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Effect of foliar application of Gibberellic acid on growth, yield, physiological and biochemical characteristics of Mung bean (*Vigna radiata* L.) under salt stress

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Abstract
The pot experiment was conducted at field experimentation center, Department of Biological sciences, Sam Higginbottom University of Agriculture, Technology & Sciences, Uttar Pradesh during summer season 2018 with Mungbean varieties Samrat and Jagrati. Effect of Gibberellic acid under Salt stress condition on Mung bean with seven treatments and three replications were laid out in complete randomized Design. This research was undertaken to assess the impact of 200 ppm and 100 ppm of Gibberellic acid (GA) on alleviation of oxidative, ionic and osmotic stress of different concentration levels of salt stress (0, 100, 150 mM Nacl, respectively). Application of GA_3 significantly increased leaf area, dry mass, leaf Chl. content, stomatal conductance and photosynthesis rate compared to salt alone. Under saline conditions, seed germination has been improved by application of GA_3 and in this experiment, growth and grain yield of wheat were decreased with increasing salinity levels, but increased relatively by seed treatment with GA_3 (Kumar and Singh 1996). In addition, GA_3 interacts with other hormones to regulate various metabolic processes in the plants.

Keywords: mung bean, NaCl, gibberellic acid, foliar spray

Introduction

Mung bean (*Vigna radiate* L.), alternatively known as the Moong bean, Monggo, Green gram, or mungis a plant species in the legume family. It belongs to the genus vigna. It is said to have originated from India and must have been derived from var. *sublobata* which occurs wild throughout India and Burma. In India Mung bean is cultivated in area of 3.38 million hectares with an average productivity of 4.7 qt / ha and production of 1.61 million tonnes. In Uttr Pradesh green gram is cultivated in an area of 0.72 lakh hectares with an average productivity of 5.5 q/ ha and production of 0.40 lakh tonnes (IIPR, Annual Report, 2015 – 2016). Mung bean has multipurpose uses as it is an excellent source of high quality protein (25%) having high digestibility. It is a good source of Riboflavin, Thiamine and Vitamin C (Ascorbic acid). It is also used as green manure crop and feed for cattle.

Salinity stress is one of the most atrocious environmental factors restricting the productivity of Mung bean in arid and semiarid regions. Salt stress is a major abiotic stress that causes detrimental effect on plant growth and productivity (Syeed *et al.*, 2011) [13]. Salt toxicity inhibits the plant growth and development and can also lead to physiological water limitation due to severe salt deposition in rhizosphere causing a low osmotic potential and ion imbalance (Zhu, 2002, Munns & Tester, 2008) [16, 10].

Gibberellic acid (also called Gibberellin A3, GA, and GA_3) is a hormone found in plants and fungi. Its chemical formula is $C_{19}H_{22}O_6$. Gibberellins (GA) influence seed germination, stem elongation, leaf expansion and reproductive development. Application of GA_3 also counteract the adverse effects of NaCl salinity on relative water content, electrolyte leakage and Chl content. Exogenous GA also increased sugar and soluble protein content, while Chl content remained unchanged.

The aim of present study is to investigate the effect of foliar application of Gibberellic acid on growth, yield, physiological and biochemical characteristics of Mung bean *(Vigna radiata* L.) under salt stress.

Materials and Methods

The present investigation entitled "Effect of foliar application of Gibberellic acid on growth, yield, physiological and biochemical characteristics of Mung bean (*Vigna radiata* L.) under salt stress" was carried out at Department of Biological Sciences, Sam Higginbottom University of Agriculture, Technology and Science Allahabad (U.P). The experiment was laid out in Completely Randomized Design comprising of seven treatments with two varieties, Samrat and Jagrati of Mung bean each replicated thrice. The seeds of Mung bean varieties were sown separately on1stMarch in the pots. The first and second observation was taken at 30 and 60 days after sowing (DAS) that was on 31th March and 30thApril 2018 respectively, the observations were recorded on growth, physiological and biochemical parameters. At 90 DAS that was on 30th May 2018, yield parameters were taken. The manures and fertilizers and the recommended dose of fertilizers (RDF- 60kg N + 30 kg P_2O_5 + 30 kg K_2O ha^{-1}) was applied to the pot before sowing in all pots uniformly before sowing. All the fertilizers were applied in a single dose at the time of sowing in the pots as basal dose. Salt with two different concentration were incorporated in the pots before sowing according to the treatments and the foliar application of two different concentration of Gibberellic acid were done at 15 and 25 DAS according to the treatments. Seven treatments were included in the trial were viz; T_0 (Control), T_1 (NaCl 100mM), T_2 (NaCl 150mM), T_3 (Gibberellic acid 100 ppm + NaCl 100 mM), T_4 (Gibberellic acid 100 ppm + NaCl 150 mM), T_5 (Gibberellic acid 200 ppm + NaCl 100 mM), T_6 (Gibberellic acid 200 ppm + NaCl 150 mM).

Results and Discussion

The results of the experiment has been presented under the following heading.

Growth parameters

The plant hight was found significantly high in T_5 (Gibberellic acid 200 ppm + NaCl 100 mM) (22.74) and low in T_3 (Gibberellic acid 100 ppm + NaCl 100 mM) (18.28) as compare to T_0 (control) (23.78 cm) after 30 DAS in samrat variety, similarly the same result was in jagrati high in T_5 (Gibberellic acid 200 ppm + NaCl 100 mM) (24.08cm.) and low in T_4 (Gibberellic acid 100 ppm + NaCl 150 mM) (18.78cm.) as compare to T_0 (control) (24.8 cm). after 60 DAS the plant hight was found significantly high in T_5 (Gibberellic acid 200 ppm + NaCl 100 mM) (36.76cm.) and low in T_6 (Gibberellic acid 200 ppm + NaCl 150 mM) (29.08cm.) as compare to T_0 (control) (38.02 cm.) in samrat variety, similarly the same result was in jagrati high in T_5 (Gibberellic acid 200 ppm + NaCl 100 mM) (37.41cm.) and low in T_6 (Gibberellic acid 200 ppm + NaCl 150 mM) (33.65cm.) as compare to T_0 (control) (39.07 cm).

The number of leaves was found significantly high in T_5 (Gibberellic acid 200 ppm + NaCl 100 mM) (11.7) and low in T_6 (Gibberellic acid 200 ppm+ NaCl 150 mM) (8.57) as compare to T_0 (control) (12.5) after 30 DAS in samrat variety, similarly the same result was in jagrati high in T_5 (Gibberellic acid 200 ppm + NaCl 100 mM) (11.6) and low in T_6 (Gibberellic acid 200 ppm + NaCl 150 mM) (8.66) as compare to T_0 (control) (12.9cm.). after 60 DAS the number of leaves was found significantly high in T_5 (Gibberellic acid 200 ppm + NaCl 100 mM) (20.8) and low in T_6 (Gibberellic acid 200 ppm + NaCl 150 mM) (16.63) as compare to T_0 (control) (21.8) in samrat variety, similarly the same result was in jagrati high in T_5 (Gibberellic acid 200 ppm + NaCl 100 mM) (20.99) and low in T_6 (Gibberellic acid 200 ppm + NaCl 150 mM) (17.93) as compare to T_0 (control) (22.38).

Vegetative growth {*viz*., plant height (cm) and number of leaves} in Mung bean plants were lowered with the increase in the concentration of salt treatment as compared to normal conditions. However, exogenous Gibberellic acid applications increased these parameters as compared to plant which treated with only salt. The experimental results are clearly indicating that the variety Jagriti had shown better resistance as compare to the variety Samrat. Both the varieties had shown good result in T_5 (Gibberellic acid 200 ppm + NaCl 100 mm) nearly as T_0 (control). As compare to Gibberellic acid (GA) @ 200 ppm the application of GA @ 100 ppm on plants under two different salt stresses (100 and 150 mM) gave the higher values for these parameters. Salt stress caused low intra-cellular water potential and water scarcity around the root zone due to which roots failed to absorb sufficient water and nutrients for adequate plant growth (Nirmala *et al*. 2015) [12]. Gibberellic acid on salt treated plants induces salt tolerance in plant by reducing ionic and osmotic stress and inducing plant growth. Similar findings have been recorded by Tufail *et al*., (2013) [15] and Akhtar *et al*., (2013) [1].

Yield parameters

The number of pods per plant was found significantly high in T_5 (Gibberellic acid 200 ppm + NaCl 100 mM) (14.5) and low in T_6 (Gibberellic acid 200 ppm+ NaCl 150 mM) (11.1) as compare to T_0 (control) (16.6) in samrat variety similarly the same result was in jagrati T_5 (Gibberellic acid 200 ppm + NaCl 100 mM) (15.1) high and low in T_6 (Gibberellic acid 200 ppm+ NaCl 150 mM) (11.1) as compare to T_0 (control) (17).

Seed yield per plant was found significantly high in T_5 (Gibberellic acid 200 ppm + NaCl 100 mM) (8.52) and low in T_6 (Gibberellic acid 200 ppm+ NaCl 150 mM) (5.67) as compare to T_0 (control) (8.9) in samrat variety similarly the same result was in jagrati T_5 (Gibberellic acid 200 ppm + NaCl 100 mM) (8.31) and low in T_6 (Gibberellic acid 200 ppm+ NaCl 150 mM) (5.69) as compare to T_0 (control) (8.48).

Yield parameter {*viz*., number of pods per plant and seed yield per plant (g)} in Mung bean plants were lowered with the increase in the concentration of salt treatment as compared to normal conditions. However, exogenous Gibberellic acid applications increased these parameters as compared to plant which treated with only salt. The experimental results are clearly indicating that the variety Jagriti had shown better resistance as compare to the variety Samrat. Both the varieties had shown good result in T_5 (Gibberellic acid 200 ppm + NaCl 100 mM) nearly as T_0 (control). As compare to Gibberellic acid (GA) @ 200 ppm the application of GA @ 100 ppm on plants under two different salt stresses (100 and 150 mM) gave the higher values for these parameters. Exogenous application of Gibberellic acid prevented the lowering of IAA and cytokinin levels in salinity stressed wheat plants resulting in the better of cell division in root apical meristem, thereby increasing yield and productivity of plants (Hayat *et al.*, 2010) [4]. Application of Gibberellic acid in salt treated Mung bean plants were beneficial which may be due to its influence on translocation of CO_2 assimilation into the seeds and enhancement of photosynthetic rate. Similar findings were reported by Khan *et al*., (2003) [8] and Karlidag *et al*., (2009) [7].

Physiological parameters

The relative water content was found significantly high in T5 (Gibberellic acid 200 ppm + NaCl 100 mM) (71.08) and low in T_6 (Gibberellic acid 200 ppm+ NaCl 150 mM) (69.45) as compare to T_0 (control) (72.49) in samrat variety similarly the same reslt was in jagrati T_5 (Gibberellic acid 200 ppm + NaCl 100 mM) (71.4) high and low in T_6 (Gibberellic acid 200 ppm+ NaCl 150 mM) (70.1) as compare to T_0 (control) (73.1).

Total chlorophyll content was found significantly high in T_5 (Gibberellic acid 200 ppm + NaCl 100 mM) (1.24) and low in T_6 (Gibberellic acid 200 ppm + NaCl 150 mM) (1.08) as compare to T_0 (control) (1.30) in samrat variety similarly the same result was in jagrati T_5 (Gibberellic acid 200 ppm + NaCl 100 mM) (1.25) high and low in T_6 (Gibberellic acid 200 ppm + NaCl 150 mM) (1.11) as compare to T_0 (control) (1.31).

Physiological parameters {*viz*., relative water content (%) and total chlorophyll content (mg/g FW)} in Mung bean plants were lowered with the increase in the concentration of salt treatment as compared to normal conditions. However, exogenous Gibberellic acid applications increased these parameters as compared to plant which treated with only salt. The experimental results are clearly indicating that the variety Jagrati had shown better resistance as compare to the variety Samrat. Both the varieties had shown good result in T_5 (Gibberellic acid 200 ppm + NaCl 100 mm) nearly as T_0 (control). As compare to Gibberellic acid (GA) @ 200 ppm the application of GA @ 100 ppm on plants under two different salt stresses (100 and 150 mM) gave the higher values for these parameters. The chlorophyll content of soybean leaves was increased due to application of Gibberellic acid (Khan *et al*., 2003) [8]. Foliar application of GA may increases the leaf diffusive resistance and lower transpiration rates and protects relative water content. Similarly it had been reported by Szepesi *et al*., (2005) [14].

Biochemical Parameter

The proline content was found significantly high in T_5 (Gibberellic acid 200 ppm + NaCl 100 mM) (0.88) and low in T_4(Gibberellic acid 100 ppm + NaCl 100 mM) (0.75) as compare to T_0 (control) (0.68) in samrat variety, similarly the same result was in jagrati T_5 (Gibberellic acid 200 ppm + NaCl 100 mM) (0.85) high and low in T_4(Gibberellic acid 100 ppm + NaCl 150 mM) (0.8) as compare to T_0 (control) (0.71).

The protein content was significantly high in T_5 (Gibberellic acid 200 ppm + NaCl 100 mM) (24.35) and low in T_4 (Gibberellic acid 100 ppm + NaCl 150 mM) (22.00) as compare to T_0 (control) (24.59) in samrat variety, similarly the same result was in jagrati T_5 (Gibberellic acid 200 ppm + NaCl 100 mM) (24.01) high and low in T_3 (Gibberellic acid 100 ppm + NaCl 100 mM) (22.39) as compare to T_0 (control) (25.23).

Biochemical parameter {*viz*., Proline content (mg/g FW) and Protein content (%)} in Mung bean plants were lowered with the increase in the concentration of salt treatment as compared to normal conditions. However, exogenous Gibberellic acid applications increased these parameters as compared to plant which treated with only salt except in Proline and Protein. The experimental results are clearly indicating that both the varieties had shown good result in T_5 (Gibberellic acid 200 ppm + NaCl 100 mM) nearly as T_0 (control). As compare to Gibberellic acid (GA) @ 200 ppm the application of GA @ 100 ppm on plants under two different salt stresses (100 and 150 mM) gave the higher values for these parameters except Proline was found highest in T_2 (NaCl 150mM) and lowest in T_0 (Control). Similar results were found by Mittler *et al*., (2004) [9], Hussein *et al*. (2007) [5] and Jaiswal *et al*., (2014) [6].

Table 1: Effect of salt stress and Gibberellic acid on plant height (cm) and number of leaves in Mung bean varieties

Treatment symbol	Treatment combinations	Plant height (cm)				Number of leaves per plant			
		Samrat		Jagrati		Samrat		Jagrati	
		30 DAS	60 DAS	30 DAS	60 DAS	30 DAS	60 DAS	30 DAS	60 DAS
T_0	Control	23.78	38.02	24.8	39.07	12.5	21.8	12.9	22.38
T_1	NaCl 100mM	16.73	28.63	17.86	30.53	8.87	15.93	9.24	16.5
T_2	NaCl 150mM	16.72	27.45	16.56	28.58	7.63	14.32	7.99	13.71
T_3	Gibberellic acid 100 ppm + NaCl 100 mM	18.28	35.06	18.79	35.56	8.57	17.52	8.66	18.38
T_4	Gibberellic acid 100 ppm + NaCl 150 mM	19.47	32.68	18.78	34.97	9.63	19.43	10.6	19.38
T_5	Gibberellic acid 200 ppm + NaCl 100 mM	22.74	36.76	24.08	37.41	11.7	20.8	11.6	20.99
T_6	Gibberellic acid 200 ppm + NaCl 150 mM	18.97	29.08	19.03	33.65	7.88	16.63	7.63	17.93
Mean		19.53	32.53	19.99	34.25	9.54	18.06	9.81	18.47
TAB. F 5%		S	S	S	S	S	S	S	S
S.Em		0.324	0.316	0.365	0.540	0.283	0.435	0.317	0.256
C.D at 5%		0.991	0.967	1.118	1.654	0.866	1.332	0.970	0.784

Table 2: Effect of salt stress and Gibberellic acid on number of pods per plant and seed yieldper plant (g) in Mung bean varieties

Treatment symbol	Treatment combinations	Number of pods per plant		Seed yield per plant (g)	
		Samrat	Jagrati	Samrat	Jagrati
T_0	Control	16.6	17	8.9	8.31
T_1	NaCl 100mM	8.49	8.47	5.34	5.47
T_2	NaCl 150mM	6.79	7.08	4.67	5.41
T_3	Gibberellic acid 100 ppm + NaCl 100 mM	11.2	11.3	6.57	6.53
T_4	Gibberellic acid 100 ppm + NaCl 150 mM	11.4	12	7.5	7.6
T_5	Gibberellic acid 200 ppm + NaCl 100 mM	14.5	15.1	8.52	8.48
T_6	Gibberellic acid 200 ppm + NaCl 150 mM	11.1	11.1	5.67	5.69
Mean	11.5		11.7	6.75	6.79
TAB. F 5%	S		S	S	S
S.E(m)	3.460		0.320	0.160	0.143
C.D at 5%	1.060		0.979	0.491	0.437

Table 3: Effect of salt stress and Gibberellic acid on relative water content (%) and total chlorophyll content (mg/g FW) in Mung bean varieties

Treatment symbol	Treatment combinations	Relative water content (%)		Total chlorophyll (mg/g FW)	
		Samrat	Jagrati	Samrat	Jagrati
T_0	Control	72.49	73.1	1.30	1.31
T_1	NaCl 100mM	69.02	68.7	0.97	1.02
T_2	NaCl 150mM	68.01	67.6	0.88	0.89
T_3	Gibberellic acid 100 ppm + NaCl 100 mM	69.81	70.3	1.16	1.17
T_4	Gibberellic acid 100 ppm + NaCl 150 mM	70.49	70.7	1.18	1.19
T_5	Gibberellic acid 200 ppm + NaCl 100 mM	71.08	71.4	1.24	1.25
T_6	Gibberellic acid 200 ppm + NaCl 150 mM	69.45	70.1	1.08	1.11
Mean	70.05		70.3	1.11	1.13
TAB. F 5%	S		S	S	S
S.Em	0.356		0.457	0.007	0.014
C.D at 5%	1.089		1.401	0.020	0.044

Table 4: Effect of salt stress and Gibberellic acid on Proline and Protein content in Mung bean varieties

Treatment symbol	Treatment combinations	Proline content (mg/g FW)		Protein content (%)	
		Samrat	Jagrati	Samrat	Jagrati
T_0	Control	0.68	0.71	24.59	25.23
T_1	NaCl 100mM	0.76	0.77	22.41	22.66
T_2	NaCl 150mM	0.69	0.78	22.04	22.3
T_3	Gibberellic acid 100 ppm + NaCl 100 mM	0.8	0.82	24.01	22.39
T_4	Gibberellic acid 100 ppm + NaCl 150 mM	0.75	0.8	22	22.72
T_5	Gibberellic acid 200 ppm + NaCl 100 mM	0.88	0.85	24.35	23.29
T_6	Gibberellic acid 200 ppm + NaCl 150 mM	0.77	0.82	23.37	24.01
Mean	0.76		0.79	23.25	23.23
TAB. F 5%	S		S	S	S
S.Em	0.032		0.023	0.462	0.512
C.D at 5%	0.098		0.071	1.414	1.568

Conclusion

From the present investigation it was concluded that the salt stress show the effect deleterious on growth and yield of Mung bean crops. Among the treatments, T_5 (Gibberellic acid 200 ppm + NaCl 100 mM) was found to be most favouring to growth, yield, physiological and biochemical parameters against the salt stress in both the varieties. Out of two concentration of Gibberellic acid i.e. 100 ppm and 200 ppm, favours more positively towards the alleviation of different concentration of NaCl stress in Mung bean plants. As compare to the variety Samrat, Jagrati showed better production of growth, yield, physiological and biochemical parameters under salt stress.

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