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Efficacy of exogenous Spermidine and Kinetin in altering the macronutrients accumulation in Mash (*Vigna mungo* (L.) Hepper) genotypes under Lead (Pb) stress

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An experiment was managed in quest of finding the effects of Spermidine and Kinetin on macronutrients accumulation in various organs of *Vigna mungo* (L.) genotypes grown in soil with 20mg/kg and 40mg/kg Lead. Four genotypes were grown in pots. After fifteen days, Pb $(NO_3)_2$ was added in soil. Spermidine and Kinetin were foliarly sprayed separately twice at age of 15 and 30 days of plants. Macro nutrients were determined in organs at physiological maturity. Spermidine increased Nitrogen contents in seeds of Mash 80 and Mash 88 as 60.87% and 33.75% respectively. Spermidine increased Phosphorus in root, stem and seeds of Mash 80 and Mash 88. Potassium was increased in root and seeds of Mash 80 and Mash 97. Kinetin increased Nitrogen in root, stem and leaves of Mash 80. Also, Phosphorus concentration was enhanced in all organs of Mash 80 and in stem and seeds of Mash 88.

Keywords: Genotypes, Kinetin, Lead, Macronutrients, Mash, Spermidine

1. INTRODUCTION

Mineral nutrients are structural components of some essential plant metabolites. These are necessary for osmotic adjustment and membrane integrity. Of these macronutrients, Nitrogen (N), Phosphorus (P) and Potassium (K) are the important which are used as fertilizers in modern agricultural practices **(**Kulcheski *et al.,* 2015**)**. The vital activities of plants are affected by heavy metals present in soil **(**Tajti *et al.,* 2018**)**. Plant growth regulators are used in the mitigation of adverse effects of these stresses **(**Ahanger *et al.,* 2018; Khan *et al.,* 2015**)**. Polyamines are important in this regard. Metal stress reduces contents of polyamines in plants. Spermidine, one of the polyamines, when exogenously applied, mitigates the adverse effects of metal stress **(**Wang *et al.,* 2003; Wang and Shi, 2004**)**. Polyamines increase uptake and transport of ions and water **(**Aldesuquy *et al.,* 2014**)**. Polyamines are nitrogenous compounds that have low molecular weight and are used to mediate several vital processes under stressful conditions **(**Agurla *et al.,* 1982**)**. These are involved in many plant vital activities such as membrane stability, synthesis of protein, scavenging of ROS, mineral uptake, activation of enzyme and hormonal regulation **(**Hu *et al.,* 2012; Ahmad *et al.,* 2012; Puyang *et al.,* 2016; Li *et al.,* 2015**)**. The most common polyamines are putrescine, spermidine, and spermine. These are involved in many plant developmental processes and are present ubiquitously **(**Ahmad *et al.,* 2012**)**. Polycationic nature of polyamines enables them to interact with proteins, nucleic acids and phospholipids to stabilize these molecules **(**Ahmad *et al.,* 2012**)**. The metabolism of polyamines is affected by external factors of stresses **(**Hu *et al.,* 2012; Puyang *et al.,* 2016**)**.

Similarly cytokinins are compounds that have low molecular weight and crucial roles in plant developmental processes **(**Zalabak *et al.,* 2013**)**. Cytokinins are involved in cell division regulation, germination, nutrient uptake, morphogenesis, assimilate, and signal transduction in plants **(**Brugiere *et al.,* 2008; Brzobohaty *et al.,* 1993; Vyroubalova *et al.,* 2009**)**. Kinetin is a synthetic cytokinin utilized in plant growth improvement under stress conditions such as metal stress **(**Singh and Prasad 2014**)**, water logging **(**Younis *et al.,* 2003**)** and salinity **(**Ahanger *et al.,* 2018**)**. The exogenously applied Kinetin up-regulates the antioxidant system **(**Wu *et al.,* 2015**)** and enhances the metabolite accumulation **(**Merewitz *et al.,* 2012**)**. Mash bean is among the most important pulses of the world. In Pakistan, it is the least researched crops due to its high nutritional and economic importance. Mash bean seed contains vitamins, oil, fats, protein and carbohydrates **(**Sharma *et al.,* 2012**)**. It has the capability of fixing free atmospheric Nitrogen for its

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own consumption and reserves it for for next crop **(**Sen,1996**)**. Considering the importance of Mash bean and considering the ever increasing toxicity of Lead (Pb) in environment, the present experiment was devised to find out the effects of Spermidine and Kinetin on nutrients uptake potential of crop grown in Pb^{2+} contaminated soil.

2. MATERIAL AND METHODS

A pot culture experiment was devised in quest of whether Kinetin and Spermidine as Plant Growth Regulators (PGRs) are effectual in mitigating the adverse effects of rhizospheric metal toxicity on Mash (*Vigna mungo* L. Hepper) in term of nutrients uptake and accumulation.

MATERIALS

After an initial survey, soil free from effluents hazards, was selected for the experiment. Soil was dried, mixed and passed through fine sieve. Seeds of four Mash genotypes i-e MASH 80, MASH 88, MASH 97 and MASH ES-1 were obtained from pulse section of Ayub Agricultural Research Institute (AARI), Faisalabad (Pakistan). Among the chemicals Pb $(NO_3)_2$ and Kinetin, 6-Furfuryl-aminopurine ($C_{10}H_9N_5O$) and Spermidine, N-(3-Aminopropyl)-1, 4-butanediamine ($C_7H_{19}N_3$) of Sigma Aldrich, Japan were used.

METHODS AND LAYOUT PLAN

For conduction of experiment sandy loam soil (10 kg) was filled in pots of 30 cm diameter which were lined with polyethylene bags ensuring seepage prevention. Placement of pots was with complete randomization by arrangement. To develop the rhizospheric metal toxicity, calculated amounts of Pb $(NO_3)_2$ was added in soil at the age of fifteen days of plants. Metals salt was added in soil as a water solution of Pb $(NO_3)_2$ (method similar to that used by Stoeva and Bineva (2003). Pots without the addition of metals salts acted as control. Seeds of four Mash genotypes after sorting by health were sterilized. Five seeds were sown in each pot. Above ground emergence of 80% seedlings was considered as germination and thinning was performed to obtain three seedlings in each pot for balanced nutrients and other resources supply to plants. Weeds were uprooted from time to time by hand weeding and hoeing in order to avoid weed crop competition. Insects and pests were control by foliar spray of Thiodon insecticides of Hoechst (Pvt) Ltd, Pakistan. Plants were irrigated with irrigation water according to the saturation percentage of soil. Solutions of Spermidine (1.0mM) and Kinetin (100.0mM) were prepared in estimated (pre determined by trial method) amount of water by taking the great care of their half life, temperature and other environmental hazards which cause the denaturation of PGRs solution. Tween-20 (0.1%) was added as a surfactant in solution. Plants were exposed to foliar spray of PGRs at the age of fifteen and thirty days of age with great care of avoiding falling of drops from leaf surface.

For data collection, three plants were selected from each genotype and treatment.. Nitrogen, Phosphorus and Potassium in root, stem and seeds were recorded at maturity of crop (90 days age plants). After digestion of material, Potassium and Phosphorus were analyzed by Jackson (1962) method. Determination of Nitrogen %age was by kjeldahal method **(**Bremner,1965**)**. The data collected were analyzed for analysis of variance for all the parameters using COSTAT computer package (CoHort Software, Berkeley, CA). Duncan's New Multiple Range test at 5% level of probability **(**Duncan, 1955**)** was used for means comparison. Significantly different means were tested by LSD tests by MSTAT-C Computer Statistical Programme.

3. RESULTS

Effect of Spermidine on Nitrogen contents

Exogenous Spermidine increased Nitrogen concentration in seeds of Mash 80 and Mash 88 statistically to a substantial level of 40.87% and 88.75% respectively grown under Pb^{2+} concentration of 20 mg/kg soil **(Table 1).** While, in seeds of Mash 97 Nitrogen was decreased to 46.99%. This action of Spermidine was not statistically justified for Nitrogen accumulation in root and stem for all genotypes. Foliar spray of Spermidine, on the other hand, was proved to be a significantly potent factor in decreasing Nitrogen contents in stem and seeds of Mash 97 and Mash ES-1 grown under 40 mg/kg Pb^{2+} soil. A reduction of 27.40% and 40.90% in stem and seed of Mash 97 respectively was conducive to the application Spermidine. This trend corresponded to Mash ES-1 as 32.97% and 66.24 % for stem and seed.

Effect of Spermidine on Phosphorus contents

The effectiveness of Spermidine in enhancing Phosphorus concentration was significant for Mash 80 and Mash 97 of 20 mg/kg soil lead applied soil **(Table 2).** This definitive trend wasfor root stem and seed of Mash 80 as 50.0%, 266.09% and 72.80% respectively.. The same as true occurred for stem and seeds of Mash 88 and root of Mash 97 as 193.29%, 68.22% and 32.39% respectively. Under 40mg/kg Pb^{2+}, the greatest promise, if the term may be used, in this fashion, in enhancing Phosphorus concentration was in seeds of Mash 80 only as 110.73%. The trend of significant decrease was noted by foliar spray of Spermidine in seeds of Mash 97 and Mash ES-1 as 27.10% and 43.89% respectively.

Effect of Spermidine on Potassium contents

Potassium significantly increased under the stimulus of Spermidine in root of Mash 80 Mash 97 and Mash ES-1 as 92.74%, 34.80% and 69.105 respectively when grown under 20mg/kg soil Pb^{2+} **(Table 3).** For stem of Mash 80 and Mash 88, Spermidine effect evidently could have a significant pivotal role in creasing Potassium level as 246.90% and 132.38% respectively. For seeds of Mash 80 and Mash 97 Spermidine role was significantly remarkable in enhancing Potassium assessed as 22.36% and 26.73% respectively. Under 40 mg/kg soil Pb^{2+}, the non significant impact of Spermidine was observed in stem Mash 80 while in others, under 40mg/kg Pb^{2+}, limitations in Phosphorus by Spermidine were determined.

Effect of Kinetin on Nitrogen contents

From the documented data for performance reflecting the role Spermidine played, it could be inferred that nonsignificant role Spermidine played for Nitrogen enhancement **(Table 4).** Under both levels of Pb^{2+} stress, even significant reduction in Nitrogen was noted in root, stem and seeds of Mash 97.

Table 1: Nitrogen contents (%) of Mash (*Vigna mungo* (L.) Hepper) grown in Pb^{2+} supplemented soil (20,40mg/kg soil) and exposed to foliar spray of Spermidine (1.00mM) at 15 and 30 days of age. (Values represent means ± SE). Values of %age difference represent increase (+)/decrease (-) over control Values followed by dissimilar letters, are different significantly from control.

Part	Genotype	Lead (20 mg/kg soil)			Lead (40 mg/kg soil)		
		No Spermidine (Control)	Foliar Spermidine (1.00mM)	Difference (%)	No Spermidine (Control)	Foliar Spermidine (1.00mM)	Difference (%)
Root	Mash-80	0.145±0.020 a	0.279±0.023 a	92.41	0.062±0.012 a	0.057±0.003 a	-8.06
	Mash-88	0.205±0.022 a	0.149±0.005 a	-27.31	0.058±0.002 a	0.051±0.009 a	-10.34
	Mash-97	0.176±0.004 a	0.236±0.039 a	34.09	0.052±0.001 a	0.051±0.006 a	-1.92
	Mash ES-1	0.209±0.043 a	0.309±0.021 a	47.84	0.050±0.003 a	0.033±0.001 a	-34.00
Stem	Mash-80	0.119±0.010 cd	0.367±0.024 bcd	208.40	0.109±0.008 cd	0.131±0.008 cd	20.18
	Mash-88	0.208±0.037 bcd	0.525±0.040 abc	152.40	0.095±0.009 cd	0.117±0.013 cd	23.15
	Mash-97	0.664±0.105 ab	0.825±0.271 a	24.24	0.135±0.012 cd	0.098±0.009 cd	-27.40
	Mash ES-1	0.310±0.060 bcd	0.300±0.060 bcd	-3.22	0.094±0.007 cd	0.063±0.006 d	-32.97
Seed	Mash-80	4.289±0.858 c	6.042±0.550 a	40.87	1.078±0.146 g	1.614±0.234 fg	49.72
	Mash-88	4.047±0.403 c	5.413±1.043 ab	33.75	1.953±0.214 ef	1.837±0.363 efg	-5.93
	Mash-97	5.222±0.795 b	2.794±0.330 d	-46.49	4.753±0.876 bc	2.809±0.265 d	-40.90
	Mash ES-1	2.440±0.474 de	1.749±0.493 efg	-28.31	3.155±0.567 d	1.065±0.045 g	-66.24

Table 2: Phosphorus contents (%) of Mash (*Vigna mungo* (L.) Hepper) grown in Pb^{2+} supplemented soil (20,40mg/kg soil) and exposed to foliar spray of Spermidine (1.00mM) at 15 and 30 days of age. (Values represent means ± SE). Values of %age difference represent increase (+)/decrease (-) over control Values followed by dissimilar letters, are different significantly from control.

Part	Genotype	Lead (20 mg/kg soil)			Lead (40 mg/kg soil)		
		No Spermidine (Control)	Foliar Spermidine (1.00mM)	Difference (%)	No Spermidine (Control)	Foliar Spermidine (1.00mM)	Difference (%)
Root	Mash-80	1.220±0.107 e	1.830±0.036 b	50.00	0.419±0.035 f	0.395±0.044 fg	-5.72
	Mash-88	1.718±0.090bc	1.189±0.070 e	-30.79	0.397±0.027 fg	0.311±0.014 fg	-21.66
	Mash-97	1.204±0.104 e	1.594±0.199 cd	32.39	0.337±0.018 fg	0.315±0.025 fg	-6.52
	Mash ES-1	1.459±0.298 d	2.106±0.265 a	44.34	0.357±0.020 fg	0.237±0.013 g	-33.61
Stem	Mash-80	0.823±0.042 de	3.013±0.194 b	266.09	0.681±0.045 e	1.005±0.053 de	47.57
	Mash-88	1.432±0.124 d	4.200±0.364 a	193.29	0.589±0.013 e	0.867±0.076 de	47.19
	Mash-97	4.590±0.598 a	4.693±0.456 a	2.24	0.876±0.022 de	0.773±0.061 de	-11.75
	Mash ES-1	2.171±0.319 c	2.382±0.247 bc	9.71	0.617±0.029 e	0.476±0.005 e	-22.85
Seed	Mash-80	5.927±0.443 cd	10.242±0.839 a	72.80	1.509±0.142 j	3.180±0.535 ghi	110.73
	Mash-88	5.671±0.929 cde	9.540±2.870 a	68.22	2.737±0.446 hij	3.737±0.324 fghi	36.53
	Mash-97	7.414±1.120 b	4.989±0.426 def	-32.70	6.626±0.709 bc	4.830±0.552 def	-27.10
	Mash ES-1	3.816±1.016 fgh	3.671±0.623 fghi	-3.79	4.360±0.480 efg	2.446±0.047 ij	-43.89

Table 3: Potassium contents (%) of Mash (*Vigna mungo* (L.) Hepper) grown in Pb^{2+} supplemented soil (20,40mg/kg soil) and exposed to foliar spray of Spermidine (1.00mM) at 15 and 30 days of age. (Values represent means ± SE). Values of %age difference represent increase (+)/decrease (-) over control Values followed by dissimilar letters, are different significantly from control.

Part	Genotype	Lead (20 mg/kg soil)			Lead (40 mg/kg soil)		
		No Spermidine (Control)	Foliar Spermidine (1.00mM)	Difference (%)	No Spermidine (Control)	Foliar Spermidine (1.00mM)	Difference (%)
Root	Mash-80	1.681±0.369 e	3.240±0.277 b	92.74	0.397±0.051 f	0.389±0.043 f	-2.01
	Mash-88	2.068±0.107 cd	1.612±0.215 e	-22.05	0.515±0.053 f	0.385±0.080 f	-25.24
	Mash-97	1.747±0.257 de	2.355±0.400 c	34.80	0.404±0.086 f	0.268±0.042 f	-33.66
	Mash ES-1	2.133±0.489 c	3.607±0.418 a	69.10	0.449±0.048 f	0.370±0.028 f	-17.59
Stem	Mash-80	1.262±0.082 fgh	4.378±0.409 cd	246.90	0.885±0.115 gh	1.240±0.149 gh	40.11
	Mash-88	2.671±0.435 defg	6.207±0.719 bc	132.38	1.173±0.131 g	1.764±0.097 efgh	50.38
	Mash-97	7.070±1.302 ab	8.388±1.354 a	18.64	1.471±0.073 efgh	0.907±0.055 gh	-38.34
	Mash ES-1	3.229±0.526 de	3.222±0.496 def	-0.21	1.030±0.105 gh	0.581±0.058 h	-43.59
Seed	Mash-80	9.452±2.477 c	11.566±0.452 ab	22.36	2.113±0.466 gh	3.611±0.705 efg	70.89
	Mash-88	10.806±0.696 bc	11.388±2.024 ab	5.38	3.139±0.867 efgh	2.607±0.690 fgh	-16.94
	Mash-97	10.273±1.068 bc	13.019±1.788 a	26.73	4.138±0.679 ef	1.887±0.414 h	-54.39
	Mash ES-1	4.708±1.133 de	5.888±1.832 d	25.06	4.506±1.136 de	1.546±0.486 h	-65.69

Table 4: Nitrogen contents (%) of Mash (*Vigna mungo* (L.) Hepper) grown in Pb^{2+} supplemented soil (20,40mg/kg soil) and exposed to foliar spray of Kinetin (100 mM) at 15 and 30 days of age. (Values represent means ± SE). Values of %age difference represent increase (+)/decrease (-) over control Values followed by dissimilar letters, are different significantly from control.

Part	Genotype	Lead (20 mg/kg soil)			Lead (40 mg/kg soil)		
		No Kinetin (Control)	Foliar Kinetin (100mM)	Difference (%)	No Kinetin (Control)	Foliar Kinetin (100mM)	Difference (%)
Root	Mash-80	0.144±0.020 a	0.266±0.003 a	84.72	0.061±0.010 a	0.055±0.004 a	-9.83
	Mash-88	0.203±0.022 a	0.211±0.025 a	3.940	0.058±0.002 a	0.078±0.012 a	34.48
	Mash-97	0.175±0.003 a	0.138±0.036 a	-21.14	0.052±0.002 a	0.050±0.001 a	-3.84
	Mash ES-1	0.208±0.044 a	0.183±0.022 a	-12.01	0.050±0.003 a	0.051±0.005 a	2.00
Stem	Mash-80	0.118±0.028 a	0.363±0.012 a	207.62	0.108±0.063 a	0.142±0.021 a	31.48
	Mash-88	0.204±0.009 a	0.419±0.052 a	105.39	0.094±0.008 a	0.133±0.013 a	41.48
	Mash-97	0.664±0.033 a	0.308±0.025 a	-53.61	0.135±0.010 a	0.149±0.012 a	10.37
	Mash ES-1	0.304±0.105 a	0.349±0.019 a	14.80	0.094±0.012 a	0.086±0.008 a	-8.51
Seed	Mash-80	4.109±0.849 b	4.581±0.879 ab	11.48	1.061±0.139 hi	1.817±0.114 fgh	71.25
	Mash-88	4.031±0.412 bc	3.276±0.634 cd	-18.72	1.942±0.218 fg	1.031±0.082 i	-46.91
	Mash-97	5.222±0.795 a	2.818±0.262 de	-46.03	4.753±0.876 ab	2.852±0.228 de	-39.99
	Mash ES-1	2.391±0.506 ef	2.706±0.462 de	13.17	3.065±0.649 de	1.222±0.115 ghi	-60.13

Table 5: Phosphorus contents (%) of Mash (*Vigna mungo* (L.) Hepper) grown in Pb^{2+} supplemented soil (20,40mg/kg soil) and exposed to foliar spray of Kinetin (100 mM) at 15 and 30 days of age. (Values represent means ± SE). Values of %age difference represent increase (+)/decrease (-) over control Values followed by dissimilar letters, are different significantly from control.

Part	Genotype	Lead (20 mg/kg soil)			Lead (40 mg/kg soil)		
		No Kinetin (Control)	Foliar Kinetin (100mM)	Difference (%)	No Kinetin (Control)	Foliar Kinetin (100mM)	Difference (%)
Root	Mash-80	1.214±0.107 d	2.014±0.126 a	65.89	0.415±0.033 ef	0.400±0.021 ef	-3.61
	Mash-88	1.702±0.101 b	1.526±0.185 c	-10.34	0.397±0.027 ef	0.496±0.039 e	24.93
	Mash-97	1.201±0.100 d	1.125±0.127 d	-6.32	0.333±0.011 f	0.315±0.015 f	-5.40
	Mash ES-1	1.453±0.303 c	1.494±0.105 c	2.82	0.356±0.020 ef	0.267±0.017 f	-25.00
Stem	Mash-80	0.817±0.044 fgi	2.006±0.051 b	145.53	0.677±0.042 ghi	1.034±0.030 f	52.73
	Mash-88	1.408±0.085 e	2.950±0.284 b	109.52	0.585±0.014 i	0.940±0.064 fg	60.68
	Mash-97	4.590±0.598 a	2.036±0.093 cd	-55.64	0.876±0.022 fg	1.075±0.082 f	22.71
	Mash ES-1	2.121±0.291 d	2.568±0.298 c	21.07	0.614±0.029 hi	0.594±0.021 i	-3.25
Seed	Mash-80	5.679±0.416 cd	8.592±2.139 a	249.57	1.486±0.136 h	3.748±0.541 fg	152.22
	Mash-88	5.652±0.961 cd	6.501±1.165 bc	116.61	2.725±0.466 gh	2.699±0.300 g	-0.95
	Mash-97	7.414±1.120 ab	5.229±0.479 de	-49.10	6.626±0.709 bc	5.216±0.549 de	-21.27
	Mash ES-1	3.744±1.069 fg	5.901±0.896 cd	21.07	4.242±0.691 ef	2.986±0.403 fg	-29.60

Table 6: Potassium contents (%) of Mash (*Vigna mungo* (L.) Hepper) grown in Pb^{2+} supplemented soil (20,40mg/kg soil) and exposed to foliar spray of Kinetin (100 mM) at 15 and 30 days of age. (Values represent means ± SE). Values of %age difference represent increase (+)/decrease (-) over control Values followed by dissimilar letters, are different significantly from control.

Part	Genotype	Lead (20 mg/kg soil)			Lead (40 mg/kg soil)		
		No Kinetin (Control)	Foliar Kinetin (100mM)	Difference (%)	No Kinetin (Control)	Foliar Kinetin (100mM)	Difference (%)
Root	Mash-80	1.671±0.357 e	2.974±0.391 a	77.97	0.392±0.047 f	0.498±0.062 f	27.04
	Mash-88	2.050±0.131 cd	2.402±0.318 b	17.17	0.515±0.053 f	0.656±0.037 f	27.37
	Mash-97	1.743±0.256 de	2.256±0.299 bc	29.43	0.397±0.073 f	0.361±0.027 f	-9.06
	Mash ES-1	2.125±0.497 bc	3.217±0.330 a	51.38	0.447±0.045 f	0.507±0.055 f	13.42
Stem	Mash-80	1.251±0.066 efg	3.361±0.214 c	168.66	0.880±0.123 fg	0.723±0.146 g	-17.84
	Mash-88	2.624±0.382 d	4.429±0.823 b	68.78	1.164±0.122 efg	1.655±0.134 e	42.18
	Mash-97	7.070±1.302 a	3.681±0.368 c	-47.93	1.471±0.073 ef	1.485±0.175 ef	0.95
	Mash ES-1	3.146±0.381 cd	4.334±0.554 b	37.76	1.024±0.096 efg	0.922±0.061 fg	-9.96
Seed	Mash-80	9.142±2.787 ab	10.471±2.505a	14.53	2.089±0.498 f	3.388±0.383 def	62.18
	Mash-88	10.765±0.761 a	8.110±1.696 b	-24.66	3.122±0.866 def	2.804±0.272 ef	-10.18
	Mash-97	10.273±1.068 a	2.212±0.525 f	-78.46	4.138±0.679 de	1.693±0.196 f	-59.08
	Mash ES-1	4.624±1.221 cd	6.277±0.674 c	35.74	4.356±1.125 de	1.681±0.434 f	-61.40

An exception, however nonsignificant, to this was observed in stem and root of Mash 88 under high level of Pb^{2+} stress. A reduction of 46.91%, 39.99% and 60.13% was noted in seeds of Mash 88, Mash 97 and Mash ES-1 respectively by Spermidine application.

Effect of Kinetin on Phosphorus contents

Exogenous Kinetin amplified Phosphorus accumulation in root, stem and seeds of Mash 80 as 65.89%, 145.53% and 249.57% respectively under 20mg/kg soil Pb^{2+} stress (Table 5). Statistically significant role of Kinetin lied for enhancing Potassium concentration in stem and seeds of Mash 88 observed as 109.52% and 116.61% respectively. Under this stress of Pb^{2+}, a statistically promising reduction appeared in Phosphorus levels in stem and seeds of Mash 97 and Mash ES-1. Under 40mg/kg soil Pb^{2+}, only stem and seeds of Mash 80 accumulated 52.73% and 152.22% more Potassium while in others organs, there was reduction of Phosphorus concentrations.

Effect of Kinetin on Potassium contents

Foliarly applied Spermidine appeared to be responsible for significant increase in Potassium concentration in root and stem of Mash 80 as 77.97% and 168.66% respectively under 20 mg/kg Pb^{2+} stress

(Table 6). Although not statistically justified, but to a considerable extent, the increase was observed in seed of Mash 80. Spermidine established a statistically similar induction for root and stem of Mash 88 and implied a performance of 17.19% and 68.78 % increase respectively. An increase of 51.38% and 37.86% was revealed for root and stem respectively of Mash ES-1. However, the observations were excluded from the ongoing trends in seeds of Mash 88 and Mash 97 thereby decreasing concentration as 24.66% and 76.46% respectively. Under higher level of Pb^{2+} in root and seeds of Mash 80 and Mash 88 statistically nonsignificant increase was observed in Potassium concentration.

4. DISCUSSION

The results of present experiment (Table 1-3) regarding enhanced accumulation of Potassium by polyamine application are in accordance with the findings of Sarjala and Kaunisto (1997). Our findings (Table 4-6) are in accordance with those of others also **(**Wierzbowska and Nowak,1999; Chakrabarti and Mukherji, 2003; Behera *et al.*, 1990**)** who reported enhanced uptake of Nitrogen and Phosphorus by Kinetin. The increased accumulation of Potassium by Kinetin application is reported also by many workers **(**Abutalybov *et al.*, 1982; Hong, 1975; Oliveira *et al.*, 1998; Neumann *et al.*, 1978**)**. Similarly, Polyamine mediated Nitrogen increase was also reported by many researchers **(**Roitto *et al.*, 2003; Balestrasse *et al.*, 2003; Neves *et al.*, 2002**)**. Plant growth regulators not only regulate plant growth and developmental process but also nutrient intake, assimilation, distribution and storage as well **(**Panwar *et al.*, 1990; Nowak and Ciecko, 1991; Nowak *et al.*, 1997; Czapla *et al.*, 2003**)**. According to Nowak and Ciecko **(1**991**)** increased quantity of minerals elements in the above ground parts of plants by application of hormones are caused by extensive root growth and enlargement of hair on root **(**Svenson,1991; Meuwly and Pilet,1991; Ali *et al.*, 2008**)**. This enlargement of hair increases absorption water and nutrients from soil. Foliar application of Kinetin mitigates the Potassium uptake reduction by regulating the stomatal functioning **(**Ahmad *et al.*, 2016**)**. Stomatal opening is regulated by guard cell turgidity **(**Assmann and Shimazak,1999; Lemtiri-Chlieh *et al.*, 2000**)** or increased stomatal pore area. This may be attributed to the effects of Kinetin **(**Barcelo *et al.*, 1986**)**. Kinetin induced enhanced K^+ accumulation may be due to growth of root **(**Sharp and Davies, 1979; Saab *et al.*, 1990**)**. Consequently, ions transported through roots are accumulated in above ground parts of plant. Polyamines regulate ions concentration and their transportation. Ion channels are modulated by polyamines **(**Johnson, 1996**)**. The activities of channel are regulated by polyamines at whole cell level and single channel as well **(**Bruggemann *et al.*, 1998**)**. Polyamines control ion channels by binding to membrane component or channel protein **(**Johnson, 1996**)**. Polyamines regulate ion channels such as KIR (inwardly rectifying K^+), NMDA (*N*-methyl-D-aspartate) and Ca^{2+} channels **(**Bruggemann *et al.*, 1998; Williams, 1997; Nichols and Lopatin, 1997**)**. In higher plants polyamines control vacuolar cation channel also.

Conclusion: Exogenous Spermidine and Kinetin have profound effects on escalation of Phosphorus and Potassium in various organs of plants.

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