Journal of Pharmacognosy and Phytochemistry

Available online at www.phytojournal.com

E-ISSN: 2278-4136
P-ISSN: 2349-8234
JPP 2019; 8(6): 387-391
Received: 14-09-2019
Accepted: 17-10-2019

Deepak Gowda K
Department of Agricultural Entomology, College of Agriculture, Raichur, Karnataka, India

Hadimani DK
Department of Agricultural Entomology, College of Agriculture, Bheemarayanagudi, Karnataka, India

Ashoka J
Department of Agricultural Entomology, College of Agriculture, Raichur, Karnataka, India

Sushila Nadagoud
Department of Agricultural Entomology, College of Agriculture, Raichur, Karnataka, India

Veeresh H
Department of Soil Science and Agricultural Chemistry, College of Agriculture, Raichur University of Agricultural Sciences, Raichur, Karnataka, India

Corresponding Author:
Deepak Gowda K
Department of Agricultural Entomology, College of Agriculture, Raichur, Karnataka, India

Comparative effect of fly ash fortified crop residue and municipal waste based vermicomposts on growth and yield of mulberry

Deepak Gowda K, Hadimani DK, Ashoka J, Sushila Nadagoud and Veeresh H

Abstract
A field experiment was conducted in a well established mulberry garden with variety V-1 to study the comparative effect of fly ash fortified crop residue and municipal waste based vermicomposts on growth and yield of mulberry at Sericulture unit, Department of Agricultural Entomology, College of Agriculture, UAS, Raichur, Karnataka during 2018-19. The experimental plot was laid in randomized block design and nine treatments with three replications. Treatment wise 5, 10, 15% fly ash fortified crop residue and municipal waste vermicomposts was produced for application to mulberry garden @ 7.5 t /ha/year along with recommended dose of chemical fertilizer. Treatment wise vermicomposts was applied to mulberry garden 10 days after pruning and incorporated into soil and mulberry crop was raised for about 65 days and mulberry growth and yield was recorded. Among the treatments, mulberry growth and yield was significantly superior in T_2 (Vermicompost produced from mixed crop residues along with fly ash fortification @ 10 % + recommended dose of chemical fertilizers) followed by T1 (Vermicomposts produced from mixed crop residues along with fly ash fortification @ 5% + recommended dose of chemical fertilizers). Significantly lower growth and yield parameters were recorded in control. The increase in yield might be due to supplementation of major and minor nutrients. This in turn might have enhanced chlorophyll synthesis and triggered the physiological activity of plants by producing required auxins which might have influenced meristematic activity, expansion of cell and formation of cell wall, cell division and differentiation leading to higher leaf yield, shoot height, leaf area and leaf yield of mulberry.

Keywords: Fly ash, fortified, crop residue, municipal waste, vermicompost, mulberry

Introduction
Mulberry, the sole nourishment plant of silkworm, *Bombyx mori* L. plays a vital role in the growth and development of silkworm and in turn the silk production. Leaf quality and quantity not just impact the silkworm growth and development but also impact the cocoon production and quality of raw silk. Almost 70 per cent of silk protein produced by silkworm is directly derived from proteins of mulberry leaves.

Fly ash a residue of burning of coal / lignite in thermal power plant has traditionally been considered as a waste product. It's generation in the country has increased from 40 MT/year (1994) to about 235 MT/year (2013). It is projected to be 325 MT/year (2016-17), 500 MT/year (2021-22) and 1000 MT/year (2031-32). If not utilized, it would demand large area of land for ash ponds and would pose a threat for air and water pollution. Fly ash utilization has increased from 1 MT/year during 1994 to 130 MT/year during 2013, primarily as an outcome of concerted efforts under fly Ash Mission-India. Fly ash, being a good soil ameliorant and source of secondary plant nutrients as well as micronutrients can significantly improves the physio-chemical properties like water holding capacity, pH, CEC, free lime etc. It can efficiently be used as a source of silicon, pesticide carrier, plant growth promoter, etc. Use of fly ash has also been reported for reclamation of degraded/problematic soils and wastelands (Vimal and Gopalkrishna, 2014) [13].

Municipal waste is an unwanted by product of modern civilization. Land fills are the most common means of solid waste disposal. But, the increasing amount of solid waste is rapidly filling existing landfills, and new sites are difficult to establish. Alternatives to landfills include the use of source reduction, recycling, composting and incineration. Information on the composition of solid wastes is important in evaluating alternative equipment needs, systems, management programs and plans. There has been a significant increase in municipal solid waste generation in India in the last few decades. This is largely because of rapid population growth and economic development in the country. Solid waste management has become a

major environmental issue in India. The per capita of municipal solid waste generated daily, in India ranges from about 100 g in small towns to 500 g in large towns. On the other hand, municipal solid waste generated in the city increased from 3200 tones per day to 5355 tones per day in the same period registering a growth of around 67%. This clearly indicated that, the growth in municipal solid waste in our urban centres has outpaced the population growth in recent years (Sudhir *et al.*,2010) [12].
Earthworms are friends of farming community, renders help in soil improvement, organic matter decomposition and also in enhancing the quality of agricultural produce. Vermicomposting is a bio-oxidation process of organic wastes involving a joint action of earthworms and micro-organisms. In this process, earthworms act as versatile bioreactors converting organic materials into fine granules called vermicast (excreta of earthworms). In view of above, the present study was under taken to utilise the municipal waste and trace element rich fly ash for vermicompost production and subsequent utilization for growth and yield of mulberry.

Materials and Methods
A field experiment was conducted to know the effect of fly ash fortified municipal waste and crop residue based vermicomposts for growth and yield parameters of mulberry. The study was initiated at Sericulture unit, Department of Agricultural Entomology, College of Agriculture, Raichur during *kharif* 2018-19. The materials used and methods employed in the study was presented here under.

Preparation of vermicompost
Vermicompost preparation was done in cement pit of size 2 ½ feet cube for each of fly ash fortification level.
Municipal waste, bio degradable farm wastes (crop residues) and fly ash were collected from thermal power station Raichur Karnataka State. Farm waste was passed through shredder (Whenever necessary) along with dung and 100 kg each of mixed crop residue waste were taken and different crop residues were equally distributed for all eight types of vermicompost preparation fortified with fly ash at rate of 5, 10 and 15 per cent separately. Based on the final weight of the substrate 20 per cent cow dung was added and allowed for pre decomposition with thorough mixing and regular watering. Similarly, 100 Kg each municipal waste was taken and fortified with fly ash at the rate of 5, 10 and 15 per cent. Cow dung was added to the municipal waste at the rate 20 per cent of substrate weight and thoroughly mixed and regularly watered. Mixed crop residue (100 kg) alone and municipal waste (100 kg) alone without fortification of fly ash was kept and 20 per cent dung was added and allowed for decomposition with regular watering. For all the substrates 12 kg each mulch cover was placed on the top to avoid drying of substrate.
Later, earthworms, *Eudrillus eugienae* was released at the rate of 2 kg/tonne of substrate below the mulch layer and watered on regular basis once in 2-3 days. The vermi-pits were regularly monitored for activity of earthworm. At the time of pit filling samples of mixed crop residue, fly ash and municipal waste were collected for initial nutrient analysis. When the vermicompost was ready for harvest, earthworms and vermicompost was separated; vermicompost yield and earthworm biomass was recorded treatment wise. Vermicompost samples were collected treatment wise for final nutrient assay.

Treatment details
T_1: Vermicompost (produced from mixed crop residues along with fly ash fortification @ 5%) + recommended dose of chemical fertilizers (CRVC5 + RDF).
T_2: Vermicompost (produced from mixed crop residues along with fly ash fortification @ 10 %) + recommended dose of chemical fertilizers (CRVC10 + RDF).
T_3: Vermicompost (produced from mixed crop residues along with fly ash fortification @ 15 %) + recommended dose of chemical fertilizers (CRVC15 + RDF).
T_4: Vermicompost produced from mixed crop residues alone without fortification (CRVC + RDF).
T_5: Vermicompost (produced from municipal waste along with fly ash fortification @ 5%) + recommended dose of chemical fertilizers (MWVC5 + RDF).
T_6: Vermicompost (produced from municipal waste along with fly ash fortification @ 10%) + recommended dose of chemical fertilizers (MWVC10 + RDF).
T_7: Vermicompost (produced from municipal waste along with fly ash fortification @ 15%) + recommended dose of chemical fertilizers (MWVC15 + RDF).
T_8: Vermicompost (produced from municipal waste alone without fortification (MWCV + RDF).
T_9: Recommended dose of chemical fertilizers (RDF) (300: 120: 120 kg NPK/ha/year)
In this experiment RCBD statistical design is fallowed with nine treatments and three replication. Mulberry garden with V-1 (Victory -1) for the study consisted three years old plants planted in paired row system with spacing of (3' x 2') × 5' and number of plants per treatment is twenty four. Treatment wise vermicompost was produced for application to mulberry @ 7.5 t /ha/year along with recommended dose of chemical fertilizer. Initial nutrient assay of mulberry soils were carried out before start of the experiment. Treatment wise vermicompost was applied to mulberry garden 10 days after pruning and incorporated into soil and mulberry crop was raised for about 65 days and growth and yield parameters of mulberry was recorded.

Results and Discussion
The utilization of fly ash fortified crop residues for vermicomposting or combined application of fly ash with organic manures will not only sustain the soil fertility but also improve the mulberry productivity, nutrient use efficiency and leaf quality. If such mulberry leaves are fed to silkworms, the silkworms put up better growth and development leading to higher cocoon production both qualitatively and quantitatively.
Data pertaining to the growth and yield parameters of mulberry were significantly influenced by fly ash fortified vermicomposts. Significantly highest leaf yield was noticed in CRVC10 (1063.33, 1303.33 and 1183.33 g/plant) during first, second crop and pooled data respectively in order. Significantly lowest leaf yield was observed in RDF treatment (T_9) (561.67, 723.33 and 642.50 g/plant) during first, second crop and pooled data respectively. Soil application of fly ash fortified crop residue and municipal waste based vermicomposts significantly affected the shoot yield. Significantly highest shoot yield was found in CRVC10 (883.33, 988.33 and 935.83 g/plant). Lowest shoot yield was observed in RDF treatment (T_9) (421.67, 521.67 and 471.67 g/plant) during first, second crop and pooled data respectively. There was no significant difference in leaf to shoot ratio in both crops and pooled data (Table1). Number of leaves per plant was significantly highest in treatment

CRVC10 (425.83, 429.50 and 427.67) during first, second crop and pooled data respectively. The effect of soil application of fly ash fortified crop residue and municipal waste based vermicomposts to mulberry did not significantly influence the average shoot length during first and second crop as well as in pooled. The 100 leaf weight of mulberry was significantly higher in CRVC10 (290.49, 383.43 and 336.96 g/100 leaf) and significantly lower 100 leaf weight was noticed in RDF treatment (189.02, 249.01 and 219.02 g/100 leaf) during first, second crop and pooled data respectively in order (Table 2). Significantly higher leaf area per plant was observed in CRVC10 (224.79, 217.49 and 221.14 cm^2) during first, second crop and pooled data respectively in order. The leaf area per plant was significantly lowest in RDF (187.44, 155.05 and 171.24 cm^2) (Table 3).

The growth and yield parameters of mulberry clearly indicated that there was significantly increase in leaf yield, shoot yield, number of leaves per plant, 100 leaf weight and leaf area in crop residue fly ash fortified vermicompost. The increase in yield might be due to supplementation of major and minor nutrients. This in turn might have enhanced chlorophyll synthesis and triggered the physiological activity of plants by producing required auxins which might have influenced meristematic activity, expansion of cell and formation of cell wall, cell division and differentiation leading to higher leaf yield, shoot height, leaf area and leaf yield.

The literature on the use of fly ash fortified based vermicompost in mulberry is very scanty and hence, comparison was made with the available literature on other crops. The studies on effect of soil application vermicomposts from crop residue and municipal wastes fortified with fly ash on mulberry indicated that there was significant response for mulberry growth and yield parameters in CRVC10 followed by CRVC5, CRVC15 and MWVC10. Beneficial effects of fly ash fortified vermicompost emphasized by many researchers. Results are in conformity with Bhattacharya *et al.* (2012) [2] who reported that the application of fly ash fortified based vermicompost to soil enhanced the availability of three major nutrient elements viz. N, P and K and also helped to maintain low solubility of heavy metals like Pb, Cr and Cd in soil and he further emphasized on the fact that vermicomposted fly ash and organic matter (1:1) @ 10 t ha/year in potato yielded significant increase in crop yield due to enhanced soil fertility and reduced risk of heavy metal toxicity. Geetanjali *et al.* (2017) [3] observed significantly highest in plant height, number of leaves per plant, dry matter production and also highest average number of grain rows per cob, average number of grains per row and grain yield in maize in both the seasons by application of fly ash @ 15 t ha + municipal compost @ 15 t ha and fly ash @ 15 t ha + vermicompost @ 2.5 t ha.

In the current study, there was increased leaf yield and might be due to more number of shoots, higher average shoot length and more number of leaves per plant by following RDF along with 7.5 tons of vermicompost per hectare in CRVC10 treatment. Sannappa *et al*. (2005) [10] opined that the application of 50 per cent recommended N through vermicompost registered significantly higher plant height, number of shoots, number of leaves, leaf area and leaf yield in mulberry. Adriano *et al*. (1978) [1] noticed a significant increase in contents of soil available N, P, K and S with application of fly ash and fly ash addition generally increases plant growth and nutrient uptake. Weinstein *et al*. (1989) [14] reported that by application of fly ash there was increased number of pods / plant, shelling per cent and kernels weight due to greater accumulation of photosynthates in source and effective translocation of the assimilates to sink. Kale *et al*. (1991) [5] application of vermicompost was found to increase the levels of N and P in soil and improve the absorption of nutrients by plants and also increased the leaf yield, shoot yield, leaf area, number of leaves per plant and leaf weight in mulberry. Further, Murarkar *et al*. (1998) [7] reported that increase in growth and yield parameters of mulberry by applying recommended dose of NPK fertilizers (300:120:120 kg NPK /ha) + vermicompost of 6000 kg/ha/year.

Shrivastava *et al.* (2007) [11] noticed that growth behavior of tree species *Andrographis paniculata* has been studied with reference to the application of various levels of fly ash, which increases growth characteristics such as plant height, number of leaves, leaf area, leaf area per plant, fresh biomass, dry biomass by applying 10 per cent fly ash incorporation into soil. Yeledhalli *et al.* (2008) [15] obtained highest total yield in treatment receiving pond ash @ 40 t / ha / year in maize and sunflower. Plant growth and yield were significantly increased from 5 to 30% level in fly ash amended soil in egg plant noticed by Rizvi and Khan (2009) [9]. Katiyar *et al.* (2012) [6] reported that fly ash application increased the number of leaves, plant height, biomass and yield of three crop plants *viz.*, palak, mung bean and chilli by applying 25% fly ash amended soils. Rajashekhar (2017) [8] stated that effect of fly ash: vermicompost: soil in 1:3:1 ratio respectively recorded the highest germination percentage maximum number leaves, number branches, and root length and stem girth in *Simarouba gluca*.

During the process of vermicomposting, there was biotransformation of considerable amount of total nitrogen, phosphorus, potassium from fly ash into more soluble form and thus resulted in increased nutrient content in the vermicompost series as reported by Jeyasimga and Vasudevan (2017) [7]. Hence, above findings were clearly indicated that mulberry growth and yield was significantly superior in T_2: Vermicompost (produced from mixed crop residues along with fly ash fortification @ 10 %) + recommended dose of chemical fertilizers (CRVC10 + RDF) followed by T1:Vermicompost (produced from mixed crop residues along with fly ash fortification @ 10 %) + recommended dose of chemical fertilizers (CRVC10 + RDF).

Table 1: Comparative effect of fly ash fortified crop residue and municipal waste based vermicomposts on leaf yield, shoot yield and leaf to shoot ratio.

Treatment details	Leaf yield (g/plant)			Shoot yield (g/plant)			Leaf/shoot ratio		
	1st crop	2nd crop	Pooled	1st crop	2nd crop	Pooled	1st crop	2nd crop	Pooled
T_1: CRVC5 + RDF	913.33^{ab}	1030.00^{b}	971.67^{b}	743.33^{b}	818.33^{b}	780.83^{b}	1.22	1.26	1.24
T_2: CRVC10 + RDF	1063.33^{a}	1303.33^{a}	1183.33^{a}	883.33^{a}	988.33^{a}	935.83^{a}	1.20	1.32	1.26
T_3: CRVC15 + RDF	886.67^{bc}	1006.67^{bc}	946.67^{bc}	721.67^{b}	770.00^{bc}	745.83^{b}	1.23	1.31	1.27
T_4: CRVC + RDF	673.33^{def}	858.33^{cdef}	765.83^{d}	543.33^{cde}	591.67^{ef}	567.50^{de}	1.25	1.47	1.36
T_5: MWVC5 + RDF	648.33^{def}	841.67^{def}	745.00^{de}	511.67^{de}	628.33^{def}	570.00^{de}	1.26	1.34	1.30
T_6: MWVC10 + RDF	803.33^{bcd}	998.33^{bcd}	900.83^{bc}	651.67^{bc}	738.83^{bc}	695.25^{bc}	1.24	1.35	1.29

T_7: MWVC15 + RDF	771.67^{bcde}	893.33^{bcde}	832.50^{cd}	620.00^{bcd}	648.33^{cde}	634.17^{cd}	1.25	1.40	1.32
T_8: MWVC + RDF	631.67^{ef}	833.33^{ef}	732.50^{de}	496.67^{d}	595.00^{ef}	545.83^{ef}	1.27	1.44	1.36
T_9: RDF	561.67^{f}	723.33^{f}	642.50^{e}	421.67^{e}	521.67^{f}	471.67^{f}	1.34	1.40	1.37
CV (%)	11.69	9.87	8.25	11.96	10.53	7.54	4.43	10.59	5.37
S.Em (±)	52.16	53.74	40.84	42.91	42.54	28.77	0.03	0.08	0.04
CD @ 5%	156.39	161.10	122.44	128.64	127.55	86.26	NS	NS	NS

NS - Non significan

Table 2: Comparative effect of fly ash fortified crop residue and municipal waste based vermicomposts on number of leaves per plant, average shoots length per plant and 100 leaf weight.

Treatment details	**Number of leaves per plant**			**Average shoot length per plant (cm)**			**100 Leaf weight (g)**		
	1st crop	**2nd crop**	**Pooled**	**1st crop**	**2nd crop**	**Pooled**	**1st crop**	**2nd crop**	**Pooled**
T_1: CRVC5 + RDF	354.83^{ab}	403.00^{a}	378.92^{ab}	167.16^{ab}	156.89^{a}	162.02^{a}	270.48^{ab}	351.26^{ab}	310.87^{ab}
T_2: CRVC10 + RDF	425.83^{a}	429.50^{a}	427.67^{a}	172.96^{a}	168.11^{a}	170.53^{a}	290.49^{a}	383.43^{a}	336.96^{a}
T_3: CRVC15 + RDF	322.67^{bc}	378.00^{a}	350.33^{bc}	160.07^{abc}	153.60^{a}	156.84^{a}	254.52^{abc}	330.53^{abc}	292.53^{bc}
T_4: CRVC + RDF	251.50^{cd}	253.33^{b}	252.42^{de}	151.02^{abc}	148.59^{a}	149.81^{ab}	223.35^{cde}	281.75^{cde}	252.55^{ef}
T_5: MWVC5 + RDF	234.67^{e}	273.17^{b}	253.92^{de}	148.64^{bc}	147.63^{a}	148.13^{b}	219.85^{cde}	289.01^{cde}	254.43^{def}
T_6: MWVC10 + RDF	315.17^{bcd}	292.83^{b}	304.00^{cd}	163.93^{abc}	152.97^{a}	158.45^{ab}	249.67^{bcd}	325.42^{bc}	287.55^{bcd}
T_7: MWVC15 + RDF	308.33^{bcd}	278.83^{b}	293.58^{d}	161.51^{abc}	156.67^{a}	159.09^{ab}	227.73^{cde}	323.84^{bcd}	275.79^{cde}
T_8: MWVC + RDF	249.17^{de}	257.33^{b}	253.25^{de}	145.51^{bc}	145.57^{a}	145.54^{b}	214.86^{de}	269.37^{de}	242.11^{ef}
T_9: RDF	216.33^{e}	223.50^{b}	219.92^{e}	141.93^{c}	138.59^{a}	140.26^{b}	189.02^{e}	249.01^{e}	219.02^{f}
CV (%)	14.12	13.20	10.14	8.18	11.39	8.01	9.58	10.36	7.29
S.Em (±)	24.25	23.62	17.79	7.41	10.00	7.15	13.15	18.63	11.55
CD @ 5%	72.72	70.83	53.34	NS	NS	NS	39.44	55.87	34.64

NS - Non significant

Table 3: Comparative effect of fly ash fortified crop residue and municipal waste based vermicomposts on leaf area and leaf moisture content of mulberry leaves.

Treatment details	**Leaf area (cm^2)**		
	1st crop	**2nd crop**	**Pooled**
T_1: CRVC5 + RDF	218.41^{ab}	211.61^{ab}	215.01^{a}
T_2: CRVC10 + RDF	224.79^{a}	217.49^{a}	221.14^{a}
T_3: CRVC15 + RDF	214.11^{abc}	205.54^{abc}	209.83^{ab}
T_4: CRVC + RDF	202.39^{d}	176.75^{de}	189.57^{cd}
T_5: MWVC5 + RDF	203.53^{cd}	189.65^{bcd}	196.59^{cd}
T_6: MWVC10 + RDF	210.19^{bcd}	187.45^{cd}	198.82^{bc}
T_7: MWVC15 + RDF	208.46^{bcd}	182.13^{cd}	195.29^{cd}
T_8: MWVC + RDF	198.71^{de}	173.44^{de}	186.07^{d}
T_9: RDF	187.44^{e}	155.05^{e}	171.24^{e}
CV (%)	3.21	6.95	3.44
S.Em (±)	3.84	7.58	3.94
CD @ 5%	11.52	22.72	11.81

Conclusion
The technology of producing fly ash fortified vermicompost is simple, eco friendly and can be adopted by layman. The present study address the issue of agriculture utility of fly ash as well as municipal waste for increased recovery of micro and macronutrients.

References

1. Adriano RC, Wooford TA, Firavola TG. Growth and elemental of coal ash. J Environ. Qual. 1978; 7(3):416 - 421.
2. Bhattacharya SS, Iftikar W, Sahariah B, Chattopadhyay GN. Vermicomposting converts fly ash to enrich soil fertility and sustain crop growth in red and lateritic soils. Resources, Conservation and Recycling. 2012; 65:100-106.
3. Geetanjali, Narayana Rao K, Ravi MV, Ashok Kumar G, Mahadevaswamy, Kulkarni S. Effect of flyash and organic manures application on growth and yield of maize (*Zea mays* L.). Agric. Update. 2017; 12(5):1233-1236
4. Jeyasimga V, Vasudevan N. Vermicomposting of coal fly ash using *Eisenia foetida*: physico -chemical analysis. Int. Multidiscip. Res. J. 2017; 1(2):2456-4613.
5. Kale RD, Bano K, Satyavathi GP. Influence of vermicompost application on growth and yield of cereals, vegetables and ornamental plants. Final Report of Karnataka State Council for Sci Technol Project. 1991; 67(4): 343.
6. Katiyar D, Singh A, Malaviya P, Pant D, Singh P, Abraham G *et al*. Impact of fly ash-amended soil on growth and yield of crop plants. Int. J. Environ Waste Manag. 2012; 10(2, 3):150-162.
7. Murarkar SR, Tayade AS, Bodhade SN, Ulemale RB. Effect of vermicompost on mulberry leaf yield. J. Soils and Crops. 1998; 8(1):85-87.
8. Rajashekhar L. Effect of fly ash added pot mixture on growth and development of nursery seedlings of *Simarouba glauca*. J. Pharmacog. Phytochem. 2017; 6(5):1616-1621.
9. Rizvi R, Khan AA. Response of eggplant (*Solanum melongena L.*) to fly ash and brick kiln dust amended soil. Biol. Med. 2009; 1(2):20-24.
10. Sannappa B, Ramakrishna Naika, Govindan R, Jagadeesh Kumar TS, Venkataramna GV. Growth and yield taits of mulberry as influenced by different levels of vermicompost. Natl. Sem. Composting and Vermicomposting., CSR&TI, Mysore, 2005, 166.

11. Shrivastava SK, Prasad SVK, Kanungo VK. Impact of coal fly ash on the growth of Andrographis paniculata. Nat. Environ. Poll. Technol. 2007; 6(4):709-714.
12. Sudhir KJ, Venkata SK, Prasada Rao PVV. Management of municipal solid waste by vermicompost. Intl. J. Environ. Sci., 2010; 1:82-90.
13. Vimal K, Gopalkrishna J. Use of fly ash in agriculture (Indian scenario): International workshop on agricultural coal ash uses., Israel, 2014, 1-10
14. Weinstein LH, Osmeloski JF, Rutzke M, Beers AO, Mccahan JB, Bache CA *et al*. Elemental analysis of grasses and legumes growing on soil covering coal fly ash landfill sites. J Food Safety. 1989; 9(4):291-300.
15. Yeledhalli NA, Prakash SS, Ravi MV, Narayanarao K. Long term effect of fly ash on crop yield and soil properties. Karnataka. J Agri. Sci., 2008; 21(4):507-512.