Archives of Phytopathology and Plant Protection
Vol. 44, No. 14, August 2011, 1343–1346

Taylor & Francis
Taylor & Francis Group

Phytotoxic effect of simulated acid rain on black gram

Abrar Ahmad Mustabeen* and Iram Khan

Department of Botany, Aligarh Muslim University, Aligarh-202002, India

(*Received 10 May 2010; final version received 11 May 2011*)

A pot experiment was carried out to observe the response of black gram (*Phaseolus mungo* L.) to acid rain. The plants were exposed to different concentrations of simulated acid rain (pH 5, 4, 3). The symptoms such as injuries and necrotic spots appeared on the leaves. Plant growth, yield and photosynthetic pigments were suppressed greatly in all the treatments. The suppressions were directly proportional to the exposure levels of acid rain on the plants.

Keywords: acid rain; black gram; growth; symptoms; yield

Introduction

Rain has always been valued for mankind, all living organisms as well as flora and fauna for their life. But nowadays, simple rain has taken on a threatening complexity in some parts of the world due to industrialisation, urbanisation and modern life style. Acid rain affects all types of plants and decreases the growth, yield, photosynthetic pigments and degrades the quality of fruits (Heck et al. 1986). Feng et al. (2002) reported that vegetables are more sensitive to acid deposition than food stuff crops. Agarwal et al. (2005) observed that all parameters of plant growth, yield and photosynthetic pigments of mustard crop were adversely affected by the simulated acid rain treatments. Pulses are very common food items in Indian houses. They are grown at a very large scale in India. In the present study it was aimed to observe the effect of acid rain on a pulse crop, black gram (*Phaseolus mungo* L.).

Materials and methods

Preparation of simulated acid rain

For the preparation of simulated acid rain (SAR), different pH levels (pH 5.0, 4.0 and 3.0) were developed by mixing of 1N H_2SO_4 and 1N HNO_3 in ratio of 3:1 in distilled water. The pH was measured with the help of a digital pH meter. The different pH levels were prepared freshly just before each treatment.

Plant culture and treatments

Seeds of black gram variety T-9 were surface sterilised (dipped in 0.01% $HgCl_2$ solution) for 15 minutes followed by three washings with distilled water. Five seeds

*Corresponding author. Email: khanab2009@gmail.com

ISSN 0323-5408 print/ISSN 1477-2906 online
© 2011 Taylor & Francis
DOI: 10.1080/03235408.2010.496558
http://www.informaworld.com

were sown (15 January 2008) in each autoclaved clay pots. After germination, seedlings were thinned to maintain single seedling per pot. Each treatment was replicated five times along with a control set. The 20 pots were used for the following treatments:

T_0 = 5 pots with plant only (control);
T_1 = 5 pots with plant + pH 5.0 of SAR treatment;
T_2 = 5 pots with plant + pH 4.0 of SAR treatment;
T_3 = 5 pots with plant + pH 3.0 of SAR treatment.

Ten-day old seedlings were showered with different doses (pH 5.0, 4.0 and 3.0) of SAR separately. Control set was showered with distilled water (DW). Each replicate set was treated with required levels of SAR inside an exposure chamber for about 4 mm rain with the help of spray nozzle from the exhaust duct. Treatment was given twice in a week till 75 days. After each exposure all pots were kept on benches in a glass house and arranged in complete randomised block design. The temperature was maintained at 27/23°C (day/night). The pots were irrigated on alternate days. The experiments were terminated after 80 days and plants were uprooted carefully. Roots were washed thoroughly under tap water to avoid soil particles and debris. Plant growth and yield were measured. The photosynthetic pigments (chl a, chl b, total chl a+b and carotenoids) were examined before maturation of crop (just after exposures finished). Data were analysed statistically for significance.

Results and discussion

Acute symptoms like yellowing, injuries on the apex, necrotic lesions over the surface of leaves and marginal necrosis were seen after fourth spraying in pH 3.0 treatment. In general, acid rain caused significant reduction in plant growth (length, fresh and dry weights of shoot and root, and number of nodules) and yield (number of pods/plant, number of seeds/pod, fresh and dry weights of pods and weight of 20 seeds) as compared to control (Tables 1 and 2). All levels of acid rain were found harmful to this crop. The reductions caused by pH 3.0 rain were greater than pH 4.0 and pH 5.0 in plants.

Similarly number of leaves and photosynthetic pigments (chl a, chl b, total chl a+b) and carotenoids of black gram were also reduced significantly by acid rain (Table 3). As levels of pH were increased, there was corresponding decrease in

Table 1. Effect of different levels of simulated acid rain on plant growth of *Phaseolus mungo* var. T-9'.

Treatment (pH)	Length (cm)		Fresh wt. (g)		Dry wt. (g)		No of nodules
	Shoot	Root	Shoot	Root	Shoot	Root	
Control	23.5	18.1	6.10	1.89	1.13	0.73	27
5.0	22.7	16.7	5.75	1.41	1.05	0.59	19
4.0	20.5	14.6	4.31	0.97	0.95	0.37	14
3.0	17.7	12.2	2.35	0.56	0.61	0.18	10
$P = 0.05$	**0.46**	**0.82**	**0.15**	**0.13**	**0.04**	**0.08**	**2.49**
$P = 0.01$	**0.65**	**1.16**	**0.22**	**0.19**	**0.06**	**0.12**	**3.52**

Each value is a mean of five replicates.

Table 2. Effect of different levels of simulated acid rain on yield of *Phaseolus mungo* var. T-9.

Treatment (pH)	No of pods	Fresh wt. of pods (g)	Dry wt. of pods (g)	No. of seeds/pod	Wt. of 20 seeds (g)
Control	11	3.64	0.99	9	0.86
5.0	9	2.58	0.80	8	0.71
4.0	7	1.70	0.43	6	0.57
3.0	5	0.98	0.25	4	0.38
$P = 0.05$	**0.81**	**0.30**	**0.07**	**0.51**	**0.06**
$P = 0.01$	**1.14**	**0.43**	**0.11**	**0.71**	**0.09**

Each value is a mean of five replicates.

Table 3. Effect of different levels of simulated acid rain on photosynthetic pigments of *Phaseolus mungo* var. T-9.

Treatment (pH)	No of leaves	Photosynthetic pigments (mg/g fresh wt.)			
		Chl a	Chl b	Total chl (a + b)	Carotenoids
Control	53	0.6603	0.9254	1.5853	0.0525
5.0	46	0.5396	0.8516	1.3908	0.0469
4.0	38	0.3952	0.7274	1.1226	0.0541
3.0	31	0.3578	0.6330	0.9908	0.0372
$P = 0.05$	2.6	0.0154	0.0365	0.0475	0.0010
$P = 0.01$	3.7	0.0217	0.0513	0.0665	0.0015

Each value is a mean of five replicates.

pigments concentration. Thus all the above parameters were adversely affected with respect to acid rain levels (pH 5.0, 4.0 and 3.0).

Highest reductions in all considered parameters were found at pH 3.0 in plants. The adverse effects of simulated acid rain can be directly correlated with pH levels of the rain. Similar results have also been observed on tomato, green pepper, potato, sunflower, etc. (Durson et al. 2002; Shripal et al. 2000; Kausar et al. 2005; Mustabeen 2007). The reports available in the literature also show that reduction in growth and chlorophyll contents of crop plants generally occurs when plants are exposed to acidified rain (Shriner and Johnston 1981; Brewer and Heagle 1983; Singh 1989). The *P. mungo* was found greatly affected by acid rain in this study. The toxicity of the levels can be arranged as follows: 3.0 pH (SAR) > 4.0 pH (SAR) > 5.0 pH (SAR).

References

Agarwal S, Raghav D, Khan AA. 2005. An evaluation of the impact of simulated acid rain on the growth of mustard in pots. TAC Ann Appl Biol (Suppl). 37:25–26.

Brewer PF, Heagle AS. 1983. Interaction between *Glomus geosporum* and exposure of soybean to ozone or simulated acid rain in the field. Phytopathology. 73:1035–1040.

Durson A, Kumlay AM, Yelderin E, Guvenc I. 2002. Effects of simulated acid rain on plant growth and yield of tomato. Acta Horticult. 579:245–248.

Feng ZW, Hong M, Fuzhu Z, Zong HY. 2002. Effects of acid deposition on terrestrial ecosystems and their rehabilitation strategies in China. J Environ Sci 14:227–233.

Heck WW, Heagle AS, Shriner DS. 1986. *Hordeum vulgare* exposed to long term fumigation with low concentration of SO_2. Physiol Plant 76:445–450.

Kausar S, Khan AA, Rahman F. 2005. Impact of simulated acid rain on potato. Paper presented at: Sattelite Session III International Conference on Plants and Environmental Pollution; December 4; Jamia Hamdard, New Delhi; pp. 78–80.

Mustabeen Khan AA, Kausar S, Saquib M. 2007. Study of air pollutants stress on sunflower. Paper presented at: International Conference on the Status of Bio Science in Caribbean and Latin American Societies; September 24–25, 2007; Greater Georgetown, Guyana; pp. 7.

Shriner DS, Jonston JW. 1981. Effects of simulated acidified rain on nodulation of leguminous plants by *Rhizobium* sp. Environ. Exp. Bot. 21:199–209.

Shripal Kumar N, Pal S, Kumar N. 2000. Effects of simulated acid rain on yield and carbohydrate contents of green pepper. Adv. Plant Sci. 13(1): 85–88.

Singh SK. 1989. Studies on interaction of air pollutants and root khot nematodes on some pulse crops [Ph.D thesis]. [Aligarh]: Aligarh Muslim University. pp. 382.