J. Soils and Crops 27 (2) 47-53, Dec. 2017

ISSN 0971-2836
NAAS Rating - 4.46
Scientific Journal Impact Factor - 4.338

AN EVALUATION OF THE POTENTIALITY OF EXOGENOUSLY APPLIED PUTRESCINE AND IBA ON BIOCHEMICAL AND YIELD CONTRIBUTING PARAMETERS OF MAIZE

R. D. Deotale[1] and B. B. Pandey[2]

ABSTRACT

In order to, examine the effects of different concentrations of growth regulators (putrescine and IBA) on biochemical and yield contributing parameters of maize, a field experiment was carried out at Botany farm, College of Agriculture, Nagpur during 2015-16. Foliar application of putrescine and IBA 25, 50, 75 and 100 ppm each was given at vegetative stage (30-35 DAS) and the data were taken at 30, 45, 60 and 75 DAS coinciding with vegetative stage, flowering stage and before harvest stage. Application of putrescine and IBA enhanced biochemical parameters *viz.,* chlorophyll content, NPK content in leaves, starch and protein content in grains, yield contributing characters *viz.,* number of grains cob^{-1}, weight of 100 grain, yield plant^{-1} and yield plot^{-1}. Analysis of data revealed that 100 ppm IBA considered most effective concentration in enhancing all biochemical and yield contributing parameters.

(Key words: Maize, putrescine, IBA, foliar application, biochemical parameters and yield)

INTRODUCTION

Maize or corn (*Zea mays*) is a plant belonging to the family of grasses (*Poaceae*). It is cultivated globally being one of the most important cereal crops worldwide. Maize is not only an important human nutrient, but also a basic element of animal feed and raw material for manufacture of many industrial products. The products include corn starch, maltodextrins, corn oil, corn syrup and products of fermentation and distillation industries. It is also being recently used as biofuel. Information on the gross chemical composition of maize is abundant. It contains about 70-75% starch, 8-10% oil and 1-3% others carbohydrates.

Cornstarch (maize flour) is a major ingredient in home cooking and in many industrialized food products. Maize is also a major source of cooking oil (corn oil) and of maize gluten. Maize starch can be hydrolyzed and enzymatically treated to produce different syrup, particularly high fructose corn syrup, a sweetener and also fermented and distilled to produce grain alcohol. In 100 g supplies maize kernel provides 86 kcal energy. It contains 18.7 g Carbohydrate, 5.7 g Starch, 6.26 g Sugar, 2 g Dietary fibre, 1.35 g Fat and 3.27 g Protein. In moderate amounts, it also supplies amino acids like Tryptophan 0.023 g and Methionine 0.067 g, Vitamins like Thiamine (13%) 0.155 mg, Vitamin C (8%) 6.8 mg and Folate (B9) (11%) 42 µg, In minerals it is good source of Iron (4%) 0.52 mg, Phosphorus (13%) 89 mg, Potassium (6%) 270 mg and Zinc (5%) 0.46 mg.

The yield of maize may be enhanced through physiological manipulation such as foliar application of putrescine and IBA. Plant growth regulators like promoters, inhibitors or retardants play a key role in internal control mechanism of plant growth by interacting with key metabolic processes such as nucleic acid and protein synthesis. The most commonly used growth regulators in maize are IBA, putrescine, ethrel, cycocel, salicyclic acid, IAA, GA_3etc. are enhancing growth and productivity of crop plants.

Putrescine, IBA, IAA, GA, kinetin, phenolics and aliphatic alcohols are reported to increase and stimulate the rate of photosynthesis. The diamine putrescine occurred widely in the higher plants. IBA is a plant growth regulator, used to promote and accelerate root formation of plant clippings and to reduce transplant shock of non-food ornamental nursery stock. IBA is also used on fruit and vegetable crops, field crops and ornamental turf to promote growth development of flowers and fruits and to increase crop yields. IBA has been classified as a biochemical pesticide because it is similar in structure and function to the naturally-occurring plant growth hormone indole-3-acetic acid.

Application of growth promoting hormones is a recent technique in this direction. Plant hormones in a broad sense are organic compounds which play an important role in plant growth development and yield of crops to prevent the fruit and flower drop for a longer.

MATERIALS AND METHODS

A field experiment was conducted at Botany farm, College of Agriculture, Nagpur to know the response of maize to growth regulators on its biochemical and yield contributing parameters. Maize variety PKVM-Shatak with field duration of 110 days was selected for the study. The

---

1. Professor, Botany Section, College of Agriculture, Nagpur
2. P.G. Student, Botany Section, College of Agriculture, Nagpur

experiment was laid out in complete randomized block design with three replications. The experiment consisted of nine treatments viz., IBA and putrscine applied at 25, 50, 75 and 100 ppm each with control (water spray). The seeds were sown with a spacing of 60 cm x 20 cm. Growth promoters were sprayed once at 30-35 DAS. First observation (30 DAS) was made before the spray and other observations were made at 45, 60 and 75 DAS. Five randomly selected plants were tagged and observations were taken on biochemical parameters (leaf chlorophyll content, N, P, K, grain starch and protein content) and yield attributing characters (Number of grains cob^{-1}, weight of 100 grain and yield plot^{-1}). Determination of nitrogen and protein was carried out by micro-kjeldhal method given by Somichi *et al.* (1972). Phosphorus content was estimated by vanadomolybdate yellow colour method, (using calorimeter) given by Jackson, (1967). Starch content was estimated by anthrone reagent method as suggested by Shirlaw and Gilchrist (1967). The observed data were analyzed statistically using analysis of variance at 5% level of significance (Panse and Sukhamate, 1954).

RESULTS AND DISCUSSION

Chlorophyll content

The application of both putrescine and IBA increased the chlorophyll content significantly in the leaves of maize plant as compared (Table 1) to non treated plants. The most effective concentration in this concern at 45 DAS was 100 ppm IBA followed by the treatments T_9 (100 ppm putrescine), T_4 (75 ppm IBA) and T_8 (75 ppm putrescine) when compared with treatment T_1 (control) and remaining treatments under study. Treatments T_7 (50 ppm putrescine), T_3 (50 ppm IBA), T_6 (25 ppm putrescine) and T_2 (25 ppm IBA) were found at par with treatment T_1 (control). Data regarding chlorophyll content at 60 DAS was also shown pronounced effect. Treatment T_5 (100 ppm IBA) followed by the treatments T_9 (100 ppm Putrescine), T_4 (75 ppm IBA) and T_8 (75 ppm putrescine), noted significantly maximum chlorophyll content over treatment T_1 (control) and rest of the treatments under study. But treatments T_3 (50 ppm IBA), T_7 (50 ppm putrescine), T_6 (25 ppm putrescine) and T_2 (25 ppm IBA) were found at par with treatment T_1 (control). At 75 DAS treatment T_5 (100 ppm IBA) followed by the treatments T_9 (100 ppm putrescine), T_4 (75 ppm IBA), T_8 (75 ppm putrescine) and T_7 (50 ppm putrescine) were most effective in increasing chlorophyll content in leaves when compared with treatment T_1 (control) and rest of the treatments under study. Treatments T_3 (50 ppm IBA), T_6 (25 ppm putrescine) and T_2 (50 ppm IBA) were found at par with treatment T_1 (control). Polyamines may retard senescence and chlorophyll loss by altering the stability and permeability of membranes and protecting chloroplast from senescing (Gonzalez-Aguilar *et al.*, 1997). A possible explanation for the promoting effect of putrescine on photosynthetic pigment of maize plant in the present work is that PAs might retard the chlorophyll destruction and / or increase their biosynthesis or stabilize the thylakoid membrane. Similar effects of PAs on photosynthetic pigments had been observed by Ahmed *et al.* (2013), who conducted a field experiment to study the effect of putrescine (0, 1 and 2 ppm) and humic acid (0, 1 and 2 %) were sprayed eight times started at 45 DAP and repeated every after 15 days on cotton and reported that foliar application of 2 ppm putrescine and 1% humic acid significantly enhanced chlorophyll content.

Nitrogen content

The present investigation showed that, putrescine and IBA treatments induced significant increase in N contents in shoots of maize plant compared to those of the untreated plants (Table 1). In this respect, data recorded at 45 DAS and 60 DAS revealed that nitrogen content was significantly maximum in treatment T_5 (100 ppm IBA) followed by the treatments T_9 (100 ppm putrescine), T_4 (75 ppm IBA), T_8 (75 ppm putrescine) and T_7 (50 ppm putrescine) in a descending manner when compared with treatment T_1 (control) and other remaining treatments under study. While, treatments T_3 (50 ppm IBA), T_6 (25 ppm putrescine) and T_2 (25 ppm IBA) were found at par with treatment T_1 (control). While, data recorded at 75 DAS exhibited maximum N content in leaves in treatment T_5 (100 ppm IBA) followed by the treatments T_9 (100 ppm putrescine) and T_4 (75 ppm IBA). Next to these, treatments T_8 (75 ppm Putrescine), T_7 (50 ppm putrescine), T_3 (50 ppm IBA) and T_6 (25 ppm putrescine) were also found superior when compared with treatment T_1 (control) in a descending manner. Treatment T_2 (25 ppm IBA) was found at par with treatment T_1 (control). From this data it is observed that leaf nitrogen content was increased up to 60 DAS and reduced thereafter at 75 DAS. The decrease in nitrogen content might be due to fact that younger leaves and developing organs, such as grains act as strong sink demand and may draw heavily nitrogen from older leaves (Gardner *et al.*, 1988). Putrescine or IBA enhances enzymatic activity and translocation processes from leaves to grains, linking or converting to other plant metabolites (Amin *et al.*, 2013). Similarly IBA increases the ability of cell division in meristematic zones of plant and hence, the ability of plant to absorb nutritive material (Ghodrat *et al.*, 2012). These might be the reasons for increase in leaf nitrogen content in the present investigation by the application of putrescine and IBA. In this, connection, Amin *et al.* (2013) tested two plant growth regulators putrescine and Indole-3-butyric acid (IBA) @ 25, 50 and 100 mg l^{-1} applied either alone or in combinations. Spraying of putrescine and IBA @ 100 mg l^{-1} significantly enhanced nitrogen content of chickpea (*Cicer arientinum* L.).

Phosphorus content

The application of various concentrations of putrsecine and IBA in the present work induced significant increase P content in leaves. The magnitude of increase P content at 45 DAS was much pronounced in case of treatment T_5 (100 ppm IBA) followed by the treatments T_9 (100 ppm putrescine), T_4 (75 ppm IBA) and T_8 (75 ppm putrescine) when compared with treatment T_1 (control) and other treatments. While, treatments T_7 (50 ppm putrescine), T_3 (50 ppm IBA), T_6 (25 ppm putrescine) and T_2 (25 ppm IBA) were found at par with control (T_1). At 60 DAS it was found that maximum leaf phosphorus content was recorded in treatment T_5 (100 ppm IBA) followed by the treatments T_9 (100 ppm putrescine) and T_4 (75 ppm IBA) in a descending manner when compared with treatment T_1 (control) and remaining treatments under study. Next to this, treatments T_8 (75 ppm putrescine), T_7 (50 ppm putrescine), T_3 (50 ppm IBA), T_6 (25 ppm putrescine) and T_2 (25 ppm IBA) were also gave superior results over control (T_1). At 75 DAS data showed that significantly maximum P content recorded in treatment T_5 (100 ppm IBA) followed by the treatment T_9 (100 ppm putrescine) and T_4 (75 ppm IBA). Next to these, treatments T_8 (75 ppm putrescine), T_7 (75 ppm putrescine), T_3 (50 ppm IBA) and T_6 (25 ppm putrescine) were found significantly superior over control (T_1) in a descending manner and remaining treatments under study. While, treatment T_2 (50 ppm IBA) was found at par with treatment T_1 (control). Application of putrescine or IBA increased enzymatic activity and translocation processes from leaves to grains, linking or converting to other plant metabolites (Amin *et al*., 2013). These might be the reasons for increase in leaf phosphorus content in the present investigation by the application of putrescine and IBA.

Amin *et al*. (2013) tested two plant growth regulators viz.,putrescine and Indole-3-butyric acid (IBA) @ 25, 50 and 100 mg l^{-1}, applied either alone or in combinations. Spraying of putrescine and IBA @ 100 mg l^{-1} significantly enhanced phosphorus content of chickpea (*Cicer arietinum* L.).

Potassium content

Potassium is an essential macronutrient for plants involved in many physiological processes. It is important for crop yield as well as for the quality of edible parts of crops. Although K is not assimilated into organic matter, K deficiency has a strong impact on plant metabolism. The foliar application of various concentrations of putrescine and IBA significantly increased K in shoots of maize plant at different stages. At all the stages (45, 60 and 75) it is found that significantly highest leaf potassium content was observed in treatment T_5 (100 ppm IBA) followed by the treatment T_9 (100 ppm putrescine). Next to these, treatments T_4 (75 ppm IBA), T_8 (75 ppm putrescine), T_7 (50 ppm putrescine), T_3 (50 ppm IBA) and T_6 (25 ppm putrescine) were also found superior in a descending manner when compared with treatment T_1 (control) and remaining treatments under study. While, treatment T_2 (25 ppm IBA) was found at par with treatment T_1 (control). Polyamines induced repression of Na^+ influx into roots and prevention of 'K' loss from shoots improved K^+/Na^+ homeostasis in barley (Zhao *et al*., 2007). Yamaguchi *et al*. (2006) also suggested that increase in cytoplasmic Ca^{+2} results in prevention of K^+/Na^+ entry into the cytoplasm, enhancement of K^+/Na^+ influx to the vacuole or suppression of K^+/Na^+ release from vacuole. These might be the reasons for increase in leaf potassium content in the present investigation by the application of putrescine and IBA. It is worthy to mention here that these results also confirmed by Deotale *et al*. (2016), who tested different concentrations of putrescine and IBA (50, 75, 100, 125 and 150 ppm each) with one control on chemical, biochemical, yield and yield contributing characters of soybean and reported that two foliar sprays of 100 ppm putrescine and 100 ppm IBA at two stages i.e. before flowering and 10 days after flowering were found to be most effective in enhancing N, P, K and chlorophyll content in seed.

Protein and starch content in grain

During the experimentation protein content was recorded in grain and it was noticed that maize protein content also increased with the increased concentrations of plant regulators. However, significantly maximum protein content was increased in treatment T_5 (100 ppm IBA) followed by the treatments T_9 (100 ppm Putrescine) and T_4 (75 ppm IBA) when compared with treatment T_1 (control) and remaining treatments. Treatments T_8 (75 ppm Putrescine), T_7 (50 ppm putrescine), T_3 (50 ppm IBA), T_6 (25 ppm putrescine) and T_2 (25 ppm IBA) were found at par with treatment T_1 (control). Foliar application of putrescine and IBA increased grain protein content in the present investigation might be due to that PAs are important cellular constituents to specific regulatory proteins. They provide a possible mechanism for the formation of polyamine-protein complexes. Kuznetsov and Shevyakova (1997) stated that, PAs could change the stability and substrate specificity of protein kinase / phosphatase systems to modify the properties of polypeptides and acting as substrate for phosphorylation, dephosphorylative enzymes and affect the stability of protein molecules in plants. El-Bassiouny (2004) demonstrated that, putrescine treatments significantly increased protein percentage of the yielded pea seeds while carbohydrate percentage was not affected as compared to control. She stated that increase in the translocation of amino acids from shoots to seeds results in the increase in protein synthesis in pea shoots. These might also be reasons for increase in protein content in present study. Amin *et al*. (2013) tested two plant growth regulators i.e. putrescine and Indole-3-butyric acid (IBA) @ 25, 50 and 100 mg l^{-1}, applied either alone or in combinations. Spraying of putrescine and IBA @ 100 mg l^{-1} was significantly enhanced potassium of chickpea (*Cicer arietinum* L.).

Similarly, it has been found in the present investigation that the application of putrescine and IBA significantly increased starch content in grain. From the data it is clear that significantly maximum starch content in grains was recorded in treatment T_5 (100 ppm IBA) followed by treatments T_9 (100 ppm putrescine) and T_4 (75 ppm IBA) over control (T_1) and rest of the treatments. Treatments T_8 (75 ppm putrescine), T_7 (50 ppm putrescine) and T_3 (50 ppm IBA) were also found superior over control in increasing starch content in grains. Treatments T_6 (25 ppm putrescine) and T_2 (25 ppm IBA) were found at par with treatment T_1 (control). El-bassiouny *et al.* (2008) reported that putrescine significantly induced significant increase in sucrose, minerals, nucleic acid content, carbohydrates and starch content. The increase in element contains concurrently with the active growth rates of maize shoots, in the present work, led to the suggestion that, the exogenous application of PAs could indicate their involvements in the maintenance of these elements level to enhance the metabolic processes in which these nutrients are utilized. In this connection, Sharma *et al.* (1997) and El-bassiouny and Bekheta (2001) revealed that, foliar application of putrescine enhanced the uptake of K, Ca, Mg, and P of rice, chickpea and wheat plants and illustrated the role of Mg in some metabolic processes. Moreover, other investigators revealed that the main role of PAs in plants in long term is to maintain cation / cation balance in plant tissue (Mansour and Al-mutawa, 1999). Foliar application of putrescine and IBA increased the uptake and availability of nutrients and its further assimilation for biosynthesis of starch. This might also be the reasons for increase in the starch content in present investigation. El-Bassiouny *et al.* (2008) tested arginine and putrescine (0.0, 0.6, 1.25, 2.5 and 5 mM) at three physiological stages (vegetative, 30 DAS; just before emergence of main spike, 60 DAS and during grain filling, 90 DAS) and reported that foliar application of 2.5 mM arginine and putrescine on wheat significantly increased starch and protein contents.

Yield contributing parameters

Results presented in table 2 showed that both the growth regulators (putrescine and IBA) have a promoting effect on yield contributing characters *viz.,* number of grains cob^{-1}, 100 grain weight, yield plant^{-1} and yield plot^{-1} of maize plant. Increasing concentrations of both the growth regulators gradually increased all the studied yield contributing parameters. The increment in all the parameters significantly recorded maximum with 100 ppm IBA followed by 100 ppm putrescine (T_9), 75 ppm IBA (T_4), 75 ppm putrescine (T_8), 50 ppm putrescine (T_7) and 50 ppm IBA (T_3) when compared with control in a descending manner. Treatments 25 ppm putrescine (T_6) and 25 ppm IBA (T_2) were found at par with control (T_1). Data regarding 100 grain weight showed that foliar application of 100 ppm IBA (T_5) gave significantly higher 100 grain weight when compared with treatment T_1 (control) and remaining treatments under study. 100 grain weight was also significantly increased in treatment receiving 100 ppm putrescine followed by treatment T_4 (75 ppm IBA). But treatments T_8 (75 ppm putrescine), T_7 (50 ppm putrescine), T_3 (50 ppm IBA), T_6 (25 ppm putrescine) and T_2 (25 ppm IBA) were found at par with treatment T_1 (control). Yield plant^{-1} and yield plot^{-1} significantly increased by the treatment T_5 (100 ppm IBA) followed by T_9 (100 ppm putrescine), T_4 (75 ppm IBA), T_8 (75 ppm putrescine), T_7 (50 ppm putrescine) and T_3 (50 ppm IBA) when compared with control (T_1) and remaining treatments. While, treatments T_6 (25 ppm putrescine) and T_2 (25 ppm IBA) were found at par with treatment T_1 (control).

The increase in yield and yield attributes may be due to altering the hormonal balance and improved water relation in plants. PA namely putrescine is involve in stabilization of D_1 and D_2 polypeptides of photosystem second which is the source of electron for NADP+ reduction at photosysytem one (Taiz and Zeiger, 1991). It is also prevented the lipid peroxidation, proteolytic attack and inhibitors of ethylene synthesis through inhibition of ACC synthase and conversion of ACC to ethylene, which is a common phenomenon occurred during senescence. The present results also in line with the report of Kabir *et al.* (1992). They stated that PAs improved the yield and yield attributes in tomato. The increments in yield components due to putrescine treatments may be attributed to the increasing growth rate, in this respect. Davies (1995) reported that polyamines play a critical role in different biological processes, including cell division, growth, somatic embryogenesis, floral initiation, development of flowers and fruits. It is worthy to mention that there is a close relationship between the effect of PAs and the stimulated growth, endogenous phytohormones, photosynthetic output (soluble sugars, polysaccharides and total carbohydrates) and nitrogen constituents. These results might increase the efficiency of solar energy conversion which maximize the growth ability of maize plant and consequently increased its productivity and yield components. Growth regulator IBA is proved to improve effective partitioning and translocation of accumulates from source to sink in the field crops. The plant growth regulators also increases mobilization of reserve food materials to the developing sink through increase in hydrolyzing and oxidizing enzyme activities and lead to increase in yield. IBA increases the ability of cell division in meristematic zones of plant and hence, increases the ability of plant to absorb nutritive material which finally leads to the increase in grain yield (Ghodrat *et al*., 2012). In support of these views, Field experiment was conducted by Mathur and Vyas (2007) to estimate the effect of salicylic acid (1, 2 and 3 mM), sitosterol as well as putrescine concentrations (0.05, 0.10 and 0.15 mM) on pearl millet (*Pennisetum typhoides*). Results showed that application of salicylic acid @ 3 mM and sitosterol or putrescine @ 0.15 mM significantly increased yield and its components i.e.ear length, ear diameter, grain yield plant^{-1}, crop index and 100 grain weight over control.

Table 1. Effect of putrescine and IBA on leaf chlorophyll, nitrogen and phosphorus contents

Treatments	**Chlorophyll content in leaves (mg g^{-1})**				**Nitrogen content in leaves (%)**				**Phosphorus content in leaves (%)**			
	30 DAS	**45 DAS**	**60 DAS**	**75 DAS**	**30 DAS**	**45 DAS**	**60 DAS**	**75 DAS**	**30 DAS**	**45 DAS**	**60 DAS**	**75 DAS**
T_1 (control)	**0.37**	**0.59**	**0.25**	**0.12**	**1.47**	**1.96**	**0.97**	**0.63**	**0.178**	**0.223**	**0.159**	**0.049**
T_2 (25 ppm IBA)	**0.43**	**0.61**	**0.26**	**0.14**	**1.61**	**2.03**	**1.08**	**0.77**	**0.182**	**0.234**	**0.185**	**0.056**
T_3 (50 ppm IBA)	**0.39**	**0.63**	**0.28**	**0.17**	**1.68**	**2.10**	**1.07**	**0.81**	**0.186**	**0.259**	**0.204**	**0.078**
T_4 (75 ppm IBA)	**0.41**	**0.69**	**0.32**	**0.20**	**1.82**	**2.17**	**1.19**	**1.02**	**0.175**	**0.294**	**0.225**	**0.107**
T_5 (100 ppm IBA)	**0.43**	**0.73**	**0.34**	**0.22**	**1.96**	**2.24**	**1.31**	**1.15**	**0.180**	**0.314**	**0.242**	**0.128**
T_6 (25 ppm putrescine)	**0.40**	**0.61**	**0.27**	**0.15**	**1.75**	**2.11**	**1.13**	**0.91**	**0.183**	**0.246**	**0.198**	**0.070**
T_7 (50 ppm putrescine)	**0.38**	**0.65**	**0.29**	**0.18**	**1.75**	**2.15**	**1.19**	**0.91**	**0.178**	**0.267**	**0.208**	**0.090**
T_8 (75 ppm putrescine)	**0.39**	**0.66**	**0.30**	**0.19**	**1.81**	**2.17**	**1.18**	**0.98**	**0.176**	**0.289**	**0.215**	**0.097**
T_9 (100 ppm putrescine)	**0.43**	**0.71**	**0.33**	**0.21**	**1.89**	**2.21**	**1.23**	**1.11**	**0.180**	**0.309**	**0.231**	**0.113**
SE (m) ±	**0.03**	**0.024**	**0.016**	**0.012**	**0.091**	**0.052**	**0.055**	**0.054**	**0.0046**	**0.0159**	**0.0064**	**0.0069**
CD at 5%	**-**	**0.071**	**0.047**	**0.035**	**-**	**0.156**	**0.165**	**0.162**	**-**	**0.0475**	**0.0191**	**0.0205**

Table 2. Effect putrescine and IBA on leaf potassium content, grain protein and starch content, grains cob^{-1}, 100 grain weight, yield plant^{-1} and yield plot^{-1}

Treatments	Leaf potassium content (%)				Protein content (%)	Starch content (%)	Grains cob^{-1}	100 grain weight (g)	Yield plant $^{-1}$ (g)	Yield plot^{-1} (kg)
	30 DAS	45 DAS	60 DAS	75 DAS						
T_1 (control)	0.237	0.245	0.117	0.058	7.77	65.97	354.00	26.18	56.50	2.83
T_2 (25 ppm IBA)	0.245	0.253	0.142	0.072	8.13	66.77	383.33	27.33	69.48	3.48
T_3 (50 ppm IBA)	0.245	0.251	0.175	0.091	8.65	69.71	409.67	27.54	71.64	3.58
T_4 (75 ppm IBA)	0.249	0.251	0.200	0.128	9.68	69.71	421.67	29.56	74.15	3.70
T_5 (100 ppm IBA)	0.242	0.277	0.224	0.152	10.39	71.79	436.67	31.03	76.49	3.82
T_6 (25 ppm putrescine)	0.234	0.257	0.152	0.083	8.16	67.55	385.00	26.72	69.85	3.49
T_7 (50 ppm putrescine)	0.289	0.258	0.180	0.102	8.89	68.99	423.00	28.19	72.35	3.61
T_8 (75 ppm putrescine)	0.239	0.262	0.192	0.113	9.25	69.13	418.33	28.06	73.35	3.66
T_9 (100 ppm putrescine)	0.245	0.268	0.210	0.144	9.89	70.68	425.33	30.22	74.77	3.73
SE (m) ±	0.0110	0.0033	0.0094	0.0057	0.523	1.064	15.64	0.92	3.47	0.17
CD at 5%	-	0.00984	0.0282	0.0169	1.558	3.129	46.14	2.77	10.41	0.50

RFERERENCES

Ahmed, A.H. Hanafy, E. Darwish, S.A. F. Hamoda and M.G. Alobaidy, 2013. Effect of putrescine and humic acid on growth, yield and chemical composition of cotton plants grown under saline soil conditions. Am-Euras. J. Agric. & Environ. Sci. **13** (4): 479-497.

Amin, A. A., F.A. Gharib, H.F. Abouziena and Mona G. Dawood, 2013. Role of indole-3-butyric acid or/and putrescine in improving productivity of Chickpea (*Cicer arientinum* L.) Plants. Pakistan J. Biol. Sci. **16**: 1894-1903.

Davies, P.J. 1995. Plant hormones: Physiology and Biochemistry and Biology Kluwer Academic Publishers, London. pp. 159.

Deotale, R.D., Y.A. Wagh, S.R. Patil and V. B. Kalamkar, 2016. Influence of putrescine and indole-3-butyric acid on chemical and biochemical parameters and yield of soybean. J. Curr. Res.Sci. **8** (3): 27248-27255.

El-Bassiouny, H.M.S., 2004. Increasing thermotolerance of *Pisum sativum* L. plants through application of putrescine and stigmasterol. Egypt. J. Biotech. **18**: 350-356.

El-Bassiouny, H.M.S. and M.A. Bakheta, 2005. Effect of salt stress on relative water content, lipid peroxidation, polyamines, amino acids and ethylene of two wheat cultivars. Int. J. Agric. Boil. **7**: 363-368.

El–Bassiouny, H.M.S., H.A. Mostafa, S. A. El–Khawas, R. A.Hassanein, S.I. Khalil and A. A. Abd El–Monem, 2008. Physiological responses of wheat plant to foliar treatments with arginine or putrescine, Aust.J. Basic and Appl. Sci. **2**(4): 1390-1403.

Gardner, F.P., R.B. Pearce and R.L. Mitchell, 1988. In: Physiology of Crop Giants. Iowa State University Press, Amen, Iowa, pp. 187-208.

Ghodrat, V., M. J. Rousta and M. S. Tadaion, 2012. Effect of priming with indole-butyric acid (IBA) on germination and growth of wheat under saline conditions. IJACS. **4**(6):289-292.

Gonzalez-Aguilar, G.A., L. Zacarias, M. Mulas and M.T. Lafuente, 1997. Temperature and duration of water dips influence chilling injury, decay and polyamine content in Fortune mandarins. Postharvest Biol. Technol. **12**: 61-69.

Jackson, M. L. 1967. Soil Chemical analysis, Printice Hall of India Pvt. Ltd. New Delhi, pp. 25-28.

Kabir. J. Maiti, T.K. and Parth Sarthy, 1992. Polyamine, ethylene and other physic-chemical parameters in tomat (*Lycopersicon esculentum*) fruits. Sci. Cult., **58:** 159.

Kuznetsov, V.V. and N.I. Shevyakova, 1997. Stress responses of tobacco cells to high temperature and salinity, proline accumulation and phosphorylation of polypeptides. Physiol. Planta, **100**: 320-326.

Mansour, M.M.F. and M.M. Al-Mutawa, 1999. Stabilization of plasma membrane by polyamines against salt stress. Cytobios, pp. **7**-17.

Mathur, Nishi and Anil Vyas, 2007. Physiological effect of some bioregulators on vegetative growth, yield and chemical constituents of pearl millet (*Pennisetum typhoides* (Burm) Stapf. and Hubb). Int. J. Agri.Res. **2** (3): 238-245.

Panse,V.G. and P.V. Sukhamte, 1954. Statistical method for agriculture works, ICAR, New Delhi, pp. 107-109.

Sharma, M., B. Kumar and D.M. Pandey, 1997, 1997. Effect of pre flowering foliar application of putrescine on ion composition of seeds of chick pea (*Cicer arietinum* L. cv. H-82-2) raised under saline conditions. Ann. Agri. Bio. Res. **22** : 111-113

Shirlaw, D.W. and D.W. Gilchrist, 1967. A practical course in agriculture chemistry. pp. 122-130.Pergaman Pub. London.

Somichi, Y., S. Y. Doughlus and A. P. James, 1972. Laboratory manual. Physiological studies in rice analysis for total nitrogen (organic N) in plant tissue. The inter. Res. Instti. Los Banos, Languna, Phillipine : II.

Taiz, L. and E. Zeiger, 1991. Plant Physiology. Benjamin/Cummings Publ. Company Inc. California.

Yamaguchi, K., Y. Takahashi, T. Berberich, A. Imai, A. Miyazaki, T. Takahashi, A. Michael and T. Kusano, 2006. The polyamine spermine protects against high salt stress in Arbidopsis thaliana. FEBS Lett, **580**: 783-6788.

Zhao, F., C-P Song, J He, H Zhu, 2007. Ployamines improve K^+ / Na^+ homeostasis in barley seedlings by regulating root ion channel activities. Plant Physiol. **145**: 1061-1072.

Rec. on 15.05.2016 & Acc. on 10.06.2017