e-ISSN: 2455-667X

Annals of Natural Sciences
Vol. 2(2), June 2016: 24-29
Journal's URL: http://www.crsdindia.com/ans.html
Email: crsdindia@gmail.com

Annals of Natural Sciences

ORIGINAL ARTICLE

Growth and Yield Patterns in Chickpea cv. P-391 Grown under Fly Ash Stress in Root-Knot Nematode and Root-Nodule Bacterial Presence

Navneet Sharma and Dinesh Kumar Singh
Section of Environmental Nematology, Department of Botany,
J.J.T. University, Jhunjhunu, Rajasthan
Email: navneetp218@yahoo.co.in, singhdk.singh955@gmail.com

ABSTRACT

Growth(length, fresh and dry weight of shoot and root) and yield (flowering and fruiting) including leaf pigment (chlorophyll a, b and total and carotenoid and seed) protein contents of chickpea cv. P-391 increased at lower levels (20% and 40%) of fly ash but reverse happened at higher levels (80% and 100%).Soil replaced by 60% fly ash fostered the chickpeas which showed suppression in growth and yield with respect to 40% fly ash grown chickpeas but was found at par with fly ash untreated grown chickpea plants. Maximum growth occurred to the plants grown in 40% fly ash.However, nitrogen contents of chickpea were suppressed progressively with gradual increasing levels of fly ash. Moreover, all referred as above growth and yield patterns were better in Rhizobium leguminosarum inoculated chickpeas compared to Meloidogyne incognita inoculated ones, particularly at 20% and 40% fly ash levels. The positive effects of R. leguminoarumon growth patterns were masked to a greater extent by M. incognita particularly at initial fly ash level. Although such effects of R. leguminosarum and/or M. incognita were found insignificant as the difference in different treatments were found negligible at higher levels of fly ash stresses.

Key words: *Root-knot nematode, Rhizobium leguminosarum, fly ash, growth, yield, protein*

Received: 10th Jan. 2016, Revised: 8st March 2016, Accepted: 27th March 2016

How to cite this article:
Sharma N. And Singh D.K. (2016): Growth and Yield Patterns in Chickpea cv. P-391 Grown under Fly Ash Stress in Root-Knot Nematode and Root-Nodule Bacterial Presence. Annals of Natural Sciences, Vol. 2[2]: June, 2016: 24-29.

INTRODUCTION

Fly ash, an important particulate air pollutant, is a major problem in the developing countries like ours and is mainly produced by the thermal power plants and other industries using coal as fuel. Depending on the level of its (fly ash) accumulation in soil, growing plants responded differently to different fly ash levels. Growth pattern with above reference could not be analysed in detail in presence of root-knot nematode and/or root-nodule bacteria particularly in plants growing under the fly ash stress. However, some efforts have been made at different research stations with referred to as above work (Singh *et al*., 2010, Singh and Prakash, 2008, Singh and Singh, 2013; Prakash and Singh, 2016). Still there are some lacunae left to make the growth patterns settable and systematizable in the presence of nematode and/or bacteria of above reference type. This aspect has, however, become much fabulous as the chickpeas have been grown with or without fly ash stresses apart from the presence of above micro-organism.

MATERIALS AND METHODS

The fly ash was collected from the thermal power plant (situated at Kasimpur, Aligarh, India) and brought to the laboratory in gunny bags after proper tagging. This ash was mixed with already autoclaved field soil (68% sand 24% silt, 8% clay and 3% organic matter) to obtain different fly ash levels. Such obtained mixtures were filled in clay pots having 30 cm as basal diameter. Seeds of chickpeas were dipped in 0.01% mercuric chloride in order to get them surface sterilized. Such seeds were sown in the clay pots and inoculated by root nodule bacteria (*R. leguminosarum*) immediately after the sowing. The seeds were germinated within a week and thinned to one to maintain the healthy seedling per pot. Three-week-oldchickpea seedlings were inoculated by freshly hatched second stage juveniles (J_2) of *M. incognita*. Micropipette controller was used for J_2 inoculation in pots. The J_2 suspension was inoculated in the hole made near the potted plant so that the roots of chickpea could ingress them through the chance factor. The following were control and fly ash the treatments-

CONTROL TREATMENTS

Treatments without fly ash were considered as controls. The total amount of soil (with or without fly ash) was maintained as 4.0 kg (= 4000 gm) per pot. The detail of control treatment can be described as follows -

Plant (=P) + 4.0 kg (= 4000 gm) field soil (fs)
P + 4.0 kg fs + *R. leguminosarum* (= RL)
P + 4.0 kg fs + *M. incognita* (MI)
P + 4.0 kg fs + RL + MI

Fly ash treatment

P + 20% fa = P + 800 g fly ash (fa) + 3200 g fs
P + 20% fa + RL
P + 20% fa + MI
P + 20% fa + RL + MI
P + 40% fa = P + 1600 mg fa + 2400 gmfs
P + 40% fa + RL
P + 40% fa + MI
P + 40% fa + RL + MI
P + 60% fa = P + 2400 mg fa + 1600 gmfs
P + 60% fa + RL
P + 60% fa + MI
P + 60% fa + RL + MI
P + 80% fa = P + 3200 mg fa + 800 gmfs
P + 80% fa + RL
P + 80% fa + MI
P + 80% fa + RL + MI
P + 100% fa = P + 4000 mg fa + 0 gmfs
P + 100% fa + RL
P + 100% fa + MI
P + 810% fa + RL + MI

Each treatment was replicated five times. Termination of the experiment was done 120 days after the sowing. Lengths, fresh and dry weights of shoot and root were determined through standard procedure. Counting of flowers and fruits was done after each 10 days starting from their setting onward and an average was calculated by dividing the total summated values by the number of replicates. Chlorophyll (a, b and total) and carotenoid contents of the chickpea leaves were calculated by using the Mac Kinney (1941) method and Mac Lachlan and Zalik (1963) method, respectively. Likewise, protein (soluble, insoluble and total protein) of chickpea seeds was evaluated through Lowry *et al* (1951) method and that of leaf nitrogen contents by Linder (1944) method.
Data analysis was done through two factorial method as suggested by Fischer (1950). To generate two factors, treatments with different fly ash levels were considered as factor

one (designated as F_1) and that of with root-nodule bacteria and/or root-knot nematode were considered as factor two (designated as F_2). CD for these two factors was evaluated separately for F_1 and F_2 at P = 0.05%. Their interactive CD (F_1 x F_2) was also determined along side.

Table 1: Effect of fly ash (P) on length of shoot and root of chickpea in presence and absence of *M. incognita* (Mi) and *R. leguminosarum* (R)

Treatments	Shoot length (cm)							Root length (cm)						
	0	20	40	60	80	100	MM	0	20	40	60	80	100	MM
P	30.30	36.25*	39.68*	32.70*	28.28^{ns}	24.96^{ns}	32.03	12.26	15.75*	20.95*	13.62*	10.95^{ns}	8.65^{ns}	13.70
P + R	39.17*	43.18*	46.32*	40.62*	34.78*	29.32^{ns}	38.90$^{@}$	16.85*	19.35*	24.60*	17.32*	14.86*	12.85^{ns}	17.64$^{@}$
P +Mi	25.72^{ns}	30.65^{ns}	35.74*	28.32^{ns}	25.36^{ns}	23.74^{ns}	28.26$^{@}$	9.46^{ns}	13.70*	17.25*	11.60^{ns}	8.40^{ns}	6.90^{ns}	11.22$^{@}$
P + R + Mi	29.00^{ns}	34.58*	39.36*	31.89*	27.74^{ns}	24.86^{ns}	31.24$^{@}$	14.60*	16.30*	20.50*	14.80*	11.87^{ns}	9.55^{ns}	14.60$^{@}$
MM	31.05	36.17$^{\#}$	40.28$^{\#}$	33.38$^{\#}$	29.04$^{\#}$	25.72$^{\#}$		13.29	16.28$^{\#}$	20.83$^{\#}$	14.34$^{\#}$	11.52$^{\#}$	9.49$^{\#}$	

CD at P=0.05, Treat = 0.654; Fly ash = 0.534; Treat x Fly ash = 1.308 Treat = 0.305, Fly ash = 0.249; Treat x Fly ash = 0.611

Table 2: Effect of fly ash (P) on fresh weight of shoot and root of chickpea in presence and absence of *M. incognita* (Mi) and *R. leguminosarum* (R)

Treatments	Shoot fresh weight (g)							Root fresh weight (g)						
	0	20	40	60	80	100	MM	0	20	40	60	80	100	MM
P	35.21	38.47*	40.19*	36.47^{ns}	33.70^{ns}	30.54^{ns}	35.76	23.90	27.74*	25.48*	24.21^{ns}	23.20^{ns}	22.84^{ns}	24.56
P + R	47.72*	49.40*	50.24*	48.04*	42.74*	33.04^{ns}	45.20$^{@}$	28.67*	29.04*	30.47*	28.87*	27.90*	24.10^{ns}	28.18$^{@}$
P +Mi	28.75^{ns}	30.67^{ns}	33.79^{ns}	29.17^{ns}	28.70^{ns}	28.54^{ns}	29.94$^{@}$	21.37^{ns}	23.42^{ns}	24.22^{ns}	21.94^{ns}	21.24^{ns}	21.80^{ns}	22.33$^{@}$
P + R + Mi	39.20*	40.17*	40.98*	38.87*	35.72^{ns}	32.14^{ns}	37.85$^{@}$	26.12*	26.20*	26.68*	26.22*	25.04*	24.17^{ns}	25.74$^{@}$
MM	37.72	39.68$^{\#}$	41.30$^{\#}$	38.14^{ns}	35.22$^{\#}$	31.07$^{\#}$		25.02	26.60$^{\#}$	26.71$^{\#}$	25.31^{ns}	24.35$^{\#}$	23.23$^{\#}$	

CD at P=0.05, Treat = 0.746; Fly ash = 0.609; Treat x Fly ash = 1.492 Treat = 0.486, Fly ash = 0.397; Treat x Fly ash = 0.973

Table 3: Effect of fly ash (P) on dry weight of shoot and root of chickpea in presence and absence of *M. incognita* (Mi) and *R. leguminosarum* (R)

Treatments	Shoot dry weight (g)							Root dry weight (g)						
	0	20	40	60	80	100	MM	0	20	40	60	80	100	MM
P	9.18	10.10*	11.47*	10.14*	9.04^{ns}	8.98^{ns}	9.82	5.98	6.77*	7.54*	6.04^{ns}	5.77^{ns}	5.12^{ns}	6.20
P + R	11.93*	12.94*	13.88*	12.17*	11.03*	9.67*	11.94$^{@}$	8.23*	9.17*	10.15*	8.94*	7.98*	6.74*	8.54$^{@}$
P +Mi	7.12^{ns}	8.87^{ns}	9.07^{ns}	10.04*	6.99^{ns}	6.74^{ns}	8.14$^{@}$	4.10^{ns}	5.10^{ns}	6.04^{ns}	4.97^{ns}	4.01^{ns}	4.00^{ns}	4.70$^{@}$
P + R + Mi	10.86*	10.97*	11.98*	10.09*	9.72*	8.82^{ns}	10.41$^{@}$	7.14*	7.82*	8.47*	7.01*	6.90*	6.25^{ns}	7.27$^{@}$
MM	9.77	10.72$^{\#}$	11.60$^{\#}$	10.61$^{\#}$	9.20$^{\#}$	8.55$^{\#}$		6.36	7.22$^{\#}$	8.05$^{\#}$	6.74$^{\#}$	6.17$^{\#}$	5.53$^{\#}$	

CD at P=0.05, Treat = 0.201; Fly ash = 0.164; Treat x Fly ash = 0.402 Treat = 0.138, Fly ash = 0.113; Treat x Fly ash = 0.276

Table 4: Effect of fly ash (P) on number of flowering and fruiting of chickpea in presence and absence of *M. incognita* (Mi) and *R. leguminosarum* (R)

Treatments	Flowering							Fruiting						
	0	20	40	60	80	100	MM	0	20	40	60	80	100	MM
P	25.10	30.20*	35.40*	27.25*	23.40^{ns}	18.70^{ns}	26.68	22.15	27.30*	32.25*	26.50*	20.70^{ns}	12.50^{ns}	23.57
P + R	32.20*	38.15*	48.05*	35.06*	28.43*	21.30^{ns}	33.87$^{@}$	30.65*	36.20*	45.15*	33.45*	25.17*	16.80^{ns}	31.24$^{@}$
P +Mi	22.40^{ns}	25.40^{ns}	30.12*	23.13^{ns}	20.20^{ns}	16.18^{ns}	22.91$^{@}$	20.75^{ns}	23.12^{ns}	27.40*	21.20^{ns}	16.70^{ns}	10.75^{ns}	19.99$^{@}$
P + R + Mi	26.45*	29.06*	36.05*	28.23*	24.20^{ns}	19.20^{ns}	27.20^{ns}	24.60*	27.00*	33.12*	26.18*	20.23^{ns}	13.65^{ns}	24.13$^{@}$
MM	26.54	30.70$^{\#}$	37.41$^{\#}$	28.42$^{\#}$	24.06$^{\#}$	18.85$^{\#}$		24.54	28.41$^{\#}$	34.48$^{\#}$	26.83$^{\#}$	20.70$^{\#}$	13.43$^{\#}$	

CD at P=0.05, Treat = 0.576; Fly ash = 0.470; Treat x Fly ash = 1.152 Treat = 0.538, Fly ash = 0.439; Treat x Fly ash = 1.076

Table 5: Effect of fly ash (P) on chlorophyll a and b of chickpea in presence and absence of *M. incognita* (Mi) and *R. leguminosarum* (R)

Treatments	Chlorophyll a (mg/g)							Chlorophyll b (mg/g)						
	0	20	40	60	80	100	MM	0	20	40	60	80	100	MM
P	0.994	1.052*	1.252*	1.120*	0.934^{ns}	0.823^{ns}	1.029	0.857	0.923*	1.142*	0.830^{ns}	0.798^{ns}	0.683^{ns}	0.872
P + R	1.134*	1.502*	1.577*	1.227*	1.008^{ns}	0.829^{ns}	1.213$^{@}$	0.984*	1.192*	1.322*	1.004*	0.933*	0.704^{ns}	1.023$^{@}$
P +Mi	0.728^{ns}	0.907^{ns}	1.057*	0.823^{ns}	0.775^{ns}	0.765^{ns}	0.843$^{@}$	0.639^{ns}	0.723^{ns}	1.004*	0.704^{ns}	0.620^{ns}	0.620^{ns}	0.718$^{@}$
P + R + Mi	0.897^{ns}	0.456^{ns}	1.214*	0.910^{ns}	0.899^{ns}	0.833^{ns}	0.868$^{@}$	0.844^{ns}	0.921*	1.140*	0.883^{ns}	0.794^{ns}	0.623^{ns}	0.868^{ns}
MM	0.938	0.979$^{\#}$	1.275$^{\#}$	1.020$^{\#}$	0.904$^{\#}$	0.813$^{\#}$		0.831	0.940$^{\#}$	1.152$^{\#}$	0.855$^{\#}$	0.786$^{\#}$	0.658$^{\#}$	

CD at P=0.05, Treat = 83.876; Fly ash = 68.485; Treat x Fly ash = 167.752 Treat = 0.042, Fly ash = 0.034; Treat x Fly ash = 0.084

Table 6: Effect of fly ash (P) on total chlorophyll and carotenoid content of leaves of chickpea in presence and absence of *M. incognita* (Mi) and *R. leguminosarum* (R)

Treatments	Total chlorophyll (mg/g)							Carotenoid (mg/g)						
	0	20	40	60	80	100	MM	0	20	40	60	80	100	MM
P	1.950	2.154*	2.433*	2.133*	2.004^{ns}	1.487^{ns}	2.027	0.493	0.507^{ns}	0.712*	0.490^{ns}	0.429^{ns}	0.395^{ns}	0.504
P + R	2.217*	2.738*	2.938*	2.337*	2.003^{ns}	1.452^{ns}	2.281$^{@}$	0.537*	0.612*	0.699*	0.580*	0.510^{ns}	0.419^{ns}	0.560$^{@}$
P +Mi	1.472^{ns}	1.732^{ns}	2.154*	1.944^{ns}	1.437^{ns}	1.451^{ns}	1.698$^{@}$	0.386^{ns}	0.427^{ns}	0.511^{ns}	0.396^{ns}	0.362^{ns}	0.320^{ns}	0.400$^{@}$
P + R + Mi	1.841^{ns}	2.124*	2.430*	2.124*	1.635^{ns}	1.437^{ns}	1.932$^{@}$	0.419^{ns}	0.502^{ns}	0.701*	0.421^{ns}	0.419^{ns}	0.397^{ns}	0.477$^{@}$
MM	1.870	2.187$^{\#}$	2.489$^{\#}$	2.135$^{\#}$	1.770$^{\#}$	1.457$^{\#}$		0.459	0.512$^{\#}$	0.656$^{\#}$	0.472$^{\#}$	0.430$^{\#}$	0.383$^{\#}$	

CD at P=0.05, Treat = 0.0403 Fly ash = 0.0329; Treat x Fly ash = 0.0805 Treat = 0.0099, Fly ash = 0.0081; Treat x Fly ash = 0.0198

Table 7: Effect of fly ash (P) on soluble and insoluble protein contents of seeds of chickpea in presence and absence of *M. incognita* (Mi) and *R. leguminosarum* (R)

Treatments	Soluble protein (%)							Insoluble protein (%)						
	0	20	40	60	80	100	MM	0	20	40	60	80	100	MM
P	13.19	13.74*	13.87*	13.16^{ns}	12.84^{ns}	12.08^{ns}	13.15	15.62	16.12^{ns}	16.94*	15.68^{ns}	14.60^{ns}	13.98^{ns}	15.49
P + R	14.24*	14.36*	14.57*	14.12*	13.93*	12.10^{ns}	13.89$^{@}$	16.67*	16.96*	17.38*	16.70*	15.14^{ns}	13.87^{ns}	16.12$^{@}$
P +Mi	12.79^{ns}	13.04^{ns}	13.53^{ns}	12.82^{ns}	12.07^{ns}	12.02^{ns}	12.71$^{@}$	14.91^{ns}	15.90^{ns}	16.14^{ns}	14.97^{ns}	14.21^{ns}	13.83^{ns}	14.99$^{@}$
P + R + Mi	13.04^{ns}	13.00^{ns}	13.21^{ns}	13.08^{ns}	12.80^{ns}	12.10^{ns}	12.87$^{@}$	15.66^{ns}	16.43*	17.99*	15.69^{ns}	14.58^{ns}	13.90^{ns}	15.71^{ns}
MM	13.32	13.54$^{\#}$	13.80$^{\#}$	13.30^{ns}	12.91$^{\#}$	12.08$^{\#}$		15.72	16.35$^{\#}$	17.11$^{\#}$	15.76^{ns}	14.63$^{\#}$	13.90$^{\#}$	

CD at P=0.05, Treat = 0.251Fly ash = .0.205; Treat x Fly ash = 0.503 Treat = 0.298, Fly ash = 0.244; Treat x Fly ash = 0.597

Table 8: Effect of fly ash (P) on total protein content of seeds and nitrogen content of leaves of chickpea in presence and absence of *M. incognita* (Mi) and *R. leguminosarum* (R)

Treatments	Total protein (%)							Nitrogen (%)						
	0	20	40	60	80	100	MM	0	20	40	60	80	100	MM
P	28.81	29.86^{ns}	30.81*	28.84^{ns}	27.44^{ns}	26.06^{ns}	28.64	4.46	3.96^{ns}	3.16^{ns}	2.96^{ns}	2.66^{ns}	2.48^{ns}	3.28
P + R	30.91*	31.32*	31.95*	30.82*	29.07^{ns}	25.97^{ns}	30.01$^{@}$	5.91*	4.91*	4.03^{ns}	3.92^{ns}	3.09^{ns}	2.57^{ns}	4.07$^{@}$
P +Mi	27.70^{ns}	28.94^{ns}	29.67^{ns}	27.79^{ns}	26.28^{ns}	25.85^{ns}	27.71$^{@}$	4.33^{ns}	3.87^{ns}	3.09^{ns}	2.89^{ns}	2.59^{ns}	2.38^{ns}	3.19$^{@}$
P + R + Mi	28.70^{ns}	29.43^{ns}	31.20*	28.77^{ns}	27.38^{ns}	26.00^{ns}	28.58^{ns}	5.02*	4.12^{ns}	3.32^{ns}	3.04^{ns}	2.71^{ns}	2.38^{ns}	3.43$^{@}$
MM	29.03	29.89$^{\#}$	30.91$^{\#}$	29.06^{ns}	27.54$^{\#}$	25.97$^{\#}$		4.93	4.22$^{\#}$	3.40$^{\#}$	3.20$^{\#}$	2.76$^{\#}$	2.45$^{\#}$	

CD at P=0.05, Treat = 0.549,Fly ash = . 0.449; Treat x Fly ash = 1.099 Treat = 0.074, Fly ash = 0.061; Treat x Fly ash = 0.149

* = data significant with 0% fly ash and at P treatment only at P = 0.05

ns = Not significant

@ = data significant within a column at P=0.05

= data significant in a raw at P =0.05

P = chickpea plant, R = *Rhizobium leguminosarum*, Mi = *Meloidogyne incognita*

RESULT AND DISCUSSION

Fly ash variably affected the plant growth (length, fresh and dry weights of shoot and root), yield (flowering and fruiting), leaf pigments (chlorophyll a, b and total and carotenoids), seed proteins (soluble, insoluble and total) and nitrogen contents of chickpea leaves. Chickpea plants showed enhanced plant growth and yield in 20 and 40% fly ash amended soil (Tables 1-4). Fly ash contains some utilizable plant nutrients (Druzina*et al.,* 1983) thereby its addition to soil can enrich it in macro and micro-nutrients. So this can be advanced as the reason behind improved plant growth and yield through the favourable effects via improvising the metabolism (Martens and Beahm, 1978). Some physico-chemical properties such as ion exchange capacity, water holding capacity and pore size also improved (Elseewi*et al*., 1981) along with the neutralization of soil acidity by the 20 and 40% fly ash addition to the soil, which may ameliorate plant growth and yield. These factors mutually or individually, might have played some determinant role in improving the chickpea growth patterns along with their biomass. Chickpea leaf pigments (chlorophylls and carotenoids) and seed proteins were also recorded to be improved at 20 and 40%, being maximum at 40% level (Tables 5-7). However further increase in fly ash level suppressed the growth and yield along with all concerns. It indicates that the changes exerted in physico-chemical properties by fly ash 40% level additions, were optimal for chick-pea fostering which is reflected in the form of improved growth, yield, leaf pigments and seed protein contents.

Chickpeas showed lesser growth and yield at higher levels (60, 80 and 100%) compared to lower fly ash levels (20 and 40%). However, suppression to growth and related concerns also occurred at 60% ash level (compared to 40% ash applied grown plants) but were found at par to fly ash untreated plants. Fly ash added some organic toxic compounds such as dibenzofuran and dibenzo-p-dioxime (Helder*et al*., 1982) in the fly ash amended field soil. Ahigher (60, 80 and 100%) fly ash levels, concentration of these substances may have exceeded the threshold limit so as to caused maximum suppressive effect on growth and yield for chickpeas. Addition of such substances beyond optimal level might have caused significant reductions to all growth concern. These suppressive effects were compounded more at higher levels due to the high alkalinity and salt excess in the soil (Adriano*et al.,* 1980).So the chickpeas suffered with the maximum adversaries, as far as the different growth patterns are concerned, due to referred as above causes particularly at 80 and 100% ash amendments.

Growth patterns of chickpeasas referred to all parameters were better in root nodule bacteria inoculated than uninoculated plants at 20 and 40% levels. However such improvements were masked significantly by *M. incognita* inoculations. Such results were also justified by earlier workers (Yadav and Singh, 2014) in their publications. Chick-pea plants inoculated by *R. leguminosarum* and *M. incognita* collectively at lower fly ash treatments (20and40%), showed a significant enhancement in all the growth parameters compared to the root-nodule bacteria + root-knot nematode inoculated plants grown in fly ash non-amended soils. Such effects were reduced at 60% fly ash level. The evaluated values of growth, and yield parameters in nematode and bacteria inoculated plants were found to differ insignificantly at 100% ash treatments. So clearly the *R. leguminosarum* and *M. incognita* were adversely impacted by higher fly ash levels particularly that of 100%. Such nullified effect of nematode and bacteria on different growth pattern can be attributed to accumulation of organic and inorganic substances beyond the bearable and threshold limit for chickpeas. Reports are also available with regard to as suppressive effects of such compounds on microbial activities (Wong and Wong, 1986) such as the nematodes and/or bacteria (Yadav and Singh, 2014).

Nitrogen content of chick-pea leaves were progressively decreased with all level of fly ash increase (Table 8). Gradual reductions in chickpea leaf nitrogen content with increasing fly ash proportion can be correlated to the absence of nitrogen in the fly ash (Mishra and Shukla, 1986). So gradual increase in fly ash proportion means the progressive decrease in nitrogen contents in the field soil. Presence of heavy metals (Eiceman and Vandivar, 1983) in fly ash is claimed to be responsible for growth reduction (Khan *et al.,* 1988). So, all concerned growth and yield parameters, were suffered adversely due to poor nitrogen availability in the ongoing field soil amendments by fly ash.

Reductions of nitrogen contentsin chickpea leaves were comparatively less in presence of root-nodule bacteria. However, reverse happened in *M. incognita* inoculated chickpeas. Concomitant inoculation of both root-nodule bacteria and root-knot nematode could cause more reductions to nitrogen contents of chickpea seeds than *R. leguminosarum* inoculated ones. Earlier reports also showed the gradual reduction in nitrogen contents with progressive increase in the fly ash concentration (Singh *et al*., 1994).

The study showed that fly ash amendment of soil was beneficial for different considered growth patterns in chickpeas at 20 and 40%, being maximum at 40% level, in either *M. incognita* and/or *R. leguminosarum* presence. At these initial fly ash levels, the beneficial effects were masked by *M. incognita* but reverse happened due to root-nodule bacteria presence. Fly ash at 80 and 100% levels, suppressed the positive effects of *R. leguminosarum* on chickpea growth pattern significantly, and the later were further antagonized by the *M. incognita* presence.

REFERENCES

1. Adriano, D.C., A.L. Page, A.L. Elseewi, A.C. Chang and J.A. Straughan, 1980. Utilization and disposal of fly ash and other coal residues in terrestrial ecosystems: A review. *J. Environ. Qual*. 9: 333-344.
2. Druzina, V.D., E.D. Miroshracheuko and O.D. Chertov, 1983.Effect of industrial pollution on nitrogen and ash content in meadow phyto-coenotic plants. *Botanizhnyl Zhurnal*. 68: 1853.
3. Eiceman, G.A. and V.J. Vandiver, 1983. Absorption of polycyclic aromatic hydrocarbons on fly ash from a municipal incinerator and a coal fired power plant. *Atmos Environ*. 15: 247-259.
4. Elseewi, A.A., S.R. Grimm, A.L. Page and I.R. Straughan. 1981. Boron-enrichment of plants and soils trated with coal ash. *J. Plant Nutr*. 3: 409-427.
5. Fischer, R.A. 1950. *Statistical Methods for Research Workers* (11thed.) Oliver and Boyd, Edinburgh.
6. Helder, T., E. Stutterheim and K. Olie. 1982. The toxicity and toxic potential of fly ash from municipal incinerators assessed by means of a fish early life stage test. *Chemosphere* 11: 965-972.
7. Jai Prakash and Singh K. 2016. Growth performance of fly ash stressed tomato plants in presence of *Meloidogyne incongita*. In: *Proceedings of CAN-SARC International Conference*, New Delhi: India, ISBN: 978-93-86083-86-9, pp. 01-06.

8. Khan, M.R. and M.W. Khan 1996.The effect of fly ash on plant growth and yield of tomato. *Environ. Pollution* 92: 105-111.
9. Khan, M.R., S.K. Singh and M.W. Khan. 1988. Response of lentil to cobalt as soil pollutant. *Ann. Appl. Biol*. (Supplement) TAC-9: 103-104.
10. Linder, R.C. 1944. Rapid analytical methods for some of the more common inorganic constituents of plant tissue. *Plant Physiol*. 19: 76-89.
11. Lowry, O.H., M.J. Rosebrough, A.L. Farr and R.J. Randoll. 1951. Protein measurement with folin phenol reagent. *J. Biol. Chem*. 193: 265-275.
12. Mackinney, G. 1941. Absorption of light of chlorophyll solution. *J Biol. Chem*. 140: 315-322.
13. Maclachlan, S and S Zalik. 1963. Plastid structure, chlorophyll concentration and free amino acid composition of chlorophyll mutant of barley. *Can. J. Bot*. 41: 1053-1062.
14. Martens, D.C. and B.R. Beahm. 1978. Chemical effects on plant growth of fly ash incorporation into soil. In: *Environmental Chemistry and Cycling Processes*. EDRA, Symp. Ser. Conf. 760429, U.S. Dept. Commerce, Springfield, V.A., USA.
15. Mishra, L.C. and K.N. Shukla 1986.Effects of fly ash deposition on growth metabolism and dry matter production of maize and soyabean*Environ.Pollution*. 42: 1-13.
16. Singh, D.K. and K. Singh. 2013. Root-knot nematode impact on some leaf epidermal characters of fly ash stressed chickpeas. *Nature &Environment*, 18(1&2): 81-88.
17. Singh, K., M.W. Khan and M.R. Khan. 1994. Growth and root-knot disease of soyabean under the stress of fly ash. In: *Emerging Technologies in Environmental Conservation National Symposium* (Abs), JamiaHamdard and Eco-Transformation Centre, New Delhi, India.
18. Singh, K., Khan, A.A., Rizvi, I.R. and Saquib, M. 2010. Morphological and biochemical responses of cowpea (cv. PusaBarsati) grown on fly ash amended soil in presence and absence of *Meloidogynejavanica* and *Rhizobium leguminosarum*. *Ecoprint*, 17: 17-22.
19. Singh, K. and J. Prakash 2008. Impact assessment of root-knot nematode on fly ash stressed plants. National Symposium on Environment of Sustainable Development, Department of Botany, Meerut College Meerut (Ch. Charan Singh University, Meerut), p. 46.
20. Wong, M.H. and J.W.C. Wong. 1986. Effects of fly ash on soil microbial activity. *Environ. Pollution* 40: 127-144.
21. Yadav, D. and Singh, K. 2014. Individual and combined effects of SO_2 and O_3 on root-knot nematode multiplication. *Indian Journal of Science*, 3(2): 57-64.
22. Yadav, D. and Singh, K. 2014. Effect of SO_2 and/or O_3 on root-knot nematode morphometrics which parasitizes green gram. *Journal of Indian Botanical Society*, 93(3 & 4): 51-58.