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Influence of Organic Acids on Growth and Yield of Groundnut (*Arachis hypogaea* L.) Grown in Calcareous Soils

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ABSTRACT

A potculture experiment was conducted in Agricultural college, Bapatla, Andhra Pradesh to study the 'Influence of organic acids on growth and yield of groundnut (*Arachis hypogaea* L.) grown in calcareous soils" during *kharif* season of 2015-16. The experimental soil was calcareous (collected from Vertisol profile), alkaline in reaction, low in organic carbon, available nitrogen, medium in available phosphorus and high in available potassium. All the micronutrients except iron were sufficient in the soil with values above their critical limits. The treatments comprised of control (T_1); $FeSO_4.7H_2O$ @ 0.25% (T_2); citric acid @ 0.25% (T_3); acetic acid @ 0.25% (T_4); oxalic acid @ 0.125% (T_5); ascorbic acid @ 0.25% (T_6) and hydroxyl amine hydrochloride (T_7) were replicated thrice in completely randomized design (CRD) with three replications. Foliar application of organic acids were applied to the respective pots at peak flowering, peg penetration and pod formation stage of the crop growth. The results recorded that foliar application of $FeSO_4.7H_2O$ @ 0.25% followed by acetic acid @ 0.25% and citric acid @ 0.25% was significantly increased the growth (plant height, dry matter production), yield attributes, yield and biochemical (chlorophyll 'a' and 'b') parameters when compare to control.

Key words: Calcareous soils, Growth, Organic acids, Yield attributes.

Groundnut is one of the most important oilseed crop; India occupies the first position in the area and in second position with regards to production of groundnut in the world. In Indian oil seed scenario groundnut is the largest component and occupies 45 per cent of the total oil seeds area while contributing 55 per cent of total production. In India, groundnut is cultivated in an area of 4.7 m ha^{-1} with a production of 4.69 million tonnes and the productivity of 995 kg ha^{-1} during 2014-15. In Andhra Pradesh, groundnut area is 1.34 m ha^{-1} with a production and productivity of 1.12 million tonnes and 829 kg ha^{-1}, respectively (Indiastat, 2014-15). Iron deficiency in extreme cases may lead to complete crop failure. For instance, Papastylianou (1990) in Cyprus observed complete failure of groundnut grown in calcareous soils (46% $CaCO_3$) and recorded pod yield of 30 kg/ha and suggested that production of the untreated plants in such condition is insignificant.

MATERIAL AND METHODS

The plant height was measured from the base of the plant to the growing tip and the mean of five plants was taken from the each treatment and expressed in centimeters. Similarly five plants were collected from each of the treatment for recording dry matter production. The samples were shade dried, followed by hot air oven at 60 ^{0}C. Then the dry weights were recorded and dry matter was expressed in g pot^{-1}. Total number of pods produced was counted from the five selected plants after harvest and their average was taken as the number of pods per plant. The weight of hundred kernels (g) was recorded from the kernels samples drawn from the produce obtained from each of the treatment. As soon as crop growth period was over, plant samples were collected, washed with water followed by 0.1 N HCl and distilled water and kept for air drying. Air dried haulm samples were oven dried at 70^{0}C for overnight. The weight of fresh and air dried pod samples were recorded, Chlorophyll 'a' & 'b' content in leaves was estimated colorimetrically by dimethyl sulphoxide (DMSO) method as described by Hiscox and Stam (1979).

RESULTS AND DISCUSSION

Plant height

The plant height at flowering was non significant, but at peg penetration and harvest, the plant height was significantly superior over control

(Table 1). At peg penetration and harvest, the treatment supplied with $FeSO_4.7H_2O$ @ 0.25% (T_2) recorded the highest plant height of 15.40 and 18.26 cm respectively. But among organic acids used citric acid @ 0.25% (T_3-13.87 & 16.58 cm) and oxalic acid @ 0.125% (T_5-13.63 & 15.97 cm) was on par with each other followed by treatment received with $FeSO_4.7H_2O$ @ 0.25% and significantly superior to control (T_1). Where as in control it was recorded 11.04 & 14.32 cm respectively. This might be due to higher chlorophyll content was recorded in those respective treatments, it would helped to increase the plant height. These results are in accordance with the finding of Revathy *et al*. (1997) and Ramireddy and Basavaraj (2012).

Drymatter Production

The dry matter production (Table 2) at flowering stage ranged from 16.27 to 27.76 g pot^{-1} in control and $FeSO_4.7H_2O$ @ 0.25%, respectively. The highest (27.76 g pot^{-1}) dry matter production was observed in T_2, which received with $FeSO_4.7H_2O$ @ 0.25% followed by T_3- 20.41 g pot^{-1} (citric acid @ 0.25%). The treatment (T_3) citric acid @ 0.25% which was on par with ascorbic acid @ 0.25% (T_6-18.64 g pot^{-1}) were significantly superior to control. Among organic acids used as foliar spray, citric acid @ 0.25% (T_3) recorded highest dry matter production when compared to remaining treatments except $FeSO_4.7H_2O$ @ 0.25% (T_2). The dry matter production at peg penetration stage ranged from 32.73 to 44.28 g pot^{-1}. The highest (44.28 g pot^{-1}) dry matter production was recorded in T_2 ($FeSO_4.7H_2O$ @ 0.25%), which was statistically on par with treatments supplied with citric acid @ 0.25% (T_3- 41.11 g pot^{-1}) and were significantly superior to control.

Pod yield (Table 2) was significantly influenced by all the treatments. Pod yield ranged from 24.86 to 33.51 g pot^{-1}. The highest pod yield of 33.51 g pot^{-1} was recorded with the application of $FeSO_4.7H_2O$ @ 0.25% (T_2) followed by acetic acid @ 0.25% (T_4- 29.45 g pot^{-1}). The treatment T_4 which was on par with T_3 (citric acid @ 0.25%) and T_3 which was on par with T_6 (ascorbic acid @ 0.25%), T5 (oxalic acid @ 0.125%) and T_7 (hydroxyl amine hydrochloride @ 0.25%) while significantly lowest pod yield of 24.86 g pot^{-1} was recorded in control (T_1). These results were in accordance with the findings of Singh and Dayal (1992). Organic acids were found to be significant in increasing pod yield over control. Tiffin (1967) reported that negatively charged Fe-containing compounds were essential for efficient iron movement through the xylem and citrate is the natural carrier of iron. These organic acids have an impact on many aspects of the physiology of iron deficient plants including excretion from roots and to supply the ferric chelate reductase enzymes with enough reducing power. This mechanism could be very important for plants growing in calcareous soils where an absolute Fe- deficiency doesn't takes place in presence of bicarbonate ion which is common in these soil conditions.

The results indicated that haulm yield (Table 2) ranged from 31.24 to 42.47 g pot^{-1}. The highest haulm yield was observed in the treatment T_2 (42.47 g pot^{-1}) followed by T_3 (37.19 g pot^{-1}), while T_3 was on par with T_4 treatment and T_4 was on a par with T_6. The lowest haulm yield was observed in treatment received with oxalic acid @ 0.125% (31.24 g pot^{-1}). Significantly higher dry matter was recorded with the treatment received foliar application of $FeSO_4.7H_2O$ @ 0.25% (T_2). These results were in confirmation with Ramireddy and Basavaraj (2012).

No of pods per plant

Number of pods per plant significantly differed with the treatments (Table 3). Among the treatments, foliar application of $FeSO_4.7H_2O$ @ 0.25% (T_2) recorded 72.54 pot^{-1} followed by acetic acid @ 0.25% (T_4-63.71). The treatment acetic acid @ 0.25% was at par with citric acid @ 0.25% (T_3-61.68) and significantly superior to control. This might be due to chlorophyll content in these respective treatments utilized efficiently by plants to produce more number of pods per plant. These results were in accordance with the results of Revathy *et al.* (1997).

Test weight (100 kernels weight)

The test weight of groundnut presented in table 3 indicated there was no significance difference among the treatments.

Table 1. Plant height (cm) of groundnut as influenced by different organic acids at different growth stages.

Treatments	Flowering	Peg penetration	Harvesting
T_1 : Control (Recommended Dose of Fertilizers only)	7.59	11.04	14.32
T_2 : $FeSO_4.7H_2O$ @ 0.25%	7.66	15.40	18.26
T_3 : Citric acid @ 0.25%	7.61	13.87	16.58
T_4 : Acetic acid @ 0.25%	7.62	12.81	15.81
T_5 : Oxalic acid @ 0.125%	7.59	13.63	15.97
T_6 : Ascorbic acid @ 0.25%	7.60	12.77	15.40
T_7 : Hydroxyl amine hydrochloride @ 0.25%	7.59	12.67	15.15
SEm±	0.23	0.43	0.50
CD (0.05)	NS	1.29	1.50
CV (%)	5.24	5.63	5.39

Table 2. Dry matter production (g pot^{-1}) of groundnut as influenced by different organic acids at different growth stages.

Treatments	Flowering	Peg penetration	Harvesting	
			Pod yield	Haulm yield
T_1 : Control (Recommended Dose of Fertilizers only)	16.27	32.73	24.86	31.62
T_2 : $FeSO_4.7H_2O$ @ 0.25%	27.76	44.28	33.51	42.47
T_3 : Citric acid @ 0.25%	20.41	41.11	28.19	37.19
T_4 : Acetic acid @ 0.25%	18.32	40.51	29.45	36.48
T_5 : Oxalic acid @ 0.125%	17.58	40.09	25.59	31.24
T_6 : Ascorbic acid @ 0.25%	18.64	40.15	26.01	34.10
T_7 : Hydroxyl amine hydrochloride @ 0.25%	17.04	37.05	25.58	33.46
SEm±	0.63	1.33	0.88	1.14
CD (0.05)	1.89	3.99	2.64	3.42
CV (%)	5.60	5.82	5.49	5.61

Chlorophyll 'a'content

The data on chlorophyll 'a' content are presented in Table 4. The influence of organic acids on chlorophyll 'a' content in leaf at different stages indicated that it increased gradually up to 60 DAS and then declined. Significant difference in chlorophyll 'a' content was found due to the foliar sprays of organic acids at all stages.

At flowering and peg penetration, chlorophyll 'a' content significantly increased over control with the foliar spray of organic acids. Among the treatments, foliar spray of $FeSO_4.7H_2O$ @ 0.25% and acetic acid @ 0.25% (T_2 & T_4) recorded significantly higher chlorophyll 'a' content (1.23, 1.28 & 1.17, 1.21 mg g^{-1} respectively), which was on par with each other followed by citric acid @ 0.25% (T_3-1.05 & 1.10 mg g^{-1} respectively). The lowest was recorded with control (T_1), the influence of remaining treatments (T_6, T_7 and T_5) were intermediate (0.89, 0.93 & 0.87, 0.92 & 0.86, 0.90 mg g^{-1}) but significantly superior to control (0.84 & 0.88 mg g^{-1}). At harvest, foliar spray of $FeSO_4.7H_2O$ @ 0.25% (T_2) recorded higher chlorophyll 'a' content (0.70 mg g^{-1}) which was followed by acetic acid @ 0.25% (T_4), citric acid @ 0.25% (T_3- 0.53 mg g^{-1}) and ascorbic acid @

Table 3. Yield attributes of groundnut as influenced by different organic acids.

Treatments	Number of pods pot^{-1}	Test weight (g)
T_1 : Control (Recommended Dose of Fertilizers only)	54.03	30.60
T_2 : $FeSO_4.7H_2O$ @ 0.25%	72.54	33.36
T_3 : Citric acid @ 0.25%	61.68	32.01
T_4 : Acetic acid @ 0.25%	63.71	32.09
T_5 : Oxalic acid @ 0.125%	54.54	31.92
T_6 : Ascorbic acid @ 0.25%	56.20	31.41
T_7 : Hydroxyl amine hydrochloride @ 0.25%	56.30	31.59
SEm±	1.86	0.96
CD (0.05)	5.58	NS
CV (%)	5.39	5.20

Table 4. Chlorophyll 'a' content (mg g^{-1}) of groundnut leaves as influenced by different organic acids at different growth stages.

Treatments	Flowering	Peg penetration	Harvesting
T_1 : Control (Recommended Dose of Fertilizers only)	0.84	0.88	0.31
T_2 : $FeSO_4.7H_2O$ @ 0.25%	1.23	1.28	0.70
T_3 : Citric acid @ 0.25%	1.05	1.10	0.53
T_4 : Acetic acid @ 0.25%	1.17	1.21	0.64
T_5 : Oxalic acid @ 0.125%	0.86	0.90	0.30
T_6 : Ascorbic acid @ 0.25%	0.89	0.93	0.36
T_7 : Hydroxyl amine hydrochloride @ 0.25%	0.87	0.92	0.35
SEm±	0.03	0.03	0.01
CD (0.05)	0.09	0.09	0.03
CV (%)	4.96	5.02	4.90

0.25% (0.36 mg g^{-1}). The treatment supplied with ascorbic acid @ 0.25% (T_6) on a par with the foliar spray of hydroxyl amine hydrochloride @ 0.25% (0.35 mg g^{-1}), and significantly superior to control. The lowest content was recorded in control (0.31 mg g^{-1}). Foliar spray of $FeSO_4.7H_2O$ @ 0.25% (T_2- 1.23, 1.28 & 0.70 mg g^{-1}) maintained constantly higher chlorophyll 'a' content at all stages of the crop. During the crop growth higher chlorophyll 'a' content was observed at peg penetration stage.

Chlorophyll 'b' content

The data pertaining to chlorophyll 'b' were presented in Table 5. At all stages, the variation observed in chlorophyll 'b' values was due to variation in sampled plants.

At flowering, significant difference was observed among the treatments. Foliar spray of $FeSO_4.7H_2O$ @ 0.25% (T_2) and acetic acid @ 0.25% (T_4) recorded higher chlorophyll 'b' content (1.53 and 1.46 mg g^{-1}) followed by citric acid @ 0.25% (1.35 mg g^{-1}). The remaining treatments *viz*., ascorbic acid @ 0.25% (1.20 mg g^{-1}), hydroxyl amine hydrochloride @ 0.25% (1.18 mg g^{-1}), oxalic acid @ 0.125% (1.17 mg g^{-1}) were on par with each other. At peg penetration, significant increase in chlorophyll 'b' content was recorded in treatments received with $FeSO_4.7H_2O$ @ 0.25%

Table 5. Chlorophyll 'b' content (mg g^{-1}) of groundnut leaves as influenced by different organic acids at different growth stages.

Treatments	Flowering	Peg penetration	Harvesting
T_1 : Control (Recommended Dose of Fertilizers only)	1.16	1.26	0.19
T_2 : $FeSO_4.7H_2O$ @ 0.25%	1.53	1.62	0.40
T_3 : Citric acid @ 0.25%	1.35	1.43	0.30
T_4 : Acetic acid @ 0.25%	1.47	1.55	0.36
T_5 : Oxalic acid @ 0.125%	1.17	1.26	0.20
T_6 : Ascorbic acid @ 0.25%	1.20	1.29	0.22
T_7 : Hydroxyl amine hydrochloride @ 0.25%	1.18	1.28	0.20
SEm±	0.04	0.04	0.01
CD (0.05)	0.12	0.12	0.03
CV (%)	4.79	4.83	4.86

(T_2-1.62 mg g^{-1}) and acetic acid @ 0.25% (T_4-1.55 mg g^{-1}) which was on par with each other, followed by the foliar spray of citric acid @ 0.25% (T_3-1.43 mg g^{-1}). The treatments received with ascorbic acid @ 0.25% (T_6-1.29 mg g^{-1}), hydroxyl amine hydrochloride @ 0.25% (T_7-1.28 mg g^{-1}), oxalic acid @ 0.125% (T_5-1.26 mg g^{-1}) were on par with each other. The treatments T_2 and T_4 showed significant increase in the chlorophyll 'b' content over remaining treatments. At harvest, foliar spray of $FeSO_4.7H_2O$ @ 0.25% (T_2) recorded higher chlorophyll 'b' content (0.40) which was followed by acetic acid @ 0.25% (0.36), citric acid @ 0.25% (0.30) and ascorbic acid @ 0.25% (0.22) treated pots. The treatment supplied with ascorbic acid @ 0.25% (0.22) was on a par with hydroxyl amine hydrochloride @ 0.25% (0.20), oxalic acid @ 0.125% (0.20) treatments. The lowest chlorophyll 'b' content was observed in control (0.19). This might be due to fact that the foliar application of organic acids will helps in regreening the chlorotic plants. The results are in confirmation with the results of Fernandez and Ebert (2005).

Conclusion

Based on the above results and discussion, it can be concluded that foliar application of $FeSO_4.7H_2O$ @ 0.25% gave higher growth (plant height, dry matter production), yield attributes, yield and biochemical (chlorophyll 'a' and 'b') parameters.

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