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Effect of humic substances on nutrient uptake and yield of soybean

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Abstract

A field experiment was conducted during *Kharif*, 2017 at Agronomy field unit, College of Agriculture, Shivamogga to study the effect of humic substances on nutrient uptake and yield of soybean **[***Glycine max* (L.) Merrill]. The experiment consisted of 10 treatments replicated thrice was laid out in Complete Randomized Block Design. Soybean variety used in this experiment was JS-335. Application of vermicompost on FYM 'N' equivalent basis was found superior by recording significantly higher grain and haulm yield and nutrient uptake of N, P, K by grain, haulm, total uptake and less available nutrient status after harvest of crop. Among humic substances treatments, soil application of humic substances @ 5 kg ha^{-1} at sowing + foliar application of humic substances extracted from vermicompost (0.2%) at 40 DAS resulted in significantly higher grain and haulm yield and nutrient uptake of N, P, K by grain, haulm, total uptake and less available nutrient status after harvest of the crop when compared to control.

Keywords: soybean, humic acid substances, vermicompost, nutrient uptake

Introduction

Soybean [*Glycine max* (L.) Merrill] is an important grain legume crop contains about 40 to 44 per cent protein and 20 per cent oil. Agronomically, it is classified under oilseed crop. Due to its high nutritional quality, higher productivity and its industrial importance there is lot of scope for its cultivation in India. Being a leguminous crop, soybean is also capable of with stand moisture stress and helps in improving the soil fertility and productivity. In India soybean is growing in an area of 11.67 m ha with production and productivity of 8.5 m t and 737 kg ha^{-1}, respectively (Anon., 2014). However, the productivity and quality of soybean was very low compared to advanced countries due to poor management practices in general and crop nutrition in particular. Ignorance attitude towards the importance of organic waste cycling and continuous application of soluble acidic based N, P and K fertilizers with an assumption that they could stimulate plant growth without organics or humic substances to the soil has caused many serious social and ecological problems. Indiscriminative application of chemicals and fertilizers has lead to soil, air, food and water pollution is one of the most important environmental and social concerns throughout the world especially in developing countries. Soil organic matter has beneficial effects not only on soil quality, but also has positive effects on crop productivity and quality of the produce. In addition, organic matters could reduce the application of industrial fertilizers in long run. It is the need of the hour to reconsider the approaches for fertilization techniques by giving priority to organic manure/amendments.

Use of bulky organic manures has been considered as a burden by the farmers as it requires large number of laborer for transportation and application. So it is necessary to go for organic end products like humic substances for better soil condition, higher input use efficiency and enhanced productivity of crops.

Extraction of humic substances from bulky organic manures and their use may help to solve many problems associated with use of bulky organic manures. Humic substances, organic matter, humus, humate, humin, humic acid and fulvic acid, play a vital role in soil fertility and plant nutrition. They help to break up clay and compacted soils, assists in transferring micronutrients from the soil to the plant, enhances water retention, increases seed germination rates and stimulates development of microbial populations in soil. They also indirectly involved in improvement of the soil properties such as aggregation, aeration, permeability, water holding capacity, serves as an effective adsorption and retention complex for inorganic plant nutrients and there by enhance the micronutrients uptake transport and availability (Tan, 2003) and it exhibits auxin-like effects. As a result of this, application of humic substances stimulates plant growth and consequently yield and quality by acting on various mechanisms such as cell respiration, membrane permeability, photosynthesis, protein synthesis, water and nutrient uptake, enzyme activities (Nardi *et al*., 2002 and Chen *et al*., 2001) [14, 3].

In this context, an attempt has been made to extract the humic substances from vermicompost available at the site and to see its effects applied either alone as foliar/ soil or through both soil and foliar application along with commercial available humic substances for comparison.

Material and Methods

A field experiment was carried out during *Kharif* 2017 at College of Agriculture, University of Agricultural and Horticultural Sciences, Navile, Shivamogga falls under Southern Transitional Zone of Karnataka. To study the effect of humic substances on nutrient uptake and yield of soybean. The location is situated between 14°0'N to 14º1'N latitude and 75°40' E to 75º42' E longitude and at an altitude of 650 meter above mean sea level. The soil of the experimental site is red sandy loam in texture with acidic pH (5.93), low in organic carbon (0.42 %) and available N (232 kg ha^{-1}), medium in available potassium (232.65 kg ha^{-1}), whereas, high in available phosphorous (58.45 kg ha^{-1}). The experiment consisted of 10 treatments *viz*., Control means no humic substance application (T_1), soil application of humic substances (humic and fulvic acid) @ 2.5 kg ha^{-1} (T_2) and 5 kg ha^{-1} (T_3), foliar application of humic substances extracted from vermicompost (0.2%) at 40 DAS (T_4), Foliar application of commercial humic substances (0.2%) at 40 DAS(T_5), T2+T4(T6), T2+T5(T7), T3+T4(T8), T3+T5(T9) and vermicompost on FYM 'N' equivalent basis *i.e*., 2.76 t ha^{-1} (T10) replicated thrice was laid out in Complete Randomized Block Design. A common dose of nitrogen, phosphorous and potassium @ 25:60:25 kg ha^{-1} was applied as basal in the form of urea, DAP and muriate of potash, respectively. Two weeks prior to sowing, recommended quantity of FYM was applied uniformly to all the treatments except for T_{10} where in vermicompost on FYM 'N' equivalent basis in place of FYM was used. All cultural practices were carried out as per package of practices except treatment imposition. The Soybean variety JS-335 was used as test crop. Seeds were sown on 2nd August after treating with suitable rhizobium culture and harvested at physiological maturity. Grain and haulm samples collected from each plot at the time of harvest were dried at 60 ^{0}C in hot air oven were grounded separately in a Willey Mill using a grinder fitted with stainless steel blades to pass through 40 mesh sieve for further analysis for nutrient content. The grounded material was collected in butter paper bags and later the samples were analyzed for N, P and K content. For Nitrogen estimation, nitrogen content in plant samples (haulm and grain) was determined by modified Kjeldhal's method as described by Jackson (1973) [6]. In this method, a powdered sample of 0.5 g was digested with concentrated H_2SO_4 in presence of digestion mixture (K_2SO_4:$CuSO_4$:Se in the proportion of 100:20:1) and distilled under alkaline medium. The liberated NH_3 was trapped in four per cent boric acid containing mixed indicator and titrated against standard H_2SO_4. For estimation of P and K content a powdered plant sample of 0.5 g was pre-digested with five ml of concentrated HNO_3 and again digested with a di-acid mixture (HNO_3: $HClO_4$ in 10:4 ratio). Volume of the digest was made up to 100 ml with distilled water and preserved for P and K analysis (Jackson, 1973) [6]. Later the phosphorus content in plant sample,(haulm as well as grain) sample was determined by taking a known volume of the digested samples by adopting the Vanadomolybdo phosphoric yellow colour method as described by Jackson (1973) [6]. For potassium, the total potassium content of the di-acid digested plant and grain samples were estimated by atomizing the digested and diluted sample to a calibrated flame photometer under suitable measuring conditions as described by Jackson (1973) [6]. Nitrogen, phosphorus and potassium uptake was calculated for haulm, grain and total plant for each treatment separately using the formula given below and expressed in kg ha^{-1}.

$$\text{Nutrient uptake} = \frac{\text{Nutrient concentration (\%)} \times \text{Weight of dry matter } (kg\ ha^{-1})}{100}$$

Statistical analysis of data was done as per the methodology suggested by Gomez and Gomez (1984) [5].

Results and Discussion

Grain yield of soybean

The grain yield of soybean varied significantly among humic acid treatments and their method of application. The highest grain yield of soybean (1957 kg ha^{-1}) was realized with application of vermicompost on FYM 'N' equivalent basis (2.76 t ha^{-1}) which was significantly superior over rest of the treatments. There was an improvement in yield to an extent of 45.80 per cent due to vermicompost application on 'N' equivalent basis. Higher grain yield with application of vermicompost was due to better release of plant nutrients and plant uptake of nutrients Table (). Similar results were obtained by Edwards (1995) and (Tomati *et al*. (1990) in radish and lettuce crops.

Among humic acid treatments, the highest grain yield of 1741 kg $ha^{-1}$was obtained with soil application of humic substances @ 5 kg ha^{-1} at sowing + foliar spray of humic substances extracted from vermicompost (0.2%) at 40 DAS closely followed by (soil application of humic substances @ 5 kg ha^{-1} + foliar application of commercial humic substances (0.2 %) at 40 DAS) which were on par with each other. The enhancement of yield in these treatments was to an extent of 29.76 and 24.89 per cent, respectively, over control. Similarly, Nanda Kumar (2004) reported 50.41 and 53.84 per cent yield improvement in rice, respectively, in clay and sandy loamy soils due to application of humic acid @ 20 kg ha^{-1}along with 100 per cent NPK. However, the control (POP) and the treatment receiving humic acid substances as foliar application (0.2 %) at 40 DAS have recorded significantly lower grain yield compared to those treatments which received either soil or foliar application of humic. The order of merit for methods of humic acid applications with respect to grain yield is soil + foliar>Soil >foliar. The variation in grain yield among treatments was mainly attributed to extent of nutrients taken up by the crop. Nutrient uptake by the crop is directly related to the yield (Table).

Nutrient uptake by soybean crop

Nitrogen uptake

Significantly higher nitrogen uptake in grain was noticed with application of vermicompost on FYM 'N' equivalent basis (135.6 kg ha^{-1}) over other treatments and entire plant (208.4 kg ha^{-1}) at harvest over rest of the treatments, while significantly higher nitrogen uptake by haulm was noticed with soil application of humic acid substances @ 5 kg ha^{-1} at sowing + foliar application of humic substances extracted from vermicompost (0.2.%) at 40 DAS (71.0 kg ha^{-1}) which were significantly superior over rest of the treatments. However, these two treatments are statistically on par with regard to nitrogen uptake by grain, haulm and total plant. Among humic substances treatments soil application of humic acid substances @ 5 kg ha^{-1} at sowing + foliar application of humic substances extracted from vermicompost (0.2%) at 40 DAS excelled over others by recording significantly higher total nitrogen uptake (193.7 kg ha^{-1}). The control treatment (no application of humic substances) registered the least nitrogen uptake ().

Among humic substances treatments soil application of humic substances @ 5 kg ha^{-1} at sowing + foliar application humic substances extracted from vermicompost (0. 2%) at 40 DAS resulted in significantly higher grain uptake of nitrogen (122.6 kg ha^{-1}) over other humic acid treatments, except T_9 (117.3 kg ha^{-1}) which are on par.

Among humic acid treatments soil application of humic substances @ 5 kg ha^{-1} at sowing + foliar application humic substances extracted from vermicompost (0.2%) at 40 DAS (193.7 kg ha^{-1}) excelled over others by recording significantly higher total nitrogen uptake (Total)

Higher nitrogen uptake is attributed to higher total dry matter (Table) and nutrient content since the uptake is the product of nutrient content and dry matter. The higher nitrogen uptake by soybean due to application of humic substances might be due to increased lateral root emergence and production of smaller but more ramified secondary roots coupled with improved cell permeability and better availability of nutrients in the soil solution (Sumathi and Rao, 2007; Bhandari *et al.*, 2000) [11, 1]. Enhanced microbial activity particularly due to humic substances particularly of ammonifiers and nitrifiers will consistently supply nitrogen resulting in improved dry matter accumulation and nutrient content due to humic substances. The results are in line with the findings of Eyheraguibel *et al*. (2008) [4].

Phosphorus uptake

Phosphorus uptake by grains

The phosphorus uptake by grain indicate the superiority of vermicompost application on FYM 'N' equivalent basis as it recorded the highest phosphorus uptake of 12.9 kg ha^{-1} significantly higher overall humic acid treatments (Table 1).

The next best treatment was soil application of humic substances @ 5 kg ha^{-1} at sowing + foliar application humic substances extracted from vermicompost (0.2%) at 40 DAS (11.3 kg ha^{-1}) closely followed by soil application of humic substances @ 5 kg ha^{-1} + foliar application of commercial humic substances (0.2 %) at 40 DAS (10.6 kg ha^{-1}) which are on par and these two were statistically superior over remaining humic acid treatments and the control.

Phosphorus uptake by haulm

However these two treatments were found significantly inferior to application of vermicompost on FYM 'N' equivalent basis (9.4 kg ha^{-1}). In those treatments where crop received humic substances both through soil and foliar were found significantly superior over treatments received either through soil or foliar spray alone (Table 1).

Higher nitrogen uptake is attributed to higher total dry matter (Table) and nutrient content since the uptake is the product of nutrient content and dry matter.

Potassium uptake

The grain potassium uptake in soybean was varied significantly among different treatments Table 1.

The highest potassium uptake was realized with vermicompost applied on FYM 'N' equivalent basis (18.8 kg ha^{-1}), haulm (9.2 kg ha^{-1}) and total ( ) which was significantly excelled over remaining treatments. Among humic acid treatments soil application of humic substances @ 5 kg ha^{-1} + foliar application humic substances extracted from vermicompost (0.2%) at 40 DAS recorded significantly higher grain uptake of k (16.4 kg ha^{-1}) except T_9 (15.6 kg ha^{-1}) and T_6 (15.1 kg ha^{-1}) which are statistically on par.

The data revealed the superiority of vermicompost application on FYM 'N' equivalent basis as it registered significantly higher potassium uptake (92.8 kg ha^{-1}) over all humic acid treated plots. The next highest uptake was noticed with soil application of humic substances @ 5 kg ha^{-1} at sowing + foliar application humic substances extracted from vermicompost (0.2 %) at 40 DAS (83.9 kg ha^{-1}) closely followed by soil application of humic substances @ 5 kg ha^{-1} and foliar application of commercial humic substances @ 0.2 per cent at 40 DAS which are statistically on par and significantly superior over others. The treatments involving both soil and foliar methods of humic acid were found statistically superior over sole application of either soil or foliar irrespective of levels. Higher nitrogen uptake is attributed to higher total dry matter (Table) and nutrient content since the uptake is the product of nutrient content and dry matter

Humic substances known to play a definite role in liberating fixed K because of their chelating power apart from the priming effect of solubilizing native i.e. fixed and non-exchangeable form of K. The enhanced microbial activity due to humic acid application would also pave way for increased availability of K by reducing its fixation in the soil and dissolution of fixed K. (Schnitzer and Khan, 1972) [8]. Further, better root metabolism and enzyme activity due to soil + foliar application of humic substances might have caused for higher nutrient uptake (Cacco *et al.*, 2000) [2]. Improved nutrient availability (Virgine and Singaram, 2005) [13] increased nutrient content in plants (Sharif *et al*., 2006) [10] high micronutrients (Kadam *et al*., 2010) [7], lesser leaching of nutrients (Selim *et al.*, 2010) [9] are some of the causes for higher nutrient uptake by the crop.

Soil available nutrient status

The soil analysis for available nutrients status after the harvest of the soybean crop as influenced by humic substances indicate that the maximum amount of available nutrients was noticed in control plot (223.63, 99.16 and 277.4 kg ha^{-1} nitrogen, phosphorus and potassium, respectively) closely followed by foliar application of commercial humic substances (0.2 %) at 40 DAS (215.25 kg ha^{-1}) for nitrogen and potassium was (275 kg ha^{-1}) and soil application of humic acid substances @ 2.5 kg ha^{-1} at sowing + foliar application of commercial humic acid (0.2 %) at 40 DAS for phosphorus (98.04 kg ha^{-1}) which are statistically on par.

The least available nitrogen, phosphorus and potassium in soil after the crop harvest were observed in the treatment where vermicompost was applied on FYM 'N' equivalent basis (132, kg ha^{-1}). All the humic acid treatments registered significantly lower available soil nitrogen after harvest of the crop over control. The treatments which received humic substances through foliar only (T_4 and T_5) >only through soil (T_2 and T_3) and soil +foliar (T_6, T_7, T_8, and T_9) are in the order of merit with respect to available nutrient status. Lower available nutrient status in soil after the harvest of the crop in plots which received vermicompost (T_1) and humic substances both through soil + foliar is mainly due to the higher nutrient uptake and higher total dry matter per plant (Table) and vice versa in control plot. The construe of the data indicate that the highest total dry matter per plant was realized with application of vermicompost on FYM 'N' equivalent basis throughout the crop period 23.85 g at harvest). This was closely followed by soil application of humic substances @ 5 kg ha^{-1} at sowing + foliar application of humic substances extracted from vermicompost (0.2%) at 40 DAS and soil application of humic substances @ 5 kg ha^{-1} at sowing + foliar application of commercial humic substances (0.2 %) at 40 DAS which are statistically on par.

Significantly least total dry matter (15.62 g plant^{-1}) was obtained with control (no humic substances application). The plots which received humic substances only through foliar spray was found inferior to soil application. However, the plots receiving humic substances for both soil as well foliar was found better than those received either from soil or from foliar alone.

Table 1: Plant uptake of major nutrients at harvest as influenced by humic substances at varied levels and method of application.

Treatments	Plant uptake (kg ha^{-1})									Grain yield (kg ha^{-1})	Haulm yield (kg ha^{-1})
	N			P			K				
	Grain	Haulm	Total	Grain	Haulm	Total	Grain	Haulm	Total		
T_1: Control (POP)	85.9	49.2	135.1	7.4	4.4	11.8	9.8	61.8	71.6	1342	2210
T_2: Soil application of humic substances (humic and fulvic acid) @ 2.5 kg ha^{-1}	104.6	55.9	157.2	9.0	6.0	14.9	12.6	71.4	84.0	1520	2499
T_3: Soil application of humic substances (humic and fulvic acid) @ 5 kg ha^{-1}	109.0	60.4	169.5	9.5	6.7	16.2	13.8	77.7	91.5	1611	2699
T_4: Foliar application of humic substances (humic and fulvic acid) extracted from vermicompost (0.2 %) at 40DAS	96.9	57.9	154.8	8.4	5.6	14.0	11.9	69.0	80.9	1485	2434
T_5: Foliar application of commercial humic substances (humic and fulvic acid) 0.2 % at 40 DAS	97.9	44.0	141.8	8.0	4.9	12.9	10.7	63.3	73.9	1424	2246
T_6: T_2+T_4	112.7	48.6	161.3	10.2	7.2	17.4	15.1	77.7	92.8	1664	2669
T_7: T_2+T_5	112.2	57.5	169.6	9.9	7.1	17.1	14.7	79.1	93.8	1656	2732
T_8: T_3+T_4	122.6	71.0	193.7	11.3	8.3	19.6	16.4	83.9	100.3	1741	2862
T_9: T_3+T_5	117.3	65.4	182.7	10.6	7.8	18.3	15.6	80.9	96.4	1676	2772
T_{10}: Vermicompost on FYM 'N' equivalent basis (2.76 t ha^{-1})	135.6	70.8	208.4	12.9	9.4	22.3	18.8	92.8	111.6	1957	3134
S.Em. ±	2.19	1.79	3.46	0.33	0.31	0.62	0.47	1.57	1.86	46.59	104.5
C.D.(P=0.05)	6.50	5.32	10.29	0.97	0.92	1.85	1.39	4.67	5.53	138.41	310.6

Table 2: Major nutrients content of soil after harvest of crop as influenced by humic substances at varied levels and method of application.

Treatments	Major nutrients (kg ha^{-1})		
	Soil N	Soil P_2O_5	Soil K_2O
T_1: Control (POP)	223.63	99.16	277
T_2: Soil application of humic substances (humic and fulvic acid) @ 2.5 kg ha^{-1}	196.00	96.00	265
T_3: Soil application of humic substances (humic and fulvic acid) @ 5 kg ha^{-1}	180.63	94.70	257
T_4: Foliar application of humic substances (humic and fulvic acid) extracted from vermicompost (0.2 %) at 40DAS	199.00	96.91	268
T_5: Foliar application of commercial humic substances (humic and fulvic acid) 0.2 % at 40 DAS	215.25	98.04	275
T_6: T_2+T_4	190.88	93.59	256
T_7: T_2+T_5	180.50	93.90	255
T_8: T_3+T_4	150.38	91.31	249
T_9: T_3+T_5	164.13	92.64	253
T_{10}: Vermicompost on FYM 'N' equivalent basis (2.76 t ha^{-1})	132.00	88.62	237
S.Em. ±	3.92	1.98	5.43
C.D.(P=0.05)	11.65	5.87	16.13

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