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Effect of different proportion of fly ash and vermicompost on growth and yield of Senna in Semi-arid regions of India

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Abstract
The field experiment was conducted during 2016 at CSIR-Central Institute of Medicinal and Aromatic Plants, Research centre Hyderabad, to study the effect of different proportion of fly ash and vermicomposting on growth and yield of senna. Among the different treatment, Application of *i.e.*, T_{13} gave significantly higher leaf yield (1603.3 kg ha^{-1}) and Pod yield (340 kg ha^{-1}) compared to rest of the treatment and was on par with T_1 and T_2 with regard to leaf yield. Among different proportion of fly ash and vermicompost T_1 gave significantly higher leaf yield at 90 DAS (453.3 kg ha^{-1}), 115 DAS (568.0 kg ha^{-1}) and 140 DAS (492.3 kg ha^{-1}). Meanwhile, the total leaf yield is also significantly higher in case of T_1 compared to rest of the treatment and was on par with T_2 and T_3. Significantly lower leaf yield was noticed in treatment T_{12} in all the stages of harvesting 90 DAS (344.0 kg ha^{-1}), 115 DAS (354.7 kg ha^{-1}), 140 DAS (337.7 kg ha^{-1}) and Total leaf yield (1035.3 kg ha^{-1}). Similar trend was noticed with regard to pod yield with treatment T_{13} recorded significantly higher pod yield in all stages of harvest at 90 DAS (95 kg ha^{-1}), 115 DAS (135 kg ha^{-1}), 140 DAS (110 kg ha^{-1}) and Total pod yield (340.0 kg ha^{-1}). However significantly lower leaf yield and pod yield was noticed in treatment T_{13}.

Keywords: Senna, fly ash and vermicompost

Introduction
Senna {Cassia angustifolia (Vahl.)} is a branched bushy plant belonging to Caesalpinaceae sub group of family Leguminaceae. It bears compound, pinnate leaves, having 5 to 8 pairs of shortly stalked leaflets. It produces a long axillary or sub terminal racemes bearing many large brilliant yellow coloured showy flowers. It is well-known purgative drug in Ayurvedic and Unani systems of medicine and has been included in India, British and many other pharmacopoeias of the world. The leaves and pods are the economic parts containing sennosides which are responsible for its laxative properties. Besides, being an excellent laxative, senna is used as a febrifuge, in splenic enlargements, anaemia, typhoid, cholera, biliousness, jaundice, gout, rheumatism, tumours, foul breath and bronchitis and also in leprosy.

Thermal power stations use pulverized coal as fuel and produce enormous quantities of coal fly as has a byproduct of combustion. A 1000 MW power station with a normal daily consumption of 12000tons of coal produces about 2400 tones of fly ash a day (Chen *et al.* 2005) [1]. At present, about 80thermal power stations in India produce nearly 100 million tonnes of coal ash per annum (Pandian 2004) [2]. The huge quantity of fly ash produced in coal based thermal power plants poses a serious disposal and environmental problems. Its deposition on leaves inhibits the normal transpiration and photosynthesis of plants (Gupta *et al.* 2002) [3]. Most industrial by-products act as pollutants, yet some may be used profitably in agriculture provided that they are used scientifically and judicially (Raman *et al.* 1997) [4]. Fly ash is rich in various essential and non-essential elements but poor in nitrogen, available phosphorus and organic carbon (Gupta *et al.* 2002, Vijayan 2000) [3, 5]. Thus, it appears that fly ash materials have potential resources for the agricultural activities. The utilization of fly ash in India is considerably low (3-5%) when compared to developed countries (Vijayan 2000) [5]. Use of organic manures to meet the nutrient requirement of crop would be an inevitable practice in years to come for sustainable agriculture.

Fertilizer management is a key factor in the success of medicinal crop cultivation. Restricted use of chemical fertilizer and inclusion of organic materials in soil fertility management is emphasized especially for medicinal plants production because of the ever increasing demand for organically produced herbs. Little or no information is available for the effect of use of different proportion of fly ash and vermicompost on growth and yield of senna. Keeping this in view, the present investigation was carried out.

Material and methods

The field experiment was conducted at Central Institute of Medicinal and Aromatic Plants, Research centre, Hyderabad, India on a red sandy loam soil of poor fertility to study the effect of different proportion of fly ash and vermicompost on growth and yield of Senna in Semi-arid regions of India. Senna seed variety Sona was collected from CIMAP, Head quarter; Lucknow and the seeds were directly sown on the field with a spacing of 30 cm x 30 cm. The field was irrigated during initial weeks and one manual weeding was done 30 days after sowing. The field was laid out in randomized complete block design. The treatment included T_1:100 % application of vermicompost, T_2: 10 % application of fly ash and 90 % application of vermicompost, T_3: 20 % application of fly ash and 80 % application of vermicompost, T_4:30 % application of fly ash and 70 % application of vermicompost, T_5: 40 % application of fly ash and 60 % application of vermicompost, T_6: 50 % application of fly ash and 50 % application of vermicompost, T_7: 60 % application of fly ash and 40 % application of vermicompost, T_8:70 % application of fly ash and 30 % application of vermicompost, T_9:80 % application of fly ash and 20 % application of vermicompost, T_{10}:90 % application of fly ash and 10 % application of vermicompost, T_{11}:100% application of fly ash, T_{12}:Zero control and T_{13}: Fertilizer control (Application of RDF). Growth and yield attributing character were recorded at periodic interval at different stages of plant growth and data were subjected to statistical analysis following analysis of variance (ANOVA) technique as applicable to randomized block design. The statistical significance of the treatment differences was tested with least significant difference (LSD) values at 5% probability level (P=0.05).

Results and Discussion

The influence of different proportion of fly ash and vermicompost in enhancing the growth character *Viz.*, plant height, No. of branches, No. of leaves, leaf area and total dry matter was well evidenced in the present study. Among the different treatment application of recommended dose of fertilizer (T_{13}) recorded significantly higher plant height (60.7 cm) compared to rest of the treatment and was on par with all the treatment except treatment T_{12} and T_{11}. Among the different proportion of fly ash and vermicompost application of 100 % recommended dose of vermicompost recorded significantly higher plant height (56.9 cm) compared to T_{12} and was on par with rest of the treatment and was followed by T_2. Similarly application of recommended dose of fertilizer (RDF) recorded significantly higher number of branches (11.4) compared to rest of the treatment and was on par with T_1 (10.1) and T_2 (9.7). Whereas, significantly lower number of branches were noticed in T12 (3.5) and T11 (3.8). Similar trend was noticed with regard to No. of leaves, leaf area, total dry matter, weight of the pod and chlorophyll content with recommended dose of fertilizer recorded significantly higher number of leaves (164), leaf area (17.3 dm2 plant-1), Total dry matter (82.3 g plant^{-1}), weight of pod (12.0 g) and chlorophyll content (11.8 mg g-1) compared to rest of the treatment and was on par with T_1, T_2 and T_3 respectively. Among different proportion of fly ash and vermicompost application of 100 % application of vermicompost recorded significantly higher number of leaves (144), leaf area (16.5 dm^2 plant^{-1}), Total dry matter (79.1 g plant^{-1}), weight of the pod (11.1 g) and Chlorophyll content (11.4 mg g^{-1}). This increase in growth parameter in application of 100 % vermicompost might be due to fact that nutrient released from both organic and inorganic fertilizers would have resulted in the increased nutrient availability, ascribed to improvement in soil health and supplied both macro and micro nutrients, which in turn enhanced the translocation of photosynthates and improved vegetative grow that tributes. The similar finding had been reported by Nadukeri (2006) [6] in coleus, Joy *et al*. (2005) [7] in black musli. In improving the growth characters, the INM treatments ie., application of 75 per cent RDF along with organic sources either as vermicompost or FYM ensured continuous supply of nutrient resulting in better growth (Panwar *et al*., 2001) [8]. The increase in number of laterals resulted in more branches which might be attributed to sufficient quantity of nutrient flow in the plants treated with organic manures and humic acid as evidenced by Kale *et al*. (1987) [9]. These results are in corroborate with the findings Atiyeh *et al*. (1999) [10] and he reported that Incorporation of vermicompost promoted plant growth due to the presence of auxin, cytokinin, vitamins and enzymes.

Yield of Senna leaves and pods

Among different treatment the application of recommended dose of fertilizer gave significantly higher leaf yield compared to rest of the treatment at 90 DAS (485.7 kg ha^{-1}), 115 DAS (585 kg ha^{-1}) and 140 DAS (533 kg ha^{-1}). Similarly, the higher leaf yield was noticed in T_{13} with application of recommended dose of fertilizer. Among different proportion of fly ash and vermicompost T_1 gave significantly higher leaf yield in 90 DAS (453.3 kg ha^{-1}), 115 DAS (568.0 kg ha^{-1}) and 140 DAS (492.3 kg ha^{-1}). Meanwhile, the total leaf yield is also significantly higher in case of T_1 compared to rest of the treatment and was on par with T_2 and T_3. Significantly lower leaf yield was noticed in treatment T_{12} in all the stages of harvesting 90 DAS (344.0 kg ha^{-1}), 115 DAS (354.7 kg ha^{-1}), 140 DAS (337.7 kg ha^{-1}) and Total leaf yield (1035.3 kg ha^{-1}). Similar trend was noticed with regard to pod yield with T_{13} recorded significantly higher pod yield in all stages of harvest 90 DAS (95 kg ha^{-1}), 115 DAS (135 kg ha^{-1}), 140 DAS (110 kg ha^{-1}) and Total pod yield (340.0 kg ha^{-1}). However among different proportion of fly ash and vermicompost 100 %application of vermicompost gave significantly higher pod yield in all the stages 90 DAS (104.0 kg ha^{-1}), 115 DAS (118.0 kg ha^{-1}), 140 DAS (112.3 kg ha^{-1}) and total pod yield (334.3 kg ha^{-1}) compared to T_{12} (288.3 kg ha^{-1}), T_{11} (302.0 kg ha^{-1}), T_{10} (304.3 kg ha^{-1}) and T_9 (305.7 kg ha^{-1}) and was on par with rest of the treatment. This increase in senna leaf yield and pod yield might be due to fact that FYM, vermicompost in combination with chemical fertilizers had increased the uptake of major nutrients in the presence of humusforming microbes and growth inducing substances. These results are in the line with the findings of Arul (2002) inashwagandha. Thus, it can be concluded that alone application 100 % vermicompost and proportion of 90 % vermicompost and 10 % fly ash gave significantly higher senna leaf yield and pod yield in Semi arid region of India.

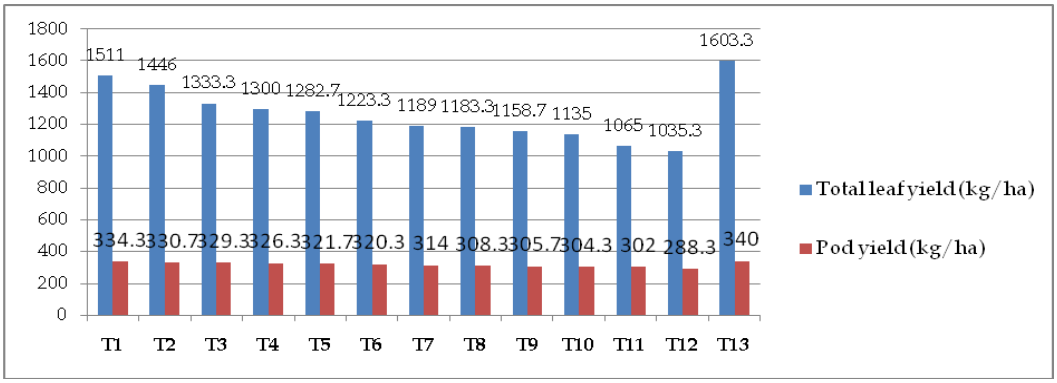

Fig 1: Effect of different proportion of fly ash and vermicompost on leaf and pod yield of senna

Table 1: Effect of different proportion of fly ash and vermicompost on growth parameters of *Cassia angustifolia*

Treatment	Plant height (cm)	No. of branches	No. of leaves	Leaf area (dm^2 $plant^{-1}$)	Total dry matter (g $plant^{-1}$)	Weight of the pod (g)	Chlorophyll content (mg g^{-1})
T1	56.9	10.1	144	16.5	79.1	11.1	11.4
T2	56.0	9.7	121	14.6	78.9	9.7	11.2
T3	52.8	9.0	117	14.5	75.1	9.0	11.1
T4	52.1	8.9	114	14.9	73.4	8.9	11.2
T5	50.1	8.3	108	14.6	69.2	8.3	10.9
T6	50.2	7.4	65	13.5	67.6	7.4	10.3
T7	55.6	6.7	88	13.7	59.3	6.3	10.3
T8	48.5	5.7	77	13.9	57.6	5.7	10.3
T9	49.5	4.2	73	14.3	56.0	4.2	10.2
T10	48.9	3.6	74	13.8	55.7	3.6	10.1
T11	47.3	3.8	70	13.4	50.7	3.1	10.1
T12	43.9	3.5	64	11.0	48.5	2.6	10.1
T13	60.7	11.4	164	17.3	82.3	12.0	11.8
SEm±	4.2	0.6	8	1.0	4.4	0.6	0.16
CD (P=0.05)	12.3	1.7	25	2.9	12.8	1.9	0.47

T_1:100 % application of vermicompost, T_2: 10 % application of fly ash and 90 % application of vermicompost, T_3: 20 % application of fly ash and 80 % application of vermicompost, T_4:30 % application of fly ash and 70 % application of vermicompost, T_5: 40 % application of fly ash and 60 % application of vermicompost, T_6: 50 % application of fly ash and 50 % application of vermicompost T_7: 60 % application of fly ash and 40 % application of vermicompost, T_8:70 % application of fly ash and 30 % application of vermicompost, T_9:80 % application of fly ash and 20 % application of vermicompostT_{10}:90 % application of fly ash and 10 % application of vermicompost, T_{11}:100% application of fly ash, T_{12}:Zero control, T_{13}: Fertilizer control (Application of RDF)

Table 2: Effect of different proportion of fly ash and vermicompost on leaf yield and pod yield of *Cassia angustifolia*

Treatment	Yield of senna leaves (kg/ha)				Yield of pod (kg/ha)			
	90 DAS	115 DAS	140 DAS	Total leaf yield	90 DAS	115 DAS	140 DAS	Total pod yield
T1	453.3	568.0	492.3	1511.0	104.0	118.0	112.3	334.3
T2	439.0	532.3	475.7	1446.0	98.7	124.7	108.0	330.7
T3	401.7	500.0	432.0	1333.3	95.3	115.0	119.3	329.3
T4	414.0	475.7	411.3	1300.0	88.3	109.0	129.3	326.3
T5	412.7	452.0	419.7	1282.7	91.7	103.7	127.3	321.7
T6	391.3	432.3	400.0	1223.3	87.0	98.7	135.0	320.3
T7	385.3	415.0	389.0	1189.0	86.7	95.0	133.7	314.0
T8	383.7	414.0	386.0	1183.3	81.0	93.0	134.0	308.3
T9	369.0	411.3	379.0	1158.7	79.3	88.0	138.3	305.7
T10	357.0	405.7	373.3	1135.0	75.7	89.3	140.0	304.3
T11	350.0	364.0	351.0	1065.0	88.0	75.3	139.0	302.0
T12	344.0	354.7	337.7	1035.3	89.7	92.7	107.7	288.3
T13	485.7	585.0	533.0	1603.3	95.0	135.0	110.0	340.0
SEm±	7.72	9.37	7.25	71.00	3.28	4.87	5.61	9.11
CD (P=0.05)	22.54	27.34	21.16	207.23	9.58	14.21	16.36	26.59

DAS; Days after sowing

T_1:100 % application of vermicompost, T_2: 10 % application of fly ash and 90 % application of vermicompost, T_3: 20 % application of fly ash and 80 % application of vermicompost, T_4:30 % application of fly ash and 70 % application of vermicompost, T_5: 40 % application of fly ash and 60 % application of vermicompost, T_6: 50 % application of fly ash and 50 % application of vermicompost T_7: 60 % application of fly ash and 40 % application of vermicompost, T_8:70 % application of fly ash and 30 % application of vermicompost, T_9:80 % application of fly ash and 20 % application of vermicompostT_{10}:90 % application of fly ash and 10 % application of vermicompost, T_{11}:100% application of fly ash, T_{12}:Zero control, T_{13}: Fertilizer control (Application of RDF)

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