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Effect of acidified press mud on growth of *Emblica officinalis* (Aonla) and soil properties in the semi-arid region

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Abstract
A field experiment was conducted on sandy loam calcareous soil in Palwan village of district Jind, Haryana in order to study the effect of four levels of Acidified Press Mud (APM) viz., 0, 5.0, 10.0 and 15.0 kg APM/ plant on growth of aonla (*Emblica officinalis*) and soil properties. In the study, it was observed that application of 15.0 kg APM/plant of aonla gave significantly higher mean growth (height 342.25 cm and girth 23.75 cm) over control. The mean increase in aonla height with the application of 15.0, 10.0 and 5.0 kg APM/plant over the control was 53.87, 29.89 and 13.48%, respectively. Application of 15.0 kg APM/plant registered an increase of 80.88% in aonla girth over the control. The concentration of all the nutrients (N, P, K, Ca, Mg, Zn, Fe, and Mn) in aonla plants were significantly increased with increased levels of APM/plant over the control, while concentration of Na in aonla plants decreased with increased levels of APM/plant. The availability of N, P, K and Ca + Mg in soil also found to increase significantly with increasing levels of APM application. However, Na content in soil was decreased with increasing levels of APM over control. The pH of the soil was decreased from 8.43 in no APM to 7.43 in 15.0 kg APM/plant. The electrical conductivity and organic C content of the soil were also significantly increased with increasing levels of APM/plant. The availability of the micronutrients (Zn, Fe and Mn) in soil recorded significantly higher levels with increasing levels of APM/plant over the control. This study suggests that the application of APM can enhance the aonla growth in poor fertile calcareous soils by improving soil fertility.

Keywords: Acidified press mud, aonla, calcareous soil, nutrient availability, soil properties

Introduction
The alluvial soils of India occurring in arid and semi arid regions of Haryana State have many constraints for satisfactory agricultural production. The prominent problems for practicing agriculture in such area include scarcity of good quality irrigation water, low rainfall, low permeability and high exchangeable sodium in soil, saline ground water, presence of *Kankar* in the root zone, high temperature during summer, low organic carbon content and poor fertility status of the soil. The presence of excess calcium carbonate further complicates the problem as it adversely affects the status of available nutrients. Although cotton tolerates higher salinity water but this crop is most uncertain as it gets attacked by many pests and diseases. Many a times the attack of pests is so high which destroy whole crop and the yield is very less to recover even the cost of cultivation. So, to reduce the heavy risk of total failure of cotton crop, there is a need for crop diversification by introducing other crops preferably some fruit trees which require less amount of water. Sulphur is known to play a role as an amendment in alkaline calcareous soils. Under such situations, press mud (also called filter cake or filter mud) is a solid waste and produced by the sugar mills. It is an enrichment source of organic matter and other nutrients such as N, P, K, Ca, Mg, Fe, Zn, Cu and Mn and can be applied to soils for improvement of physical, chemical and biological properties (Nehra and Hooda, 2002; Jamil *et al*., 2008; Muhammed and Khattak 2011) [11, 4, 9]. It also contains sulphur which helps to acidify the soil. These sugar factories use sulphur in the sulphitation process while preparing sugar from sugar cane juice. To increase the effectiveness of press mud, it is normally treated with low cost sulphuric acid and the product is named as acidified press mud (APM) having pH 2.0 to 4.0 which can be used for improving sodic soils and water (Mehta, 2004) [8]. In India, there are more than 730 sugar mills producing more than 14850 thousands matric tonnes of press mud every year. Some part of this huge quantity of press mud can be converted into APM for using it as amendment for improving sodic soils and water. It is also a useful source of organic carbon which helps to increase the soil organic carbon content.

Being acidic in nature, it can dissolve some of the calcium carbonate in calcareous soils and likely to decrease soil pH and thus can increase the available nutrients in the soil. Keeping this in view, a field experiment was conducted to study the effect of APM on growth of aonla, soil properties and nutrients availability in the semi-arid region of the India.

Materials and Methods

A field experiment was conducted during July 2016 to June 2018 on farmer's field in Palwan village of district Jind (Haryana). Initial soil analysis showed that it belongs to sandy loam texture having 8.47 pH, 0.69 dSm^{-1} EC, 0.32% organic C, 82.5 kg ha^{-1} available N, 9.3 mg kg^{-1} Olsen's P; 8.4, 1385.7 and 21.5 mg kg^{-1} soil saturated extracted K, Na and Ca + Mg, respectively; and 0.80, 12.15, 31.60 and 2.90 mg kg^{-1} DTPA extracted Zn, Fe, Mn and Cu, respectively. Initially, there were 80 aonla plants planted by pit method (1m x 1m x 1m) on 0.4 ha by keeping the distance of 10 m x 5 m (R x P) in August 2014. After the growth of two years, sixteen aonla plants of approximately same height (161 cm) were selected for this experiment in July 2016. The treatments consisted of four levels of acidified press mud (APM), viz., 0, 5.0, 10.0 and 15.0 kg APM/plant. Each treatment was replicated four times in completely randomized block design. The aonla plants received recommended doses of N (100 g/plant) and P (50 g/plant) through urea and di- ammonium phosphate, respectively. The APM was applied by mixing in upper soil surface (0- 15 cm) in one meter area around the aonla plants. The area received very little rainfall and the ground water is highly saline (EC 6.0 dSm^{-1}). The plants were irrigated through drip irrigation during establishment and growth period using canal water (EC 0.26 dSm^{-1}) stored in concrete tank. The height, girth and branches per plant of aonla plants were recorded in July 2016 and in June 2018. The leaves of the plants and surface soil samples were collected for nutrients analysis in June 2018. The leaves of the plants were oven dried, grounded and passed through 16 mesh sieve for the determination of nutrients concentration in plants. The concentration of nitrogen in plant samples were determined by using Kjeldahal method. For the other nutrients, the samples were digested in di-acid (HNO_3: $HClO_4$, 3:1) and concentration of P, K, Ca, Mg, Zn, Mn, Fe, Cu and Na were determined by using standard procedures. Surface (0-15 cm) soil samples were collected from 30 cm distance of the plants. The soil pH, EC, organic C, available N, Olsen's P; K, Ca + Mg and Na in soil saturated extracts and DTPA extractable Zn, Mn, Fe and Cu were determined by standard procedures (Jackson, 1973) [3]. Press mud (pH 6.8) was brought from Karnal Co-operative sugar mill and Acidified Press Mud (pH 4.0) was prepared by mixing low cost commercial grade sulphuric acid as described by Mehta (1998) [7]. The composition of the prepared APM was 4.0 pH, 9.0 dSm^{-1} EC, 24.23% organic C, 1.55% total N, 0.74% total P, 0.34% total K, 1021 mg kg^{-1} total Fe, 54 mg kg^{-1} total Zn, 124 mg kg^{-1} total Mn and 37 mg kg^{-1} total Cu.

Results and Discussion

Effect of acidified press mud

Growth

Application of APM had positive and significant influence on the height and girth of aonla, while its effect on branches/plant was not significant (Table 1). Higher height, girth and branches/plant were obtained with highest level of APM application (15.0 kg/plant). The mean increased in aonla height with application of 15.0, 10.0, and 5.0 kg APM/plant over the control was 53.87, 29.89 and 13.48%, respectively. Application of 15.0 kg APM/plant registered 80.88% increase in girth and 144.44% in branches/plant over the control. It may be due to the application of APM increased the availability of the nutrients by decreasing the soil pH.

Nutrients uptake

Concentration of N, P, K, Ca, Mg, Zn, Fe and Mn in aonla leaves indicated significant and progressive increase with the APM application (Table 2). The concentration of N, P, K, Ca, Mg, Zn, Fe and Mn were increased by 32.81, 19.56, 32.35, 64.04, 29.17, 19.81, 67.27, and 71.98%, respectively at 15.0 kg APM/plant over control. The increased nutrients concentration in aonla leaves showed the progressive increased in their uptake which may be due to the decreased in the soil pH (Table3) with APM application. These results are similar to the results obtained by Nehra *et al*. (2009) [12] in the leaves of Khejri (*Prosopis cineraria*) trees with the application of APM. Kaplan and Orman (1998) [6] also reported increased uptake of Zn and Mn by plants when sulphur containing waste was applied to calcareous soil. However, concentration of Na in aonla leaves decreased significantly with the increasing levels of APM. Singh *et al*. (1999) [15] also reported similar results in Pomegranate leaves with the application of acidic sulphitation cane filter cake.

Soil chemical properties

Application of APM had significant influence on soil pH (Table 3). The pH of the soil was decreased with increasing levels of APM. Application of 15.0 kg APM/plant registered higher decrease in soil pH (12.25% or 0.91 units) over the control. This reduction in pH of soil could be due to the acidfying effect of organic and inorganic acids produced during the process of decomposition of APM. These results are sympathy with the results of work done by Prapagar *et al*. (2012) [14], Abdel-Fattah (2012) [1] and Negim and Mustafa (2016) [10]. The EC of the soil was significantly increased with increased levels of APM. The increase in EC may be due to the presence of dissolved salts in APM. Similar findings were also observed by the Orman and Kaplan (2000) [13], Nehra *et al*. (2009) [12] and Negim and Mustafa (2016) [10].

Nutrients availability

Application of APM had positive and significant effect on the organic C content, available N and available P around the aonla plants (Table 3). Higher organic C content, available N and available P were recorded with higher level of APM (15.0 kg/plant) application. Application of 15.0 kg APM/plant registered an increase in organic C (168.57%), available N (59.81%) and in available P (755.70%) over the control. Similar increase in organic C, available N and available P were also reported by Kapur (1995) [5] and Singh *et al*. (1999) [15] with the application of acidic materials, Nehra *et al*. (2009) [12] with the application of APM and Sinha *et al*. (2016) [16] with the application of bio-compost.

The application of APM also had positive and significant effect on exchangeable and soluble ions of potassium and calcium + magnesium in soil saturated extract. While the effect on exchangeable Na ions was negatively significant (Table 3). It may be due to the acidic nature of APM which mobilized the native soil Ca^{2+} ions, which further facilitates the replacement of Na^+ ions. Similar results were also obtained by Nehra *et al*. (2009) [12] and Negim and Mustafa (2016) [10].

Availability of DTPA extractable Zn, Fe and Mn in soil was found to increase significantly with APM application (Table 3). DTPA extractable Zn, Fe and Mn were increased by 183.23, 169.28 and 105.06%, respectively at 15.0 kg APM/plant over the control. These results are in conformity with the findings of Haroon and Subash Chandrabose (2004) [2] and Nehra *et al*. (2009) [12]. Wallace and Muller (1978) [17] also suggested that application of sulphuric acid in calcareous soils increases the availability of micronutrients by lowering the soil pH.

Table 1: Effect of APM on mean height, girth and branches of aonla plants.

APM doses kg/plant	Height (cm)		Girth (cm)	Branches/plant
	Initial (July, 2016)	After two years (June, 2018)		
0	162.00	222.50	13.13	2.25
5.0	159.50	252.50	16.38	3.00
10.0	161.70	289.00	19.50	4.75
15.0	160.85	342.25	23.75	5.50
CD at 5%	-	15.48	2.48	NS

Table 2: Effect of APM on various nutrients concentration in aonla plant leaves

APM doses kg/plant	Nutrient concentration									
	(%)						mg kg^{-1}			
	N	P	K	Ca	Mg	Na	Zn	Fe	Mn	Cu
0	1.28	0.092	0.34	1.08	0.24	0.027	21.0	103.9	98.5	3.4
5.0	1.45	0.098	0.36	1.19	0.27	0.023	27.5	142.3	117.2	4.5
10.0	1.57	0.102	0.39	1.28	0.30	0.021	48.5	160.9	148.4	5.0
15.0	1.70	0.110	0.45	1.75	0.31	0.017	62.6	173.8	169.4	4.4
CD at 5%	0.81	0.004	0.023	0.096	0.016	0.0015	5.06	9.52	12.21	NS

Table 3: Effect of APM on soil properties and nutrients availability.

APM doses kg/plant	pH	EC (dSm^{-1})	O.C. (%)	Available N (kg ha^{-1})	Olsen's P (mg kg^{-1})	Saturated extracted (mg kg^{-1})			DTPA extracted (mg kg^{-1})			
						K	Na	Ca+ Mg	Zn	Fe	Mn	Cu
0	8.34	0.63	0.35	82.6	8.9	8.09	1378.7	20.3	0.78	11.72	30.01	2.70
5.0	8.09	0.73	0.44	93.3	20.4	10.35	979.4	24.6	1.38	15.69	45.92	2.90
10.0	7.81	0.91	0.73	103.6	42.6	27.26	767.4	32.0	1.98	24.04	51.87	3.70
15.0	7.43	1.07	0.94	132.0	76.5	37.97	606.8	40.0	2.21	31.56	61.54	2.07
CD at 5%	0.18	0.092	0.06	5.49	6.97	1.68	45.92	2.20	0.138	3.38	3.16	NS

Conclusion

The results of the studied showed that the application of APM in calcareous soils under irrigated condition is useful for the better growth, nutrients availability and uptake of nutrients by aonla plants.

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