels weight (g)
Varieties (V)	3	356540***	33303***	239633***	549.743***	495.843***
Salinity (S)	1	6506***	27643***	149058***	13.390*	14.405**
Treatment (T)	2	261 ns	540074**	38314***	7.229*	3.112*
V × S	3	6706***	63221**	23816***	33.793***	30.453**
V × T	6	268 ns	4876321ns	6007***	2.907^{ns}	1.0654ns
S × T	2	4 ns	33564ns	25985***	39.154***	43.415**
V × S × T	6	4 ns	3465**	2675***	25.209***	19.3354***
Error	48	243	274	165	1.950	1.8864
Total	**71**					

***= *p*<0.001; **= *p*<0.01; *= *p*<0.05; ns= Non-significant

Shoot and root Mg^2+: The maximum plant shoot Mg^{2+} content (5.44 mg/g D. W.) was observed in FH 1275 (28% decrease) while the lowest value (2.4 mg/g D. W.) (47.8% decrease) was noted in FH 1227 under saline conditions compared to control. Foliar application 10mg/L methionine resulted in highest value of shoot Mg^{2+} in FH 1275 (8.17 mg/g D. W.) (24.6% increase) while lowest value was observed in FH1227 (4.3 mg/g D. W.) (38.7% increase) (Fig. 3, Table 2). Root Mg^{2+} under saline conditions showed maximum (4.8 mg/g D. W.) (27 % decrease) value and lowest value (2.4 mg/g D. W.) (44.18 % decrease) was observed in FH 1227 as compared to control. Genotype FH 1275 was recoded to accomplish high value (6.7 mg/g D. W.) (24.0 % increase) of plant root Mg^{2+} with spray of methionine10 mg/L whereas the lowest value (3.6 mg/g D. W.) (24.1% increase) was noted in FH 1227 (Fig. 3, Table 2).

Yield parameters: Maximum value of weight of ear (180 g) (51.3% decrease) in FH1275 and minimum was observed in FH-1227 (56.6 g) (41.6% decrease) under the effect of salinity as compared to control. The maximum weight by FH-1275 (256 g) (42.2% increase) under the treatment of methionine 10 mg/L was recorded whereas the lowest value was calculated by FH-1227 (190 g) (235% increase) compared to saline stress of 80 mM (Fig. 4, Table 3).

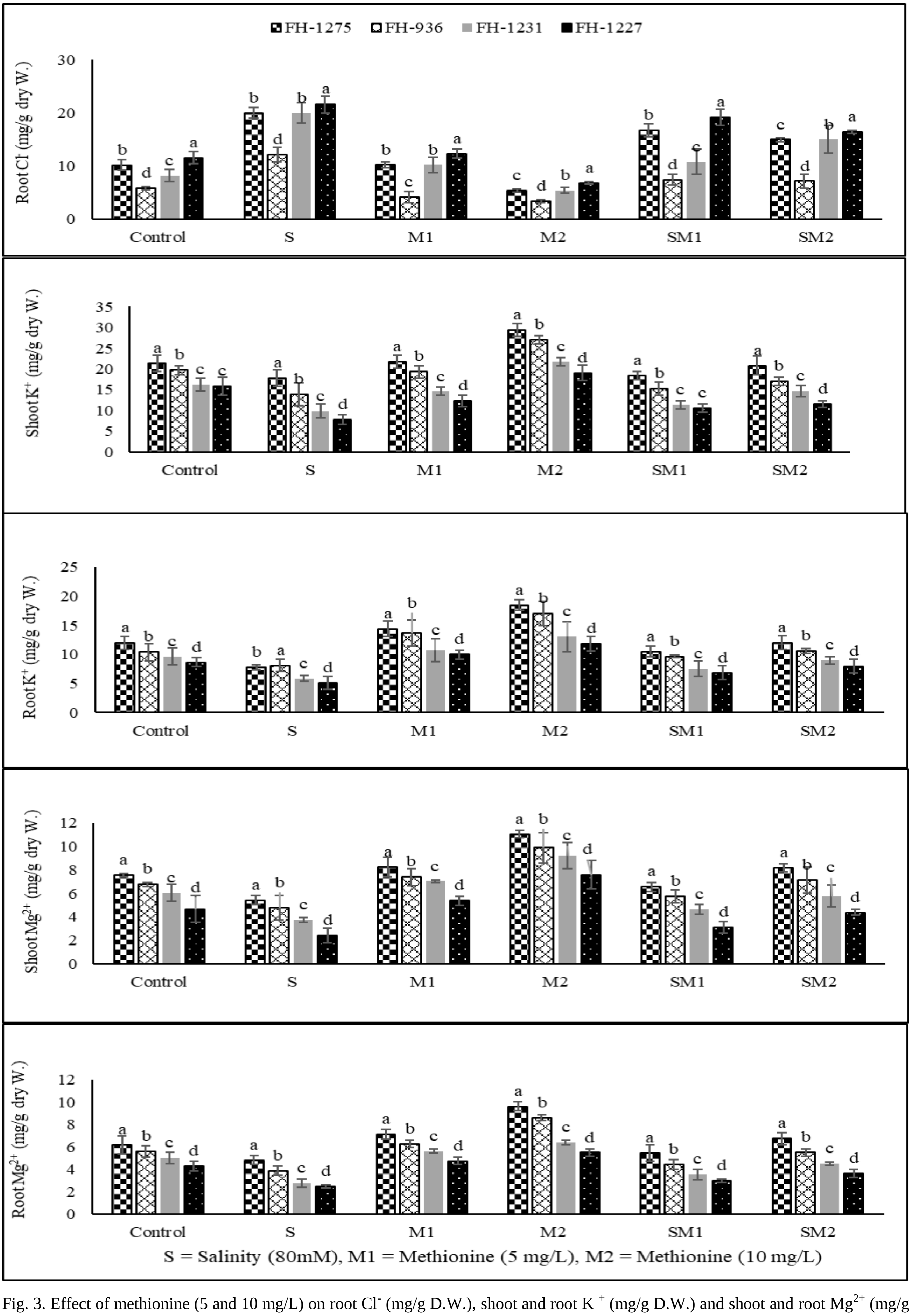

Fig. 3. Effect of methionine (5 and 10 mg/L) on root Cl^- (mg/g D.W.), shoot and root K^+ (mg/g D.W.) and shoot and root Mg^{2+} (mg/g D. W.) of four maize genotypes (FH 1275, FH 936, FH 1231 and FH 1227) under 80 m*M* NaCl stress.

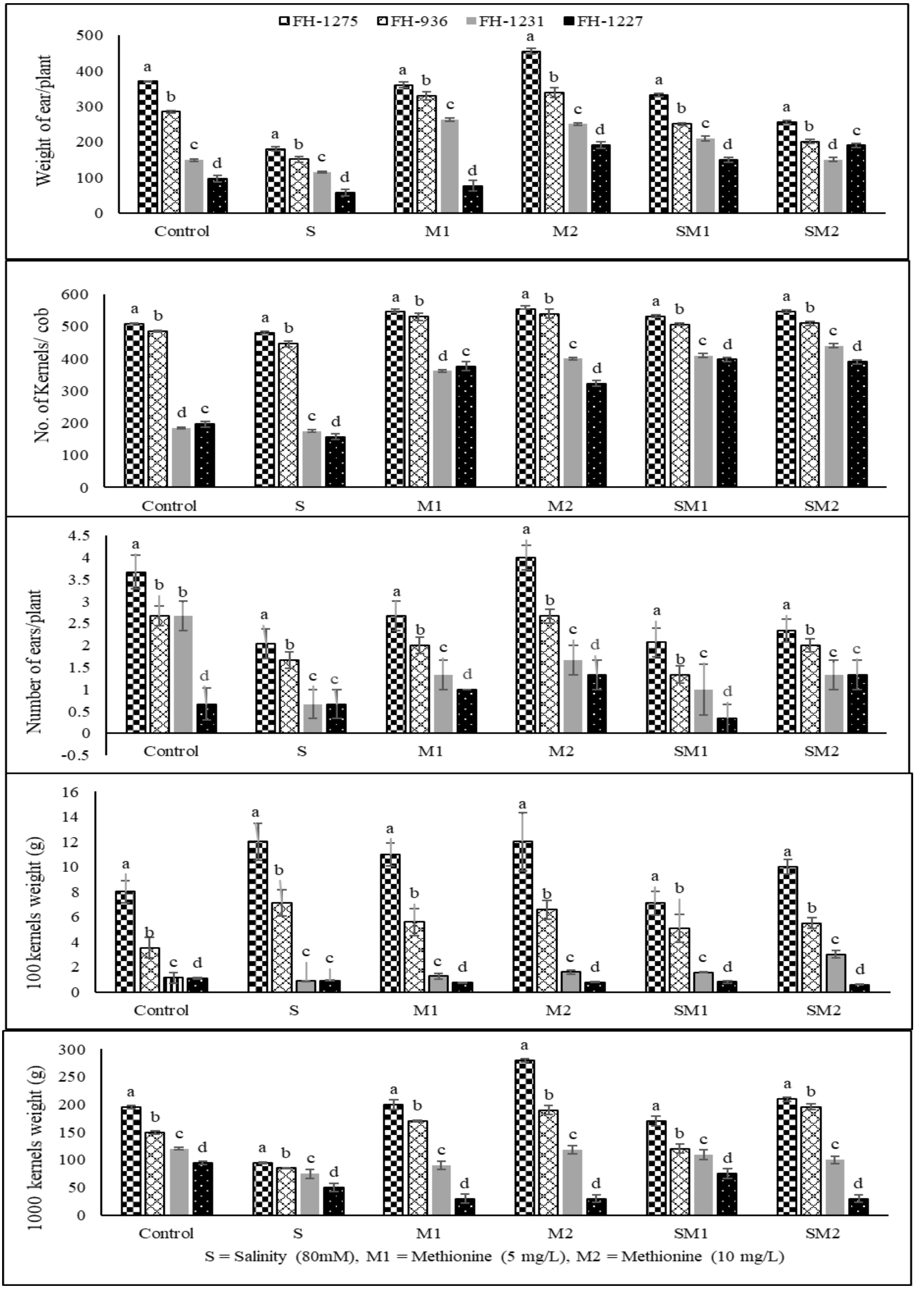

Fig. 4. Effect of methionine (5 and 10 mg/L) on weight of ear/plant (g), number of kernels /cob, number of ears/plant, 100 kernels weight (g) and 1000 kernels weight (g) (mg/g D.W.) of four maize genotypes (FH 1275, FH 936, FH 1231 and FH 1227) under 80 m*M* NaCl stress.

Maximum value of number of ears/plant (2.03) (44.5% decrease) in FH 1275 and minimum was observed in FH-1227 (66) under the effect of salinity as compared to control (.01% decrease). The maximum number of ears/plants was recorded by FH-1275 (2.3g) (13.7% increase) under the treatment of methionine 10 mg/L whereas the lowest value was calculated by FH-1227 (1.3) (100 % increase) as compared to saline stress of 80 mM (Fig. 4, Table 3).

Peak value of number of kernels/cob (480) (5.6 % decrease) in FH 1275 and minimum was observed in FH-1227 (156) (20.4 % decrease) under the effect of salinity compared to control. The maximum number of kernels/cobs was recorded by FH-1275 (546) (2.82% increase) under the treatment of methionine 10 mg/L whereas the lowest value was calculated by FH-1227 (390) (100% increase) as compared to saline stress of 80 mM (Fig. 4, Table 3).

Highest value of 100 kernels weight (12 g) (50% decrease) in FH 1275 and minimum was observed in FH-1227 (0.9) (15.9% decrease) under the effect of salinity compared to control. The maximum weight was recorded by FH-1275 (10g) (16.6% decrease) under the treatment of methionine 10 mg/L whereas the lowest value was calculated by FH-1227 (0.59 g) (34.4 % increase) as compared to saline stress of 80 mM (Fig. 4, Table 3).

Peak value of 1000 kernels weight (95 g) (51% decrease) in FH 1275 and minimum was observed in FH-1227 (50) (47.3% decrease) under the effect of salinity compared to control. The maximum weight was recorded by FH-1275 (210g) (121% increase) under the treatment of methionine 10 mg/L whereas the lowest value was calculated by FH-1227 (30) (40 % increase) as compared to saline stress of 80 mM (Fig. 4, Table 3).

Discussion

Saline soils adversely affect plant growth and development throughout in the world. Various studies demonstrated the negative impacts of salinity on several plant morphological and biochemical traits (Hussein *et al*., 2017; Di Mola *et al*., 2017; Marium *et al*., 2021). Salinity reduced the leaf surface expansion and biomass of purslane (*Portulaca oleracea* L.) (Alam *et al*., 2015). The relative shoot length of seedlings of salt tolerant sorghum plants, enhanced the biomass production of plants and increased the absorption of K^+ while lowered the shoot Na^+ contents (Krishnamurthy *et al*., 2007). Exogenous application of methionine (5 and 10 mg/L) enhanced the salinity tolerance of maize genotypes in their morphological parameters, nutrients uptake and yield features. Present results depicted that foliar application of methionine significantly enhanced the root and shoot lengths, fresh and dry weights of all four maize genotypes. Similar results were presented by Hammad & Ali, (2014) and Zaki *et al*., (2007) showing that bio stimulants i.e., amino acids when applied then amplified all developmental traits of wheat. Earlier investigations showed that salinity badly effects plant biomass and productivity which results in the less crop yield because number of soluble salts in soil and water, increased (Ahanger *et al*., 2014; Flowers *et al*., 2015). Khan *et al*., (2014) reported improvement in plant growth upon the spray of methionine with and without saline environments, suggesting ethylene formation under salt stress. The increased methionine level leads to the production of osmolytes as glycine betaine or other antioxidants and reduces ethylene production in salinity as depicted in current studies and found in mung bean (*Vigna radiata* L (El-Zohiri & Asfour, 2009). It was proved that methionine enhanced the tolerance potential of plants maize and Faba beans (Sh Sadak *et al*., (2015).

In present study the absorbance of nutrients is badly affected by salinity, but the methionine meaningfully enhanced the nutrients uptake (K^+, Ca^{2+}, Mg^{2+}). It may be due to presence of antagonistic role of toxic ions. According to Wang *et al*., (2012), the plants that are grown under salinity, the absorbance of essential nutrients (K^+, Ca^{2+}, Mg^{2+}) is highly affected by competition with the other lethal ions like Na^+ and Cl^- (Kausar & Gull, 2019). All maize genotypes, in present experiment, gathered a significant extent of shoot plus root Na^+ and Cl^- in saline environment but genotype FH 1231 and FH 1227 enhanced the amount of these toxic nutrients as compared to FH 1275 and FH 936. Wang *et al*., (2012) described that enhanced level of root and shoot Na^+ and Cl^- have been ascribed to the struggle with other nutrients like K^+, Ca^{2+} and Mg^{2+}. Similar observations were noticed in tomato by Tantawy *et al*., (2009) and in faba beans by Sh Sadak *et al*., (2015) that foliar spray of amino acid resulted in increased amount of Ca^{2+}, P^{2+}, K^+ and K^+/Na^+ in faba bean. In present experiment the enhanced amounts of K^+, N^+, Mg^{2+} and Ca^{2+} stored in shoot and root resulted in better yield of the crop which were similar with the study of Nahed *et al*., (2010) who worked on *Thuja orientalis* and suggested that N, P, K (%) was increased by amino acid spray on the plant.

Salinity drastically reduced the crop yield in several crops (Ashraf, 2010) like maize (Ali *et al*., 2008), wheat (Ranjbar, 2010), sorghum (kausar & Gull, 2019) and in cucumber (Marium *et al*., 2021). Similar outcomes were observed in present trial where NaCl decreased the number of ears on each maize plant and regular yield, but the foliar application of methionine reduced the fatal influence of salinity on all maize genotypes. However, genotypes FH 1275 and FH 936 exhibited more tolerance to salinity by better maintenance of different yield attributes than the other genotypes (FH 1231and FH 1227). According to Muneer *et al*., (2014) while working on *Solanum lycopersicum* noticed in the reduction of plant yield due to low rate of photosynthesis under saline environment. According to Shahbaz *et al*., (2012) working on different vegetables showed an increase in crop yield under foliar spray of osmo-protectants. It has been depicted from the results that FH 1275 and FH 936 exhibited better performance under saline and non-saline conditions by the foliar application of 10mg/L of methionine compared to FH 1231and FH 1227. Moreover 10mg/L foliar spray enhanced the plant growth and nutrients uptake which may be due to activation of salt tolerant genes through the signaling effect of methionine.

Conclusion

Methionine enhanced the plant biomass and nutrient uptake of all maize genotypes both under salinity and normal conditions. It is concluded that FH 1275 and FH 936 and 10 mg/L level of methionine foliar spray showed better results as compared to the FH 1231 and FH 1231 and could be recommended to farmers to grow in saline soils to increase growth and yield of maize genotypes in salt hit areas of the world.

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