Effect of micro-nutrients and artificial acid rain on growth parameters of Mungbean [*Vigna radiata* (L.) Wilczek]

Mariam Jallani[1], Muhammad Mubashar Zafar[2*], Muhammad Saqib Mushtaq[3], Muhammad Tahir[2], Zafar Hussain[2], Hafiz Saad Bin Mustafa[4]

[1]Department of Botany, University of Agriculture, Faisalabad, Pakistan
[2]Department of PB & G, University of Agriculture, Faisalabad Pakistan.
[3]Department of Plant Pathology, University of Agriculture, Faisalabad, Pakistan.
[4]Directorate of Oilseeds, Ayub Agricultural Research Institute, Faisalabad, Pakistan.
*Corresponding author's email: m.mubasharzafar@gmail.com

Abstract: A pot experiment was conducted to investigate the effect of artificial acid rain and micronutrients (alone and in combination) on the morphological, physiological and yield attributes of Mungbean [*Vigna radiata* (L.) wilczek]. The experiment was performed in the Old Botanical Garden, University of Agriculture, Faisalabad (Pakistan). Two lines of Mungbean i.e., NM 2006 and NM 2011 were subjected to six treatments including control, each with four replicates. Treatments for acid rain and micronutrients were applied in the form of foliar spray after 20 days of germination. The experiment was laid out in completely randomized design. The data for various morphological, physiological and yield parameters were recorded and examined statistically. The exposure of mungbean [*Vigna radiata* (L.) wilczek] to simulated acid rain negatively affected growth and yield parameters while micronutrients solution in combination with acid rain ameliorated the adverse effect of acid rain. It was also observed that both the varieties responded non-significantly to acid rain treatments.

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1. Introduction:

Air pollution has become a severe environmental problem due to industrial development especially in urban areas (Ling *et al.,* 2010). The oxides of sulphur, nitrogen, and carbon that are emitted by the industries, burning of fossil fuel and smoke of automobiles are responsible for the formation of acid rain. These poisonous gases which after mixing with rain, fog, and snow fall to ground as acid rain and prove highly damaging for biota (plants and animals) and buildings (Bouwman *et al*., 2002). Acid rain is the major source of polluting the aquatic and terrestrial lives (Odiyi and Bamidele, 2014).

Many experiments have been performed to determine the adverse effect of acid rain on cultivated crops which showed reduced growth rate and chlorophyll contents of plants (Gabara *et al*., 2003). It enhanced the level of toxic metals and inhibited concentration of essential nutrients in the soil (Tomlison and G. H. 2003). It diffuses into the leaves by damaging the waxy layer of leaves and stomatal structure thus affects gas exchange, transpiration rate and photosynthetic rate (Sant Anna-Santos *et al*., 2006). Some plant species are greatly sensitive to acid rain and some show tolerance. The effect on plants that show sensitivity can be controlled by the micronutrient application (Liu *et al*., 2011).

The foliar application of simulated acid rain reduced the nitrogen contents of leaves (Memon *et al.,* 1996). Shri and Naresh (2000) observed that due to acid rain overall growth rate and yield decreased in *Capsicum annum* L. Hussain *et al.,* (2010) applied the foliar spray of micronutrients having (Zinc, Iron, Copper, Boron and Manganese) on wheat and noticed the positive effect in growth rate. Ibrahim *et al.,* (2009) found the significant increase in growth and yield with application of micronutrients.

Mungbean [*Vigna radiate* (L.) Wilczek] belongs to family Fabaceae. It is used as food and green manure for increasing the fertility of soil (Ghanem and Abbas, 2009). The total area of mungbean cultivation was 140,800 hectares in Pakistan and the annual production was about 93,000 tons during 2013 (Anonymous 2013). Faisalabad is an industrial city and these industries (textile, chemical, pharmaceuticals, and leather) release a high quantity of many air pollutants which are responsible for the formation of acid rain when reacting with wet depositions. The purpose of this study was to determine the effect of simulated acid rain and micronutrients on Mungbean [*Vigna radiate* (L.) Wilczek].

2. Materials and methods

The experiment was performed in the Old Botanical Garden, University of Agriculture, Faisalabad (Pakistan). The seeds of 2 Mungbean lines NM 2006 and NM 2011 were obtained from Ayub Agricultural Research Institute (AARI) Faisalabad (Pakistan). The seeds were sown in plastic pots having 10 kg of soil and plant manure at a ratio 3:1following the Completely Randomized Design (CRD). After the germination, the plants were thinned to six plants in each pot. Simulated acid rain (SAR) of H_2SO_4 at pH 3 and pH 3.5 alone and in mixture with growth tonic solutions were sprinkled once 20 days after germination of the crop. The data for the relative increase per week for three consecutive intervals were recorded for various growth attributes and converted to per day growth rate. Samples were oven dried at 75^oC to get a constant dry weight. The yield parameters were taken after the crop matured. The data were analyzed through the statistical software COSTAT.

3. Result and discussion

The growth of both lines on Mungbean was harmfully affected by the application of artificial acid rain but the application of micronutrients (Super Habib) proved beneficial. The shoot length of NM-2011 plants got reduced up to 17.24% (T2 with pH 3.5) and 20.69% (T3 with pH 3.0) by artificial acid rain during 1st harvest as compared to control (Table 1). The treatments comprising the acid rain along with micronutrients (Super Habib) showed the reduction of 3.45% in T_4(Super Habib and acid rain at pH 3.5) and 6.89% in T_5 (Super Habib and acid rain at pH 3.0) respectively in shoot length than control. A similar pattern was seen in shoot length during 2nd harvest interval for both lines.

During the 1st and 2nd harvest, more adverse effect of artificial acid rain was observed in root growth of the NM-2011 as compared to NM-2006. The combination of H_2SO_4 and Super Habib had significant positive effect on growth rate and joint application of acid rain and growth promoter reduced the negative effect of H_2SO_4 to some extent and showed positive results in both lines of Mungbean (Table 2).

The more negative effect of foliar application of acid rain T2 and T3 was noticed during the 2nd harvest as compared to first one. The plant dry weight got reduced by 13.95% and 16.28% in NM-2011 and 25% and 31.25% in NM-2006 respectively (Table 3). In T1 the application of micronutrients enhanced the dry weight of both lines as compared to control T0. The combined effect of micronutrients and acid rain T4 and T5 the effect of acid rain was counteracted by micronutrient by 4.65% and 6.97% as compared to T2 and T3 in NM-2011 respectively. NM-2011 showed more tolerance as compared to NM-2006.

The application of micronutrients (T1) indicated the positive increase in total chlorophyll contents by 16.50% as compared to control however the application of acid rain in treatments T_2 and T_3 significantly decreased the chlorophyll contents up to 12.99 % and 20.49 % respectively as compared to control. The combined application of artificial acid rain along with micronutrients (Super Habib) in treatments T_4 and T_5 decreased chlorophyll contents up to 0.99% and 5.47% respectively in NM-2011.

Table 1. Growth in shoot length (cm) of two lines of mungbean (NM-2011 and NM-2006) in response to application of micronutrients and artificial acid rain

	NM-2011						NM-2006					
	T0	T1	T2	T3	T4	T5	T0	T1	T2	T3	T4	T5
Growth per day in 1st harvest	0.029	0.04	0.024	0.023	0.028	0.027	0.024	0.036	0.02	0.019	0.023	0.022
% difference		37.93	-17.24	-20.69	-3.45	-6.89		50	-16.67	-20.84	-4.16	-8.34
Growth per day in 2nd harvest	0.021	0.036	0.017	0.016	0.02	0.019	0.02	0.033	0.015	0.014	0.018	0.017
% difference		71.43	-19.05	-23.81	-4.76	-9.52		65	-25	-30	-10	-15

Table 2. Growth in root length (cm) of two lines of mungbean (NM-2011 and NM-2006) in response to application of micromutrients and artificial acid rain

	NM-2011						NM-2006					
	T0	T1	T2	T3	T4	T5	T0	T1	T2	T3	T4	T5
Growth per day in 1st harvest	0.238	0.544	0.214	0.208	0.223	0.217	0.218	0.406	0.2	0.194	0.211	0.204
% difference		128.57	-10.08	-12.6	-6.3	-8.82		86.24	-8.26	-11.01	-3.21	-6.42
Growth per day in 2nd harvest	0.181	0.456	0.16	0.157	0.173	0.17	0.268	0.451	0.233	0.22	0.248	0.238
% difference		151.93	-11.6	-13.26	-4.42	-6.07		68.28	-13.06	-17.91	-7.462	-11.19

Table 3. Growth in shoot dry weight (g) of two lines of mungbean (NM-2011 and NM-2006) in response to application of micromutrients and artificial acid rain

	NM-2011						NM-2006					
	T0	T1	T2	T3	T4	T5	T0	T1	T2	T3	T4	T5
Growth per day in 1st harvest	0.046	0.071	0.04	0.039	0.044	0.043	0.037	0.052	0.03	0.028	0.036	0.034
% difference		54.35	-13.04	-15.22	-4.35	-6.52		40.54	-18.92	-24.32	-2.7	-8.11
Growth per day in 2nd harvest	0.043	0.067	0.037	0.036	0.041	0.04	0.032	0.044	0.024	0.022	0.03	0.028
% difference		55.81	-13.95	-16.28	-4.65	-6.97		37.5	-25	-31.25	-6.25	-12.5

T0=control; T1=Micronutrient (Super Habib); T2=H2SO4 pH3.5; T3=H2SO4 pH3.0; T4=Micronutrient+H2SO4 pH3.5; T5=Micronutrient+H2SO4 pH3.0

In the physiological features, the maximum reduction of CO_2 assimilation rate (*A*), transpiration rate (E), water use efficiency (WUE), stomatal conduction (gs), and sub stomatal concentration (Ci) was calculated in acid rain treatments T_3 followed by T_2 as compared to control. In comparison to control the highest increase in physiological parameters was noted in Super Habib treatment T_1. In combined treatments $T_4$and T_5 the CO_2 assimilation rate (*A*), transpiration rate (E), water use efficiency (WUE), stomatal conduction (gs), and sub stomatal concentration (Ci) got reduced respectively.

Yield parameters of both lines were much affected by the application of acid rain. This deteriorating effect was observed in all yield parameters. Spray of H_2SO_4 at pH 3.5 (T2) and pH 3.0 (T3) showed a strong negative effect on pods length, pods per plant, seeds per pod and 100-seed weight in both lines of mungbean (NM-2011 and NM-2006). Treatments of plants with growth promoter (Super Habib) enhanced all these parameters. The negative effect of acid rain was reduced to some extend in treatments (T4) and (T5) when micronutrients were applied along with acid spray. The maximum reduction of 85.31% in yield/plant was calculated in acid rain treatments T_3 followed by 71.33% in T_2 as compared to control. In combined treatments T_4 and T_5 Super Habib reduced the yield/plant by 19.58% and 52.45% respectively than control and thus the application of micronutrients considerably reduced the harmful effects of acid rain.

The foliar application of simulated acid rain caused negative effect on understudy two lines of mungbean and SAR decreased both lines of mungbean. Resembling results have already been reported in peas (*Pisum sativum* L.) and sunflower (*Hallianthus annuus* L.) (Asghar *et al.,* 2013; and Khalid *et al., 2013*). Verma *et al.,* (2010) also recorded reduction in growth parameters of various vegetables. Acid rain decreased the chlorophyll contents and also affected the gas exchange parameters. In the wheat reduction of chlorophyll contents observed due to SAR (Shamee *et al*., 2010). Quing *et al.,* (2010) reported reduction in gas exchange characteristics and chlorophyll contents in *Castanopsi ssclerophylla*. Acid rain stress reduced yield in both lines of mungbean in present study.

The application of micronutrients during this study is used for opposing the effects of acid rain. Zinc, iron, copper and manganese are present in Super Habib. Zinc, iron, copper and manganese are used for balancing their deficiency in to the plants and as growth promoter (Kaya *et al*., 2005). The application of different fertilizers like potassium, nitrogen and phosphorus enhance the number of leaves, area of leaf, plant height, yield and growth rate (Law-Ogbomo, 2009). The foliar application of micronutrients like zinc, iron, manganese and magnesium enhance the plant growth, yield and protein in seeds of mungbean (Kassab and O.M, 2005). Similar results were obtained by Mawgoud *et al*. (2011), Khalifa *et al*. (2011) and Bashir *et al*. (2013) that improvement in plant height by the application of micronutrients in green beans. Ghasemian *et al*. (2010) resulted the effects of micro-nutrients significantly increase the achene yield. Moosavi (2012) also reported increase in grain yield of maize under the effect of different levels of nitrogen fertilizer.

It is possible that negative effect of acid rain can be reduced by the application of micronutrients either in soil or foliar spray. Micronutrients have essential components of biomolecules for DNA, RNS, synthesis of proteins, carbohydrates, alcohols and fats, but micronutrients are requires in small quantity. The unequall absorption of micronutrients from the soil has been attributed to significant yield losses in different edible crop (Malakouti, 2008; Habib, 2009; Imtiaz *et al*., 2010). During the study application of artificial acid rain considerably affected the availability of nutrients but the application of macro and micronutrients (Super Habib) caused positive effects in both lines of mungbean by improving the adverse effects of acid rain. More noticeable effect of acid rain was seen on growth of MN-2006 which proved less tolerant against acid stress.

4. Conclusions

During this study of artificial acid rain considerably reduced the growth of both mungbean lines, while the combined application of macro and micronutrients (Super Habib) along with SAR reduced

the adverse effects of acid rain in both lines and gave better growth as compared to application of acid rain alone. Yield was also severely affected by the acid rain; however, growth tonic counteracted the adverse effects of acid rain. The results showed that MN-2011 proved to be more tolerant hybrid towards acid rain as compared to MN-2006. On the basis of the present study it is recommended that growth tonics should be used in agricultural practices to overcome the hazardous effects of air pollution.

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