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RESEARCH PAPER

Effect of different application method of humic acid on nodulation and seed yield of soybean

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Abstract : The field experiment was conducted in field at Regional Research Center, Amravati during *Kharif* season of 2012-13, 2013-14 and 2014-15. The topography of experiment site was fairly uniform, leveled and have medium black soil. The experiment was laid out in Randomized Block Design with four replications consisting of eight treatments comprising of control (T_1), humic acid 6 per cent (T_2), 100 per cent recommended dose of fertilizers (T_3), 75 per cent recommended dose of fertilizers (T_4), 50 per cent recommended dose of fertilizers (T_5), humic acid 6 per cent spray schedule +100 % recommended dose of fertilizers with humic acid 6 per cent (T_6), humic acid 6 per cent spray schedule +75 % recommended dose of fertilizers with humic acid 6 per cent (T_7), humic acid 6 per cent spray schedule +50 % recommended dose of fertilizers with humic acid 6 per cent (T_8). Soil application mixing with fertilizer @ 2.5 lit per ha at the time of along with basal dose (full dose of N, P, K) were given to the treatment T_6, T_7 and T_8 only. From the three years pooled data, it can be conclude that significantly highest grain and straw yield (2065 and 2890 kg ha^{-1}, respectively) of soybean was obtain with application schedule humic acid 6 per cent at different growth stages of crop with 100 per cent RDF along with 2.5 lit/ha of humic acid 6 per cent as soil application at the time sowing but found at par with higher dose of treatment *i.e.* T_7.

Key Words : Humic acid, Nodulation, Seed yield, Soybean

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INTRODUCTION

Today there is a recognized and increasing use of humic acids for their beneficial impact on the growth and cultivation of crop. Humic acid is not a fertilizer as it does not directly provide nutrition to plants, but is a compliment fertilizer. Humic acid can break up compacted soils, allowing for enhanced water penetration and better root zone growth and development. Plant growth is also improved by the ability of the plant to uptake and receives more nutrients. Humic acid is especially beneficial in freezing up nutrients in the soil so that they are made available to the plant as needed. Humic acid is also especially important because of its ability to chelated micronutrients increasing their bio availability. To increase the production of soybean by using the bio stimulants like humic acid. Humic acids are intermediates in complexity between humans and folic acids persist in soil for a larger period, so that to be useful to the crops. Humic acid with high molecular

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weight are not known to be assimilate while, those with low molecular weight are said to be assimilate by the plant (Chandrashekharan, 1992). Between three humic substances, humic acid have received the most attention and has been extensively studied to find out its effect on several crop plants. Therefore, the present investigation was undertaken to study the effect of humic acid 6 per cent on productivity of soybean crop.

MATERIAL AND METHODS

The field experiment was conducted in field at Regional Research Center, Amravati during *Kharif* season of 2012-13, 2013-14 and 2014-15. The topography of experiment site was fairly uniform, leveled and have medium black soil. The experiment was laid out in Randomized Block Design with four replications consisting of eight treatments comprising of control (T_1), humic acid 6 per cent (T_2), 100 per cent recommended dose of fertilizers (T_3), 75 per cent recommended dose of fertilizers (T_4), 50 per cent recommended dose of fertilizers (T_5), humic acid 6 per cent spray schedule +100 % recommended dose of fertilizers with humic acid 6 per cent (T_6), humic acid 6 per cent spray schedule +75 % recommended dose of fertilizers with humic acid 6 per cent (T_7), humic acid 6 per cent spray schedule +50 % recommended dose of fertilizers with humic acid 6 per cent (T_8). Foliar application guideline for humic acid 6 per cent to treatment T_2, T_6, T_7 and T_8 were followed soil application mixing with fertilizer @ 2.5 lit. per ha at the time of along with basal dose (full dose of N, P, K) were given to the treatment T_6, T_7 and T_8 only (Table A).

Table A : Foliar application guideline for humic acid 6 per cent to treatment

Sr. No.	Crop stag for spray	Dose/lit water
1st spray	4-5 leaves stage	1.5 ml
2nd spray	Branching stage	2.5 ml
3rd spray	Flower initiation stage	2.5ml
4th spray	Pod formation stage	2.5ml
5th spray	Grain development stage	2.75ml

Soybean cv. JS-335 was used for the study. After seed bed preparation, sowing was done by dibbling. The grass plot size was 5m x 3.6m and net plot size was 4.8 m x 2.7 m. The observations on mean plant height, number of branches per plant, number of nodules per plant, dry weight of nodules per plant, root length, Biomass, grain yield and straw yield.

RESULTS AND DISCUSSION

The results obtained from the present investigation as well as relevant discussion have been summarized under following heads :

Plant height :

From the three years pooled it reveals that, significantly maximum plant height was noticed in treatment humic acid 6 per cent spray schedule + 100 % recommended dose of fertilizers with humic acid 6% @ 2.5 lit/ha (T_6) followed by 100 per cent recommended dose of fertilizers (T_3), humic acid 6 per cent spray schedule + 75 % recommended dose of fertilizers with humic acid 6% @2.5 lit/ha (T_7), 75 per cent recommended dose of fertilizers (T_4) and humic acid 6 per cent spray schedule +50 % recommended dose of fertilizers with humic acid 6% @2.5 lit/ha (T_8).

Humic sources exert their influence on foliar transport in number of ways. The foliar application enhances the absorption of nutrients by the leaf at site of application. The above findings are consonance with the findings of Chen and Solovitch (2003). They found that foliar application of humic acid enhances shoot growth in different crops *viz.*, wheat, maize, barley, bean etc (Table 1).

Collectively, soil application of HA modify aggregation, aeration and permeability of soil as well as increase its water holding capacity. Apart from that HA increases microbial activity, consequently increases the rate of organic matter mineralization and solubilization. This further enhances the availability of macro and micro nutrients to meet the demand of rapid growing crops. The hormonal activity of HA also regulates endogenous hormonal mechanism (Nardi *et al*., 2002 and Trevisan *et al*., 2010).

Number of branches per plant :

Significantly maximum number of branches plant^{-1} was recorded in treatment of humic acid 6 per cent spray schedule + 100 % recommended dose of fertilizers with humic acid 6% @ 2.5 lit/ha (T_6) followed by humic acid 6 per cent spray schedule +75 % recommended dose of fertilizers with humic acid 6% @2.5 lit/ha (T_7), humic acid 6 per cent spray schedule +50 % recommended dose of fertilizers with humic acid 6% @2.5 lit/ha (T_8), 100 per cent recommended dose of fertilizers (T_3), 75 per cent recommended dose of fertilizers (T_4) and 50 per cent recommended dose of fertilizers (T_5) in a

Table 1 : Effect of humic acid on growth parameter and nodulation of soybean

Treatments	Plant height (cm)				No. of branches/plant				No. of nodules/ plant at 30 DAS				No. of nodules/ plant at 45 DAS			
	2012	2013	2014	Pooled	2012	2013	2014	Pooled	2012	2013	2014	Pooled	2012	2013	2014	Pooled
T_1- Control	32.07	34.97	33.93	33.66	2.80	2.80	0.27	2.87	8.87	11.53	6.39	8.93	27.40	15.87	26.52	23.26
T_2- Humic acid 6%	38.40	37.20	37.39	37.66	3.07	3.07	3.13	3.09	12.73	12.07	11.03	11.94	50.53	16.47	46.29	37.76
T_3- 100 % recommended dose of fertilizers	49.47	40.67	39.60	43.24	3.56	3.56	3.65	3.59	17.47	15.20	13.95	15.54	56.20	23.13	51.95	43.76
T_4- 75 % recommended dose of fertilizers	44.27	39.33	39.40	41.00	3.51	3.51	3.40	3.47	11.00	14.67	11.05	12.24	46.33	19.73	44.27	36.78
T_5- 50 % recommended dose of fertilizers	35.80	38.90	37.60	37.43	3.20	3.20	3.33	3.24	10.07	13.53	9.18	10.93	46.60	18.10	45.30	36.67
T_6- humic acid 6% spray schedule + 100 % recommended dose of fertilizers with humic acid 6% @ 2.5 l/ha	50.13	53.00	40.27	47.80	4.27	4.27	4.07	4.20	14.27	18.13	14.41	15.60	63.00	39.13	62.10	54.74
T_7- humic acid 6% spray schedule + 75 % recommended dose of fertilizers with humic acid 6% @2.5 l/ha	40.00	46.42	40.20	42.21	3.93	3.93	3.93	3.93	12.13	17.13	11.45	13.57	57.27	34.40	55.37	49.01
T_8- humic acid 6% spray schedule +50 % recommended dose of fertilizers with humic acid 6% @2.5 l/ha	38.27	42.07	39.87	40.07	3.77	3.77	3.87	3.80	10.93	15.44	9.42	11.93	50.57	26.63	49.89	42.36
S.E. ±	1.84	1.81	2.85	2.20	0.20	0.20	0.27	0.22	0.91	0.64	0.44	0.67	3.43	1.02	2.10	2.33
C.D. (P=0.05)	5.57	5.50	NS	6.29	0.61	0.61	0.78	0.62	2.75	1.96	1.30	1.91	10.42	3.10	6.16	6.67
CV%	7.75	7.55	12.79	9.44	9.97	9.97	12.97	10.63	12.87	7.59	7.10	9.22	11.96	7.32	7.64	9.97

NS=Non-significant

Table 2 : Effect of humic acid on growth parameter and biomass of soybean

Treatments	Dry weight of nodules/ plant at 30 DAS				Dry weight of nodules/ plant at 45 DAS				Root length (cm)				Biomass /plot (kg)			
	2012	2013	2014	Pooled	2012	2013	2014	Pooled	2012	2013	2014	Pooled	2012	2013	2014	Pooled
T_1- Control	33.33	36.78	24.56	31.56	100.00	51.42	91.30	80.91	13.10	11.03	15.22	13.11	1.87	1.91	1.62	1.80
T_2- Humic acid 6%	36.67	38.70	38.46	37.94	110.00	53.34	92.87	85.40	13.74	11.79	15.65	13.73	2.51	2.40	2.10	2.34
T_3- 100 % recommended dose of fertilizers	60.00	48.77	41.79	50.19	156.67	74.68	99.10	110.15	15.93	15.60	16.33	15.95	2.66	2.91	2.29	2.62
T_4- 75 % recommended dose of fertilizers	20.00	46.81	35.23	34.01	126.67	63.80	100.48	96.98	14.23	13.23	15.90	14.45	2.50	2.77	2.37	2.55
T_5- 50 % recommended dose of fertilizers	22.33	43.21	32.17	32.57	100.00	58.57	80.70	79.76	13.24	13.07	14.99	13.77	2.46	2.73	2.30	2.49
T_6- humic acid 6% spray schedule + 100 % recommended dose of fertilizers with humic acid 6% @ 2.5 l/ha	80.00	67.98	42.25	63.41	259.00	147.40	105.63	170.68	19.93	22.01	17.24	19.73	2.98	4.28	2.48	3.25
T_7- humic acid 6% spray schedule + 75 % recommended dose of fertilizers with humic acid 6% @2.5 l/ha	61.67	64.42	41.59	55.89	183.00	129.65	99.76	137.47	19.47	21.05	15.47	18.66	2.72	3.74	2.31	2.92
T_8- humic acid 6% spray schedule +50 % recommended dose of fertilizers with humic acid 6% @2.5 l/ha	45.00	58.07	31.51	44.86	176.67	100.53	98.77	125.32	19.02	19.97	15.45	18.15	2.52	2.97	2.06	2.51
S.E. ±	3.87	2.40	1.69	2.72	10.95	3.49	4.58	7.47	0.58	0.63	0.86	0.68	0.14	0.18	0.10	0.14
C.D. (P=0.05)	11.74	7.28	4.95	7.77	33.22	10.58	13.41	21.34	1.74	1.92	NS	1.94	0.41	0.54	0.30	0.40
CV%	14.94	8.21	8.16	10.75	12.52	7.12	8.26	11.67	6.20	6.87	9.44	7.39	9.32	10.46	8.13	9.58

NS=Non-significant

descending manner when compare with control and remaining treatments. Jape *et al*. (2013) also reported application of humic acid proved effective on increasing the number of branches plant^{-1} in groundnut.

Number and dry weight of root nodules :

The pooled data of number of root nodules and dry weight of root nodules are presented in Table 2. The number of root nodules at 30 DAS and 45 DAS ranged from 15.60 to 8.93 and 54.36 to 23.26, respectively.

At 30 DAS the treatment receiving humic acid 6 per cent spray schedule + 100 % recommended dose of fertilizers with humic acid 6% @ 2.5 lit/ha (T_6) increased number of root nodules significantly over control (T_1) and other remaining treatments. At 45 DAS, humic acid 6 per cent spray schedule + 100 % recommended dose of fertilizers with humic acid 6% @ 2.5 lit/ha (T_6) significantly maximum number of root nodules was recorded over control followed by humic acid 6 per cent spray schedule + 75 % recommended dose of fertilizers with humic acid 6% @2.5 lit/ha (T_7), humic acid 6 per cent spray schedule +50 % recommended dose of fertilizers with humic acid 6% @2.5 lit/ha (T_8), 100 per cent recommended dose of fertilizers (T_3), humic acid 6 per cent (T_2), 75 per cent recommended dose of fertilizers (T_4) and 50 per cent recommended dose of fertilizers (T_5). In case of dry matter of root nodules at 30 and 45 DAS maximum dry weight was observed in treatment humic acid 6 per cent spray schedule + 100 % recommended dose of fertilizers with humic acid 6% @ 2.5 lit/ha (T_6) *i.e*. 63.41 and 170.68 g and minimum in control 31.56 and 80.91 g, respectively.

Nodule development appeared to be dependent on source-sink relationship. This is a function of growth habit of legume crop. Treatments which produced and maintained more active photosynthesis are able to nodules well due to availability of adequate photosynthetic products. Humic acid application had a definite input on the protein synthesis and nucleic acid synthesis. The high cation exchange capacity of humic acid prevents nutrients from leaching. It absorbs the nutrients from chemical fertilizer and these exchanges of nutrients are slowly released to the plants. Foliar application of humic acid fastens the absorption of N and P through foliage and induces nodules formation and rhizobial activity (Metre *et al*., 2013)

Root length :

Significantly maximum root length was recorded in treatment of humic acid 6 per cent spray schedule + 100 % recommended dose of fertilizers with humic acid 6% @ 2.5 lit/ha (T_6) followed by humic acid 6 per cent spray schedule + 75 % recommended dose of fertilizers with humic acid 6% @2.5 lit/ha (T_7), humic acid 6% spray schedule +50 % recommended dose of fertilizers with humic acid 6% @2.5 lit/ha (T_8), 100 per cent recommended dose of fertilizers (T_3), 75 per cent recommended dose of fertilizers (T_4) and 50 per cent recommended dose of fertilizers (T_5).

Table 3 : Effect of humic acid on seed yield of soybean

Treatments	Seed yield (kg/ha)				Straw yield (kg/ha)			
	2012	2013	2014	Pooled	2012	2013	2014	Pooled
T_1- Control	1414	1454	1131	1333	1735	1769	1304	1602
T_2- Humic acid 6%	1759	1596	1231	1529	2322	2222	1540	2028
T_3- 100 % recommended dose of fertilizers	1853	2108	1387	1783	2464	2690	1630	2261
T_4- 75 % recommended dose of fertilizers	1795	2012	1339	1715	2314	2568	1581	2154
T_5- 50 % recommended dose of fertilizers	1733	1914	1156	1601	2276	2525	1491	2097
T_6- humic acid 6% spray schedule + 100 % recommended dose of fertilizers with humic acid 6% @ 2.5 l/ha	2207	2451	1539	2065	2759	3965	1946	2890
T_7- humic acid 6% spray schedule + 75 % recommended dose of fertilizers with humic acid 6% @2.5 l/ha	2074	2269	1450	1931	2516	3463	1694	2558
T_8- humic acid 6% spray schedule +50 % recommended dose of fertilizers with humic acid 6% @2.5 l/ha	1878	2123	1426	1809	2329	2748	1739	2272
S.E. ±	91.21	95.11	80.57	87.29	125.87	165.69	84.26	128.04
C.D. (P=0.05)	276.64	288.47	235.72	249.45	381.78	502.53	246.50	365.90
CV%	8.59	8.27	10.47	8.79	9.32	10.46	9.03	9.93

Biomass :

Economic yield is that part of biomass that is converted into economic product (Nichiporvic, 1960). Significantly maximum biomass was recorded in treatment of humic acid 6 per cent spray schedule + 100 % recommended dose of fertilizers with humic acid 6% @ 2.5 lit/ha (T_6) followed by humic acid 6% spray schedule + 75 % recommended dose of fertilizers with humic acid 6% @2.5 lit/ha (T_7), humic acid 6% spray schedule +50 % recommended dose of fertilizers with humic acid 6% @2.5 lit/ha (T_8), 100 per cent recommended dose of fertilizers (T_3), 75 per cent recommended dose of fertilizers (T_4), 50 per cent recommended dose of fertilizers (T_5) and humic acid 6 per cent (T_2) over the control (T_1).

Seed yield and straw yield :

Seed yield is the economic yield which is final result of physiological activities of plants. The maximum seed yield ha^{-1} was observed in treatment receiving humic acid 6% spray schedule + 100 % recommended dose of fertilizers with humic acid 6% @ 2.5 lit/ha (T_6) *i.e.* 2065 kg when compared with control *i.e* 1333 kg and rest of the treatments under study. Next to treatment T_7 maximum seed yield was recorded in treatment of humic acid 6 % spray schedule+ 75 % recommended dose of fertilizers with humic acid 6 per cent @2.5 lit/ha (T_7) followed by humic acid 6 per cent spray schedule + 50 per cent recommended dose of fertilizers with humic acid 6 per cent @2.5 lit/ha (T_8), 100 per cent recommended dose of fertilizers (T_3), 75 per cent recommended dose of fertilizers (T_4), 50 per cent recommended dose of fertilizers (T_5) and humic acid 6 per cent (T_2) over the control (T_1). Similar trend was observed in straw yield also Kamthane (2012) (Table 3).

The higher grain yield due to HA application in this research corroborates the findings of Khan *et al*. (2010), Vanitha and Mohandass (2014) and Almarshadi and Ismail (2014). These authors suggested the use of HA due to its beneficial effect on grain yield in several crop species like wheat, aerobic rice, groundnut, mustered, Brassica raya, and barley. Similarly Shuixiu and Ruizhen (2001) reported the HA application to soil increased the yield of spring soybean.

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