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Influence of cadmium and FYM on growth, yield and quality of fodder sorghum

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Abstract

In order to evaluate the effects of different combinations of cadmium and FYM on growth parameters, yields and quality parameters of semi *rabi* sorghum (*var.* Gundari), a pot experiment was conducted at Junagadh Agriculture University, Junagadh. The treatments comprising of different five levels of cadmium *viz.*, 0, 10, 20, 40 and 80 mg kg⁻¹ and three levels of farmyard manure *viz.*, 0, 10 and 20 t ha⁻¹ in Completely Randomization Design (Factorial) repeated thrice. The result revealed that higher value of growth, yield and quality parameters were achieved in treatment Cd₀ (0 mg Cd kg⁻¹) and decreased with increasing levels of Cd from 0 to 80 mg kg⁻¹. The highest values of growth, yield and quality parameters were achieved under the application of 20 t FYM ha⁻¹ (F₂₀). Among all treatment combinations, the highest values of plant height, number of leaves, stem diameter, dry leaves, dry stem, dry root yield, green forage yield and dry matter yield were observed with treatment combination F₂₀Cd₀. However, interaction effect of Cd and FYM was found non-significant with respect to quality parameters *viz.*, crude protein, crude fiber and ash content of sorghum at harvest.

Keywords: Sorghum, cadmium, FYM, yield, quality parameters

Introduction

Among metal pollutants, cadmium is toxic to human beings, animals and plants and has to be prevented from entering the food chain as it adversely affects the plant growth as well as human health. Though it occurs naturally in soil, its addition as a pollutant has increased in recent times causing cancer. This has necessitated research on Cd added to soil. It is a naturally found in soil as mineral combined with other element such as oxygen, chlorine or sulphur.

Phytostabilization involves the reduction of the mobility of heavy metals in soil. Immobilization of metals can be reducing contaminant solubility or bioavailability to the food chain. The addition of organic matter can decrease solubility of metals in soil and minimize leaching to groundwater. The mobility of contaminants is reduced by the accumulation of contaminants by plant roots, absorption onto roots, or precipitation within the root zone. The availability of Cd in soil and uptake by plants depend upon pH, organic matter content, CEC, soil type and plant species, among this organic material is an important.

Farmyard manure is a cheap source of primary, secondary and micronutrients to the plant growth. It is a constant source of energy for heterotrophic microorganisms, help in increasing the availability of nutrient and quantity of crop produce. It improves the crop production (Kaihura *et al.*, 1999)^[7] and can be used to reduce heavy metals hazards in plants (Yassen *et al.*, 2007)^[22]. The OM with reactive groups such as hydroxyl, phenoxy and carboxyl effectively controls the adsorption and complexation of heavy metal and the activity of metal in the soil (Mahmood, 2010)^[12]. Keeping all the above aspects in view and in order to test the combine effect of both factors with its various levels of application, an investigation was carried out to study the "Effect of cadmium and FYM on growth, yield and quality parameters of forage sorghum in medium black calcareous soil".

Materials and Methods

A pot experiment was conducted on semi *rabi* sorghum (*var.* Gundari) at Department of Agricultural Chemistry and Soil Science, College of Agriculture, Junagadh Agricultural University, Junagadh, during semi *rabi* seasons of 2019. The experimental soil was medium black calcareous, clayey in nature.

Which was slightly alkaline in reaction, pH_{2.5} 7.9 and EC_{2.5} 0.28 dS m⁻¹, medium in available nitrogen (249 kg ha⁻¹) and phosphorus (32.20 kg ha⁻¹), and high in available potassium (316 kg ha⁻¹) and sulphur (25.50 mg kg⁻¹). Micronutrient status was medium in DTPA iron (9.0 mg kg⁻¹) and zinc (0.85 mg kg⁻¹), high in DTPA manganese (12.6 mg kg⁻¹) and copper (1.84 mg kg⁻¹) and low in DTPA cadmium (0.08 mg kg⁻¹). The treatments comprising all possible combination of five levels of cadmium *viz.*, 0, 10, 20, 40 and 80 mg kg⁻¹ and three levels of farm yard manure (FYM) *viz.*, 0, 10 and 20 t ha⁻¹ in Completely Randomization Design (Factorial) with three replications.

Forty-five pots were filled with each 2 mm sieved soil bulk of 15 kg in each polythene lined earthen pots. Calculated quantities of graded levels of Cd (Cd₀, Cd₁₀, Cd₂₀, Cd₄₀ and Cd₈₀) in the form of 3CdSO₄.7H₂O and FYM (0, 10 and 20 t ha⁻¹) were added. FYM and Cd were mixed properly as per treatments and kept it for stabilization for one month period. After stabilization of Cd and FYM recommended dose as N and P were applied in the form of Urea and DAP before sowing. The pots were brought to desired moisture level (Field capacity) and 12 seeds of sorghum were sown on 01/10/2019 in each pot. After germination, sorghum plants were thinned to 8 plants per pot. Top dressing of nitrogen was applied through Urea at 30 DAS. The observation like plant height at 30 and 60 DAS, and leaf number and stem diameter at the time harvesting were taken according with the growth of crop. When the sorghum was at booting stage (60 DAS), the plants uprooted carefully. The fresh and oven dry weight of leaves, stem and roots were recorded from each pot and quality parameters *viz.* crude protein, crude fiber and ash content were estimated.

Results and Discussion

Effect of Cd and FYM on growth parameters

Effect of Cd

The values of plant height (at 30 and 60 DAS), number of leaves and stem diameter were significantly influence by Cd application. The highest value of plant height at 30 DAS (77.5 cm), 60 DAS (123 cm), number of leaves (7.9) and stem diameter (6.1 mm) at 60 DAS (harvest) was observed in treatment Cd₀ (0 mg Cd kg⁻¹). While, the least value of plant height at 30 DAS (61.9 cm), 60 DAS (98 cm), number of leaves (6.4) and stem diameter (4.7 mm) was observed in treatment Cd₈₀ (80 mg Cd kg⁻¹). However, it was statistically at par with treatment Cd₁₀ for all these parameters (Table 1). The reduction in growth parameters due to increasing levels of Cd application rates was reported by Gupta and Dixit (1992)^[5] for sorghum, pearl millet, maize, green gram, cluster bean, cowpea crops and Liu *et al.* (2011)^[10] for sorghum. This reduction in plant height may be due to increased level of Cd content in shoot and other plant parts, which interfered in translocation of various metabolites and nutrients (Mahler *et al.*, 1978)^[11]. The plant height reduction also correlated with photosynthetic processes. The net photosynthesis and chlorophyll content in plant generally decreased with Cd concentration. This inhibition may be primarily attribute to the closure of stomata (Huang *et al.*, 1974)^[6].

Effect of FYM

The values of plant height (at DAS and 60 DAS), stem diameter and number of leaves were significantly affected by FYM levels and found to be increased with each unit increment in levels of FYM (Table 1). The highest value of plant height at 30 DAS (76.1 cm), 60 DAS (120 cm), number

of leaves (7.8) and stem diameter (6.1 mm) at 60 DAS (harvest) was achieved under the application of 20 t FYM ha⁻¹ (F₂₀). While, the least values of plant height at 30 DAS (64.6 cm), 60 DAS (102 cm), number of leaves (6.5) and stem diameter (4.9 mm) was observed with the treatment having no FYM (F₀). The increase in plant height with application of FYM could be mainly due to improvement in physico-chemical and biological properties of soil due to increased organic carbon status of soil and supplying secondary and micronutrients. Similar results were also reported by Yassen *et al.* (2007)^[22], Ranpariya *et al.* (2017)^[18], Babaria *et al.* (2010)^[2] and Sapana *et al.* (2020)^[19].

Effect of Cd × F interaction

The faced interaction effect was found significant on growth parameters (Table-2). Among all treatment combinations, higher value of plant height at 30 (79.6 cm) and 60 DAS (127 cm), number of leaves (8.2) and stem diameter (6.6 mm) was observed with treatment combination F₂₀Cd₀. While, lower value of plant height at 30 (51 cm) and 60 DAS (81 cm), number of leaves (5.2) and stem diameter (3.7 mm) observed in treatment combination Cd₈₀F₀. Application of FYM may reduce the toxicity of Cd through phytostabilization of Cd in soil and thus increased growth parameters (Patel *et al.*, 2018)^[15]. Similar results were also reported by Singh and Agrawal (2011)^[20] in palak.

Effect of Cd and FYM on yields

Effect of Cd

The results furnished in Table 2 revealed that the application of Cd significantly reduced the dry leaves, stem, root yields, green forage yield and dry matter yield of sorghum. The highest value of dry leaves (66.91 g pot⁻¹), dry stem (47.44 g pot⁻¹), dry root (15.75 g pot⁻¹) yield, green forage yield (301 g pot⁻¹) and dry matter yield (130 g pot⁻¹) were registered in the treatment Cd₀ (0 mg Cd kg⁻¹). This reduction in dry matter yield might be due to increased level of Cd content in shoot and other plant parts, which interfered with translocation of various metabolites and nutrients (Mahler *et al.*, 1978)^[11]. These results were in conformity with the findings of Patel *et al.* (2017)^[16] in fodder maize and sorghum and Adam *et al.* (2017)^[1] in rice.

Effect of FYM

The dry leaves, stem, root yield, green forage yield and dry matter yield (Table 2) of sorghum plant increased with increasing the application of FYM. The highest value of dry leaves (65.17 g pot⁻¹), dry stem (46.84 g pot⁻¹), dry root (15.39 g pot⁻¹) yield, green forage yield (283 g pot⁻¹) and dry matter yield (127 g pot⁻¹) were registered in the FYM application 20 t ha⁻¹ (F₂₀). Higher yields with FYM application might be due to its contribution in supplying additional plant nutrients, improvement of soil physical conditions and biological processes in soil. The results can be easily explained in light of the findings of Sapana *et al.* (2020)^[19], Patel *et al.* (2017)^[16], Ranpariya *et al.* (2017)^[18] and Sushila and Giri (2000)^[21].

Effect of Cd × F interaction

The interaction effects of Cd × F was found to be significant with respect to dry leaves, stem, root yield, green forage yield and dry matter yield of sorghum (Table -3 & 4). Among all fifteen treatment combinations, Cd₀F₂₀ recorded significantly the maximum dry leaves (68.7 g pot⁻¹), dry stem (49.49 g pot⁻¹), dry root (16.2 g pot⁻¹) yield (Table-3) as well as green forage (317 g pot⁻¹) and dry matter (134 g pot⁻¹) yield (Table-

4). Farmyard manure (FYM) improves the crop production (Kaihura *et al.*, 1999) [7] as well as improves soil physical properties (Chen *et al.*, 1996) [3] and can be used to reduce heavy metal hazards in plants (Yassen *et al.*, 2007) [22]. Organic matter with respective groups such as hydroxyl, phenolic and carboxyl effectively controls the adsorption and complexation of heavy metal and the activity of metal in the soil (Lee *et al.*, 2004 and Mahmood, 2010) [9, 12]. These findings were corroborated the results of Patel *et al.* (2018) [15] reported in forage sorghum and maize.

Effect of Cd and FYM on quality parameters

Effect of Cd

The results furnished in Table-1 revealed that the application of Cd significantly reduced the quality parameters of sorghum. The quality parameters were decreased with the increasing levels of Cd. The highest value of crude protein (12.72 %), crude fiber (30.78 %) and ash content (9.57 %) was achieved in the treatment Cd₀ (0 mg Cd kg⁻¹). The decrease in quality parameters due to increased Cd level could partly be owing to its toxic effect and partly due to its ionic imbalance (Dahiya *et al.*, 1987) [4]. These results were in

conformity with these of Prince *et al.* (2002) [17].

Effect of FYM

The quality parameters were significantly influence due to FYM application (Table 1). The quality parameters were increased with increasing levels of FYM. The highest value of crude protein (12.63 %), crude fiber (31.37 %) and ash content (10.50 %) were achieved in the application 20 t FYM ha⁻¹ (F₂₀). FYM is the source of primary, secondary and micronutrients to the plant growth. It is a constant source of energy for heterotopic microorganisms, helps in increasing the availability of nutrient and quality of crop produce (Patel *et al.*, 2017) [16]. Similar results were found by Patel and Patel (1992) [14], Marvaniya *et al.* (2016) [13] and Kumar *et al.* (2002) [17].

Effect of Cd × F interaction

The interaction effects of Cd × F were found to be non-significant with respect to quality parameters *viz.*, crude protein, crude fiber and ash content of sorghum at harvest (Table 1).

Table 1: Effect of cadmium and FYM on growth, yield and quality parameters of forage sorghum

Treatments	Plant height at 30 DAS (cm)	Plant height at 60 DAS (cm)	No. of leaves	Stem diameter (mm)	Dry leaves yield (g pot ⁻¹)	Dry stem yield (g pot ⁻¹)	Dry root yield (g pot ⁻¹)	Dry matter yield (g pot ⁻¹)	Green forage yield (g pot ⁻¹)	Crude protein (%)	Crude fiber (%)	Ash content (%)
Cadmium levels												
Cd ₀ : 0 mg kg ⁻¹	77.5	123	7.9	6.1	66.91	47.44	15.75	130	301	12.72	30.78	9.57
Cd ₁₀ : 10 mg kg ⁻¹	76.2	120	7.6	6.0	65.86	46.40	15.41	128	291	12.54	29.84	9.50
Cd ₂₀ : 20 mg kg ⁻¹	73.3	116	7.4	5.8	63.06	44.87	14.79	123	267	12.21	28.83	9.34
Cd ₄₀ : 40 mg kg ⁻¹	68.3	108	6.9	5.3	58.74	41.76	13.73	114	232	11.72	26.96	9.03
Cd ₈₀ : 80 mg kg ⁻¹	61.9	98	6.4	4.7	49.50	35.70	11.61	97	176	11.05	24.54	8.59
S.Em.±	1.0	1.5	0.1	0.1	0.92	0.55	0.22	1.33	4.84	0.13	0.39	0.10
CD at 5 %	2.9	4	0.3	0.2	2.65	1.60	0.63	4	14	0.38	1.13	0.29
FYM levels												
F ₀ : 0 t ha ⁻¹	64.6	102	6.5	4.9	56.88	39.34	13.01	109	220	11.56	25.51	8.40
F ₁₀ : 10 t ha ⁻¹	73.5	116	7.4	5.6	60.39	43.52	14.38	118	258	11.96	27.68	8.72
F ₂₀ : 20 t ha ⁻¹	76.1	120	7.8	6.1	65.17	46.84	15.39	127	283	12.63	31.37	10.50
S.Em.±	0.8	1.1	0.1	0.1	0.71	0.43	0.17	1.03	3.75	0.10	0.30	0.08
CD at 5 %	2.2	3	0.3	0.2	2.05	1.24	0.49	3	11	0.30	0.87	0.22
Cd × F												
S.Em.±	1.7	2.6	0.2	0.1	1.59	0.96	0.38	2.30	8.38	0.23	0.68	0.17
CD at 5 %	4.9	7	0.6	0.4	4.59	2.77	1.09	7	24	NS	NS	NS
CV %	4.2	4.0	4.7	3.8	4.52	3.84	4.58	3.37	5.73	3.32	4.16	3.27

Table 2: Interaction effect of cadmium and FYM on plant height and number of leaves of sorghum

Treatments	Plant height (cm) At 30 DAS					Plant height (cm) At 60 DAS					No. of leaves At 60 DAS					Stem diameter (mm) At 60 DAS				
	Cd ₀	Cd ₁₀	Cd ₂₀	Cd ₄₀	Cd ₈₀	Cd ₀	Cd ₁₀	Cd ₂₀	Cd ₄₀	Cd ₈₀	Cd ₀	Cd ₁₀	Cd ₂₀	Cd ₄₀	Cd ₈₀	Cd ₀	Cd ₁₀	Cd ₂₀	Cd ₄₀	Cd ₈₀
F ₀	73.3	71.6	67.2	5.7	5.7	5.7	5.7	5.7	95	81	7.5	7.2	6.9	6.1	5.2	5.7	5.5	5.3	4.5	3.7
F ₁₀	79.4	77.7	75.4	6.1	6.1	6.1	6.1	6.1	111	102	7.9	7.7	7.5	7.2	6.7	6.1	6.0	5.8	5.4	4.9
F ₂₀	79.6	79.1	77.2	6.6	6.6	6.6	6.6	6.6	118	111	8.2	8.0	7.9	7.4	7.2	6.6	6.5	6.2	5.9	5.5
Cd × F																				
S.Em.±	1.7					2.7					0.2					0.1				
CD at 5 %	4.9					7					0.6					0.4				

Table 3: Effect of cadmium and FYM on dry leaves, stem and root yield (g pot⁻¹) of forage sorghum

Treatments	Leaves					Stem					Root				
	Cd ₀	Cd ₁₀	Cd ₂₀	Cd ₄₀	Cd ₈₀	Cd ₀	Cd ₁₀	Cd ₂₀	Cd ₄₀	Cd ₈₀	Cd ₀	Cd ₁₀	Cd ₂₀	Cd ₄₀	Cd ₈₀
F ₀	65.7	64.1	60.5	53.9	40.1	45.64	43.86	41.50	37.33	28.38	15.5	14.8	13.7	12.4	8.7
F ₁₀	66.4	65.2	61.8	58.3	50.3	47.19	46.54	45.38	42.28	36.20	15.6	15.3	15.0	13.8	12.3
F ₂₀	68.7	68.3	66.8	64.0	58.1	49.49	48.78	47.74	45.68	42.52	16.2	16.1	15.7	15.0	13.9
Cd × F															
S.Em.±	1.6					0.96					0.4				
CD at 5 %	4.6					2.77					1.1				

Table 4: Interaction effect of cadmium and FYM on stem diameter, dry matter yield and green forage yield of sorghum

Treatments	Green forage yield (g pot ⁻¹) At 60 DAS					Dry matter yield (g pot ⁻¹) At 60 DAS				
	Cd ₀	Cd ₁₀	Cd ₂₀	Cd ₄₀	Cd ₈₀	Cd ₀	Cd ₁₀	Cd ₂₀	Cd ₄₀	Cd ₈₀
F ₀	286	270	240	186	119	126	123	116	104	77
F ₁₀	299	294	268	241	186	129	127	122	114	99
F ₂₀	317	310	294	270	222	134	133	130	125	115
Cd x F										
S.Em.±	8.38					2.30				
CD at 5 %	24					7				

Conclusion

The experimental results revealed that application of Cd 80 mg kg⁻¹ in soil significantly reduced and plant height at 30 and 60 DAS, leaf number and stem diameter as well as quality parameters *viz.*, crude protein, crude fiber and ash content of forage sorghum over other levels of cadmium. The effect mitigated by FYM application 20 t ha⁻¹. In absence of cadmium (Cd₀) the crops recorded maximum of plant height at 30 and 60 DAS, leaf number and stem diameter as well as quality parameters. The dry matter yield of shoot, root and total dry matter as well as green forage yield also followed the same trend. If we look through the data even application of Cd 10 ppm had significant depressing effect on all the parameters measured.

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