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Effect of humic acid on growth, yield and yield attributes of *Rabi* sorghum (*Sorghum bicolor* L.)

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Abstract
A field experiment was conducted during *Rabi* 2019 to study the effect of humic acid (HA) at Organic Farming Research Institute, UAS, Raichur during 2019-20. Various methods of humic acid application (*viz*., seed priming, soil application and foliar spray) in combination and at different concentrations was used to study the effect of humic acid on crop performance, nutrient uptake and nutritional quality of *rabi* sorghum. The experiment was laid out in Randomized Complete Block Design with 10 treatments. Significantly higher grain yield of sorghum (1662 kg ha^{-1}) and nutrient uptake was recorded in treatment T_9 due to application of recommended dose of N through FYM along with seed priming in 1 percent HA solution, soil application of HA @ 10 kg ha^{-1} and foliar spray @ 0.5 percent compared to supplementation of N through FYM, seed priming in 1 percent HA solution and soil application of humic acid @ 10 kg ha^{-1} alone (T_5: 1365 kg ha^{-1}). The results revealed that significantly higher growth parameters were recorded in treatment receiving FYM along with seed priming, soil and foliar application of HA. The net return realized from T_9 and T_{10} (Seed priming with cow urine @ 25 percent + RDF + FYM) treatment was ₹ 23612 and ₹ 22576, respectively.

Keywords: Humic acid, sorghum, seed priming, soil application, foliar spray, nutrient uptake and yield

Introduction
Sorghum (*Sorghum bicolor* L.) is the king of millets and third important crop in the country after rice and wheat. It is one of the main staple foods for the world's poorest and most food insecure people across the semi-arid tropics. In India, the area under sorghum is approximately 3.84 million hectare with an annual production of about 3.76 million tonnes and an average productivity of 979 kg ha^{-1} (Anon., 2018) [2]. Karnataka occupies second place with respect to area and production of sorghum in the country during the year 2018-19 with 0.87 million hectare of area and 0.91 million tonnes of production with productivity of 1048 kg ha^{-1} (Anon., 2018) [2].

Humic substances (HS) are the largest constituent of soil organic matter (~60%), known to contain complex and heterogeneous mixture of poly dispersed materials formed by biochemical and chemical reactions during the decay and transformation of plant and microbial remains (a process called humification) and are considered as a key component of the terrestrial ecosystem. Humic substances have positive effects on plant physiology by improving soil structure and fertility and by influencing nutrient uptake and root architecture and they have been shown to contain auxin and an "auxin-like" activity. HS seem to positively influence metabolic and signalling pathways involved in the plant development by acting directly on specific physiological sites of action. Humic substances influence many soil properties irrespective of the quantities present. Thus humic acid derived from organic wastes like cocopeat, pressmud, coffee pulp, sewage sludge, poultry manure, urban compost etc., which have substantial quantities of humic materials and are of great importance in maintaining soil organic matter levels especially in semi-arid tropics of India. To take the advantage of the facts that HA offers great promise for agricultural utilization, this study was conducted to see the effect of HA on growth and yield parameters of *rabi* sorghum.

Materials and Methods
A field trial was conducted to study the "Effect of Humic Acid on Crop Performance, Nutrient Uptake and Nutritional Quality of *Rabi* Sorghum (*Sorghum bicolor* L.)" at Bio-Farm, Organic Farming Research Institute, UAS, Raichur. The soil was clay loam in texture and pH of the soil was alkaline (8.18) with an electrical conductivity of 0.72 dS m^{-1}. The soil was medium in organic carbon (6.66 g kg^{-1}) and low in available nitrogen (137.9 kg ha^{-1}), medium in available

phosphorus (53.8 kg ha^{-1}), high in potassium (654.0 kg ha^{-1}) as well as sulphur (51.3 kg ha^{-1}). The DTPA extractable micronutrients *viz*., Zn, Cu, Fe and Mn were 0.73, 1.37, 11.70 and 12.00 mg kg^{-1}, respectively.

The sorghum variety M 35-1 was sown on 15th October, 2019 (*rabi*) with a spacing of 45 cm x 15 cm. The experiment was laid out in Randomized Block Design with 10 treatments and replicated thrice. The treatments consisted of T_1: Control (Dry seeding); T_2: Seed priming in 0.5% HA solution; T_3: Seed priming in 1% HA solution; T_4: Seed priming in 0.5% HA solution + Soil application of HA @ 10 kg ha^{-1}; T_5: Seed priming in 1% HA solution + Soil application of HA @ 10 kg ha^{-1}; T_6: Seed priming in 0.5% HA solution + Soil application of HA @ 10 kg ha^{-1}+ Foliar application of HA @ 0.25%; T_7: Seed priming in 0.5% HA solution + Soil application of HA @ 10 kg ha^{-1}+ Foliar application of HA @ 0.5%; T_8: Seed priming in 1% HA solution + Soil application of HA @ 10 kg ha^{-1}+ Foliar application of HA @ 0.25%; T_9: Seed priming in 1% HA solution + Soil application of HA @ 10 kg/ha + Foliar application of HA @ 0.5%; T_{10}: Seed priming with cow urine @ 25 percent solution + FYM + RDF (RPP).

A 100 percent recommended dose of N was supplied through farm yard manure in T_1 to T_9 treatments. The T_{10} (RPP) treatment was supplied with recommended dose of fertilizer (50:25:0 kg ha^{-1}) and FYM @ 5 t ha^{-1}. Humic acid was applied to soil @ 10 kg ha^{-1} at the time of sowing in T_4 to T_9 treatments. Besides, crop was foliar sprayed with humic acid @ 0.25 (T_6 and T_8) and 0.50 (T_7 and T_9) percent at 45 and 60 DAS.

Humic acid applied to the crop was extracted from pressmud and its properties were characterized. Humic acid yield and ash content of pressmud was (11.7% and 1.6%) respectively. Total organic carbon, total N, total P and total K content in pressmud HA were 57.1, 2.3, 0.05 and 0.2 percent, respectively. The concentration of micronutrient in pressmud HA was total Fe 5016.5, total Mn 815.2, total Zn 295.4 as well as total cu 157.6 mg kg^{-1}. Paola *et al.* (2006) [4] stated that humic acid obtained from municipal solid waste compost had 1.2 percent ash, 4.7 percent N, 5.0 percent H and 52.4 percent C. The work carried out by Sathisha and Devarajan (2011) [5] also reported organic carbon content of 46.36 percent in the extracted humic acid from pressmud which might be due to greater content of organic carbon in the test materials.

Results and Discussion

Growth parameters: Plant height and leaf area are the two important and easily noticeable form of growth changes in the plant which ultimately leads to the increase in total dry matter of the plant and which has been observed with the application of different methods of humic acid (Table 1).

Supplementation of N through FYM, seed priming with HA @ 1 percent, soil application of HA @ 10 kg ha^{-1} and foliar spray of HA @ 0.5 percent (T_9 treatment) recorded significantly higher plant height (238.0 cm), leaf area index (4.41), leaf area plant^{-1} (2979.6 cm^2 plant^{-1}) and total dry matter accumulation (110.0 g plant^{-1}) at harvest of sorghum crop growth over the RPP treatment (T_{10}) which received seed priming with cow urine @ 25 percent solution, RDF and FYM @ 5 t ha^{-1} (237.5 cm, 4.25, 2867.6 cm^2 and 107.6 g plant^{-1}, respectively) followed by T_7 treatment where recommended dose of N was supplied through FYM, seed priming in 0.5 percent HA solution, soil application of HA @ 10 kg ha^{-1} and foliar spray of HA @ 0.5 percent (234.6 cm, 4.23, 2856.7 cm^2, 106.5 g plant^{-1}, respectively). Increase in growth parameters in T_9 treatment might be due to favourable effect of HA on the root length and thereby increasing the uptake of plant nutrients from the soil, which in turn supplying it to the aerial parts of the plant and ultimately enhancing the vegetative growth of plants which augmented the photosynthetic activity and dry matter accumulation of sorghum. The increment in growth parameters with seed priming, soil application and foliar spray of humic acid may be due to better cell division, cell elongation and increased physiological processes which contributed to greater plant height (Thakur *et al.*, 2013) [7].

Yield parameters

The overall increase in the growth of the plant has been reflected ultimately in the yield and yield related parameters (Table 2). The higher accumulation of assimilates in the treatment (T_9) receiving N supplementation through FYM, seed priming with HA @ 1 percent, soil application of HA @ 10 kg ha^{-1} and foliar spray of HA @ 0.5 percent reflected in higher number of grains per ear head, 100 seed weight (g), grain yield (kg ha^{-1}) and stover yield (kg ha^{-1}). Increase in all the yield attributing characters might have contributed for increased grain yield in T_9 treatment (1662 kg ha^{-1}) which received FYM incorporation to supplement N, seed priming in 1 percent HA solution, soil application of HA @ 10 kg ha^{-1}, foliar spray of HA @ 0.5 percent. The latter had on par yield level (T_{10}: 1600 kg ha^{-1}) with RPP treatment that received seed priming with cow urine @ 25% + RDF + FYM @ 5 t ha^{-1}. Increase in grain yield was due to increase in the test weight and number of grains per ear head. Higher grain yield recorded might be attributed to improvement in physical condition of soil, higher translocation of nutrients from source to sink as well as more uptake of nutrients by the plant. Increase in concentration of humic acid application up to 120 kg ha^{-1} enhanced the plant growth parameters of potato-tuber production, biochemical indicators *i.e*., ascorbic acid, total soluble solids, starch and protein contents (Selim *et al.*, 2012) [6]. Humic acid application @ 10 kg ha^{-1} to green gram and soybean resulted in yield increase of 80.65 and 71.07 percent, respectively (Khungar and Manoharan, 2000) [3]. Germination percentage and tallest root in wheat were produced with seed produced priming with humic acid compared with those primed in water (Ali *et al*., 2014) [1].

Economics

Higher gross returns of sorghum per hectare (₹ 46865 ha^{-1}) was observed in T_9 treatment due to application of recommended dose of N through FYM along with seed priming at 1 percent HA solution, application of HA @ 10 kg ha^{-1} and foliar spray @ 0.5 percent which resulted in higher yield of grain and stover. The higher net returns were obtained with T_9 treatment receiving recommended dose of N through FYM along with seed priming of 1 percent HA solution, application of HA @ 10 kg ha^{-1} and foliar spray @ 0.5 percent (₹ 23612 ha^{-1}) which was closely followed by T_{10}: RPP treatment (₹ 22576 ha^{-1}) comprising of seed priming in 25 percent cow urine, recommended dose of fertilizer, FYM @ 5 t ha^{-1} and T_7 treatment (₹ 18285 ha^{-1}) receiving recommended dose of N through FYM along with seed priming of 0.5 percent HA solution, application of HA @ 10 kg ha^{-1} and foliar spray @ 0.5 percent (Table 3).

Table 1: Effect of humic acid on Plant height, leaf area, LAI and dry matter accumulation in sorghum

Treatment	Plant height (cm)	Leaf area (cm^2)	Leaf area index	Dry matter accumulation (g $plant^{-1}$)
T_1: Dry seeding	202.7	1692.0	2.51	85.3
T_2: Seed priming in 0.5% HA solution	210.8	2301.7	3.41	103.8
T_3: Seed priming in 1% HA solution	215.3	2452.9	3.63	104.3
T_4: Seed priming in 0.5% HA solution + Soil application of HA @ 10 kg ha^{-1}	215.8	2607.0	3.86	104.8
T_5: Seed priming in 1% HA solution + Soil application of HA @ 10 kg ha^{-1}	219.8	2751.1	4.08	105.0
T_6: Seed priming in 0.5% HA solution + Soil application of HA @ 10 kg ha^{-1} + Foliar application of HA @ 0.25%	223.5	2764.0	4.09	105.9
T_7: Seed priming in 0.5% HA solution + Soil application of HA @ 10 kg ha^{-1} + Foliar application of HA @ 0.5%	234.6	2856.7	4.23	106.5
T_8: Seed priming in 1% HA solution + Soil application of HA @ 10 kg ha^{-1} + Foliar application of HA @ 0.25%	229.1	2800.8	4.15	106.0
T_9: Seed priming in 1% HA solution + Soil application of HA @ 10 kg ha^{-1} + Foliar application of HA @ 0.5%	238.0	2979.6	4.41	110.0
T_{10}: Seed priming with cow urine @ 25 percent solution + RDF + FYM @ 5 t ha^{-1} (RPP)	237.5	2867.6	4.25	107.6
S.Em.±	6.4	194.0	0.25	3.4
CD at 5%	19.1	576.2	0.74	10.2

Table 2: Effect of humic acid on No. of grains/ear head, Test weight, Grain and stover yield in sorghum

Treatment	No. of grains/ ear head	Test weight (g)	Grain yield (kg ha^{-1})	Stover yield (kg ha^{-1})
T_1: Dry seeding	1254.0	2.7	1250	3333
T_2: Seed priming in 0.5% HA solution	1319.0	2.8	1322	3573
T_3: Seed priming in 1% HA solution	1350.3	2.8	1325	3667
T_4: Seed priming in 0.5% HA solution + Soil application of HA @ 10 kg ha^{-1}	1482.3	2.9	1333	3803
T_5: Seed priming in 1% HA solution + Soil application of HA @ 10 kg ha^{-1}	1501.0	2.9	1365	4023
T_6: Seed priming in 0.5% HA solution + Soil application of HA @ 10 kg ha^{-1} + Foliar application of HA @ 0.25%	1614.7	3.4	1451	4222
T_7: Seed priming in 0.5% HA solution + Soil application of HA @ 10 kg ha^{-1} + Foliar application of HA @ 0.5%	1631.3	3.9	1539	4401
T_8: Seed priming in 1% HA solution + Soil application of HA @ 10 kg ha^{-1} + Foliar application of HA @ 0.25%	1630.7	3.5	1531	4320
T_9: Seed priming in 1% HA solution + Soil application of HA @ 10 kg ha^{-1} + Foliar application of HA @ 0.5%	1684.7	4.2	1662	4651
T_{10}: Seed priming with cow urine @ 25 percent solution + RDF + FYM @ 5 t ha^{-1} (RPP)	1666.3	3.9	1600	4574
S.Em.±	64.7	0.2	46.4	116.8
CD at 5%	192.1	0.4	137.9	347.1

Table 3: Economic analysis of sorghum production as influenced by different treatments

Treatment	Cost of cultivation (₹ ha^{-1})	Gross returns (₹ ha^{-1})	Net returns (₹ ha^{-1})	B:C ratio
T_1: Dry seeding	24653	35000	10347	1.42
T_2: Seed priming in 0.5% HA solution	24708	37088	12380	1.50
T_3: Seed priming in 1% HA solution	24713	37301	12588	1.51
T_4: Seed priming in 0.5% HA solution + Soil application of HA @ 10 kg ha^{-1}	25253	37697	12444	1.49
T_5: Seed priming in 1% HA solution + Soil application of HA @ 10 kg ha^{-1}	23253	38795	15542	1.66
T_6: Seed priming in 0.5% HA solution + Soil application of HA @ 10 kg ha^{-1} + Foliar application of HA @ 0.25%	25253	41157	15904	1.63
T_7: Seed priming in 0.5% HA solution + Soil application of HA @ 10 kg ha^{-1} + Foliar application of HA @ 0.5%	25253	43538	18285	1.72
T_8: Seed priming in 1% HA solution + Soil application of HA @ 10 kg ha^{-1} + Foliar application of HA @ 0.25%	25253	43224	17971	1.71
T_9: Seed priming in 1% HA solution + Soil application of HA @ 10 kg ha^{-1} + Foliar application of HA @ 0.5%	23253	46865	23612	2.02
T_{10}: Seed priming with cow urine @ 25 percent solution + RDF + FYM @ 5 t ha^{-1} (RPP)	22685	45261	22576	1.99

Conclusion

It can be concluded that in the present investigation, significant improvement in growth, yield and higher net returns were recorded with application of recommended dose of N through FYM along with seed priming of 1 percent HA solution, application of HA @ 10 kg ha^{-1} and foliar spray @ 0.5 percent over the treatments receiving different concentration of HA through soil application alone.

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