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Effect of humic acid on the growth and yield of *rabi* pigeon pea [*Cajanus cajan* (L.) Millsp] in the New Alluvial Zone of West Bengal

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ABSTRACT

Pigeon pea is grown either as sole crop or an intercrop / mixed crop with a wide range of crops in India during rainy season. In spite of adoption of high yield potential varieties across the country, the average yield is quite less (nearly 770 kg ha^{-1}). To increase the yield the crop may be grown as a post-rainy season crop or winter (rabi) crop with proper inputs. Humic acid, one of the major components of soil and organic matter (manures), may improve overall soil quality and thus can play an important role for improving plant growth, development and nutrient uptake. The present experiment was conducted to study the effect of humic acid on performance of rabi (winter) pigeon pea crop at University Farm (22°92′76″ N latitude and 88°55′05″ E longitude) located under New Alluvial Zone (NAZ) of West Bengal. The crop growth in terms of LAI and aerial dry mass per unit area and the main yield component (number of pods plant^{-1}) were significantly higher in the treatments got humic acid along with compost. The highest seed yield (1208.61 kg ha^{-1}) was recorded in the treatment where humic acid was applied in soil @7.5 litre ha^{-1} with compost @10 ton ha^{-1}, followed by the treatment where humic acid was applied in soil @15 litre ha^{-1} with compost (1146.71 kg ha^{-1}). Results revealed that the application of humic acid had a distinct effect to increase the yield of rabi pigeon pea crop.

***Keywords* :** Crop yield, humic acid and *rabi* pigeon pea

Pigeon pea [*Cajanus cajan* (L.) Millsp.], an important grain legume of Asia, has a unique place in Indian farming, and India accounts for about 90 per cent of the global production. It is the second most important pulse crop next to chickpea, which has diversified uses as food, feed, fodder and fuel, and mainly consumed as dry split *dal* (Dutt *et al*., 2016). It is an excellent source of protein (20-22%), supplementing energy rich cereal diets for vegetarian population (Saxena *et al*., 2010). To meet the demand of increasing population and to make the nation pulse sufficient our pulse production has to be increased. Due to photo and thermo sensitivity and long duration the area under pigeon pea cultivation could not be extended for different cropping systems and cropping patterns. Recently some completely day neutral and photo insensitive varieties have been developed, thus the crop can be sown in any part of the year and offer a chance for the horizontal expansion for different cropping systems (Vales *et al*., 2012). One of the possible area of expansion is rice-fallows cropping system in eastern India, particularly the watershed areas. Indo-Gangetic plains normally receive heavy rains and experience frequent water logging during rainy season which cause considerable loss to normal sown *kharif* pigeon pea. According to Sengupta and Roy (1982) One of the most significant achievement in the field of grain legume cultivation in India is that pigeon pea can be grown as *rabi* (winter) crop, particularly in areas where winter is mild and short like West Bengal, Andhra Pradesh, and part of Bihar and Odisha. Better productivity may be expected during *rabi* season due to less attack of pests and diseases. Sustainable agricultural production and food security are the basic concerns of societies as of now. A variety of grains, especially pulses, are the most important protein sources of world people diet. Humic acid is a natural polymeric composition which is produced as a result of decaying organic matters in soil, peat and lignin and can be used in order to increase crop product. Among various chemical inputs used for sustainable crop production, humic acid is an important one (Shafeek *et al*., 2013). Usually humic acid is applied to soil as organic amendment but there are several reports that foliar application of humic acid can also improve the plant growth and accumulated photosynthetic matters. A distinction on the effects of humic acid should be made between indirect and direct effects on plant growth. Indirect effects are mainly exerted through properties such as enrichment in soil nutrients, increase of microbial population, higher cation exchange capacity (CEC), improvement of soil structure; whereas direct effects are various biochemical actions exerted at the cell wall, membrane or cytoplasm and mainly of hormonal nature (Varanini and Pinton, 2001). The hormone like activities of humic acid is well documented in various papers (Piccolo *et al*., 1992 and Pizzeghello *et al*., 2002). Directly, they affect the processes associated with the uptake and transport of humic substances into the plant tissues. Stimulation of root growth is generally more apparent than shoot growth (Neri *et al*., 2002). However, positive effects of humic

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acid seem to depend on the concentration and source of the substance and on the plant species.

Use of humic acid in agriculture is increasing day by day due to its synergistic effects on plant growth as well as improving soil health. The commercially available products of humic acid are applied both as soil application as well as foliar feeding to plant. Humic acid have lot of direct and indirect effects on plant growth like increasing photosynthesis, protein synthesis, nutrient availability, chelation of metal cations, improving soil structure, water holding capacity and cation exchange capacity of soil. Humic substances also increase microbial population in soil and help in reducing metal poisoning. Singaroval *et al.* (1993) have stated that the auxin like growth promoting activity of humic acid might be the reason of accumulation of more dry matter in plant. Improvement of soil conditions and establishing equilibrium among plant nutrients are also important for soil productivity and plant production. They have an auxin like effect improving cell division and elongation, they can penetrate leaves, roots and stems while carrying different nutrients. Foliar application increases chlorophyll content. It helps to increase oxygen uptake resulting in better plant growth. Root growth is improved and consequently uptake of nutrients and water is more efficient. Foliar application of humic acid reduces the nitrogen applications to the soil (Sani, 2014).

A modest attempt has been thus made to grow *rabi* pigeon pea with different levels of humic acid, both as soil and foliar applications to study the effect of humic acid on performance of *rabi* pigeon pea.

The experiment was carried out during two consecutive winter seasons (2015-16, 2016-17) at farm of Bidhan Chandra Krishi Viswavidyalaya, Mohanpur, Nadia, West Bengal. The geographical location of the experimental at 22°92′76″ N latitude and 88°55′05″ E longitude and the lands are generally fertile, loamy soil under *Gangetic* basin, New Alluvial Zone of West Bengal. The early duration variety of pigeon pea ICPL-88039 was grown with a spacing of 60 × 20 cm. The experiment was laid out in a randomized block design with 8 treatments and 3 replications where the size of each plot was 4 × 3m. The treatments were: T_1= control plot (received only N-P_2O_5-K_2O @20:60:40 kg ha^{-1}), T_2=soil application of humic acid @7.5 litre ha^{-1}, T_3=soil application of humic acid @15 litre ha^{-1}, T_4=soil application of humic acid @7.5 litre ha^{-1} with compost @10 ton ha^{-1}, T_5=soil application of humic acid @15 litre ha^{-1} with compost @10 ton ha^{-1}, T_6=foliar application of humic acid @1ml litre^{-1} of water at 30 DAS, T_7=foliar application of humic acid @1ml litre^{-1} of water at 30 DAS and 45 DAS, T_8=soil application of compost @10 ton ha^{-1}. All the treatments, including the control treatment (T_1), received N-P_2O_5-K_2O @20:60:40 kg ha^{-1} as basal dose.

Leaf area index (LAI) and dry mass of aerial plant parts (DMA) were recorded at different growth stages to analyze the performance and progress of growth of the crop. Leaf area index is an important growth factor of a crop. Both LAI and DMA of the crop were determined at 45, 75 and 105 DAS and are presented in the table 1. The highest values of LAI were recorded in 75 DAS in comparison with 45 and 105 DAS.

LAI was increased gradually up to 75 DAS but declined thereafter. The highest LAI was recorded in T_5 (soil application of Humic acid@15 litre ha^{-1} with compost @10 ton ha^{-1}) treatment in the observation taken at 45 DAS (*i.e.* 3.34). For the data taken at both 75 DAS and 105 DAS, highest LAI is recorded for T_4 (soil application of Humic acid @7.5 litre ha^{-1} with compost @10 ton ha^{-1}) treatment. The lowest value of LAI is obtained in T_1 (control plot received only N-P_2O_5-K_2O @20:60:40 kg ha^{-1}) for all the three dates of observation.

The real picture of crop growth was obtained from the data of dry matter accumulation. Study on aerial dry matter accumulation of pigeon pea showed progressive increase with the advancement of crop growth (Table 1). During initial growth period the accumulation of dry matter was slow due to slow growth rate. However, from 45 DAS to 75 DAS, there was a conspicuous increase in dry matter as the crop growth was more. The aerial dry mass varied significantly for all the treatments at 45 DAS, 75 DAS and 105 DAS. At 45 and 105 DAS, the highest aerial dry matter accumulation is obtained in T_5 treatment; however, at 75 DAS the value was highest for T_5 treatment. The lowest value of dry matter was obtained in control plot *i.e.* T_1 (control plot). Positive effect of Humic acid on dry matter accumulation was also noticed by Sarwar *et al*. (2014).

In the experiment the plant population was at par and there was no significant difference among the plots. Number of pods plant^{-1} has positive correlation with grain yield of pigeon pea. With regard to pod number plant^{-1}, T_5 (Soil application of Humic acid @15 litre ha^{-1} with compost @10 ton ha^{-1}) recorded maximum number of pods plant^{-1} which is statistically at par with T_4 (Soil application of Humic acid @7.5 litre ha^{-1} with compost @10 ton ha^{-1}). Lowest number of pods plant^{-1} was obtained in T_1 (control plot)

The number of seeds per pod and seed Index were at par in all treatments (Fig. 1 and 2). None of the treatments had any significant effect on number of seeds per pod and 100-seed mass of pigeon pea. Similar trend was reported by Kaya *et al*. (2005).

Seed yield differed significantly among eight treatments tested in the investigation. The seed yield

Table 1: Effect of humic acid on LAI and aerial dry biomass of *rabi* pigeon pea (pooled)

Treatments	45 DAS		75 DAS		105 DAS	
	LAI	DB	LAI	DB	LAI	DB
T_1	1.98	102.7	2.56	213.65	2.17	269.33
T_2	3.11	130.92	3.73	384.12	3.06	449.82
T_3	3.07	134.73	4.29	381.23	3.32	453.28
T_4	3.18	187.96	5.01	398.03	3.58	475.54
T_5	3.37	211.05	4.86	377.47	3.83	486.06
T_6	2.59	116.77	2.76	327.64	2.45	431.05
T_7	2.93	122.16	3.52	338.26	3.21	440.11
T_8	2.85	126.64	3.41	348	3.09	436.7
SEm±	**0.24**	**11.87**	**0.41**	**37.84**	**0.28**	**39.14**
LSD (0.05)	**0.71**	**35.45**	**1.22**	**113.01**	**0.84**	**116.89**

Note: DB= Dry biomass*

Table 2: Effect of humic acid on yield components of *rabi* pigeon pea (pooled)

Treatment	Number of pods plant^{-1}	Seed Yield (kg ha^{-1})	Harvest index
T_1	71.1	864.23	0.13
T_2	137.3	1064.17	0.17
T_3	139.5	1146.71	0.17
T_4	158.8	1208.61	0.19
T_5	155.9	1154.07	0.18
T_6	131.6	987.68	0.15
T_7	136.0	995.40	0.15
T_8	133.5	1033.09	0.16
SE m±	**19.41**	**58.74**	**0.01**
LSD (0.05)	**57.98**	**176.18**	**0.03**

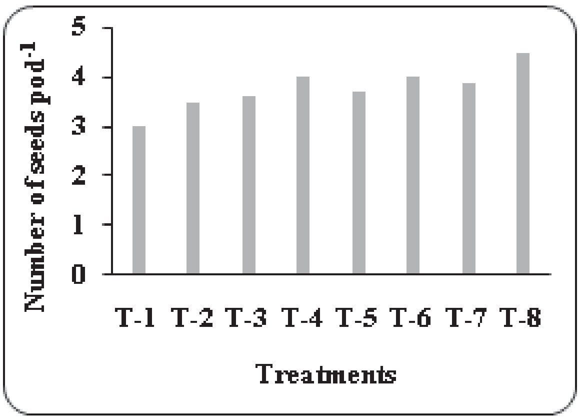

Fig. 1: Effect of humic acid on seeds per pod

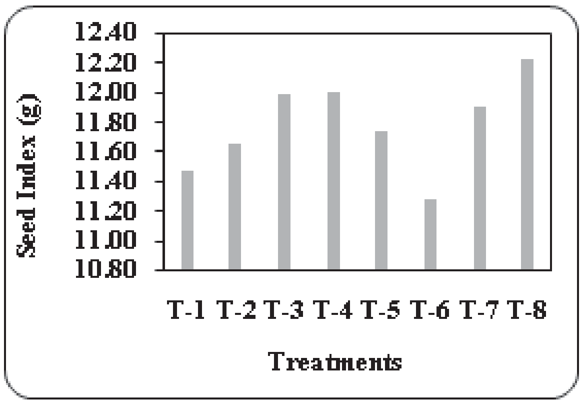

Fig. 2: Effect of humic acid on seed index

values are given in the table 2. The treatment T_4 (soil application of Humic acid @7.5 litre ha^{-1} with compost @10 ton ha^{-1}) recorded highest seed yield *i.e*. 1208.61 kg ha^{-1}, followed by treatment T_5 (soil application of Humic acid @15 litre ha^{-1} with compost @10 ton ha^{-1}) having seed yield 1154.07 kg ha^{-1} where as lowest seed yield (864.23 kg ha^{-1}) was obtained in treatment T_1 (control plot, received only N-P_2O_5-K_2O @20:60:40 kg ha^{-1}).

The harvest index of the eight treatments varied differentially due to variation between the economical and biological yields. Maximum harvest index was recorded in T_4 (0.187) followed by T_5 (0.177) and the lowest harvest index was observed in control treatment

T_1 (*i.e.* 0.132). Application of humic acid in different doses both as foliar and soil application influences plant growth and ultimately the final production. Humic acid encourages the development of yield components of pigeon pea like the pods per plant and ultimately seed yield. Sarir *et al.*(2005) suggested that application 200 g humic acid per hectare as soil spray along with basal dose of NPK had great potential to improve maize yield. The highest seed yield might be attributed due to more number of pods plant^{-1}. Fahramand *et al*. (2014) reported that the grain yield of legumes, such as mung bean (*Vigna radiata* L.), soybean (*Glycine max* L.) and pea (*Pisum sativum* L.) was increased by the use of the humic substances. Similar results were reported by Waqas *et al*. (2014) and Kaya *et al*. (2005). Probably there was synergetic effect of combined application of humic acid and compost. The higher grain yield due to humic acid application in this research corroborates the findings of Vanitha and Mohandass (2014), Thenmozhi *et al*. (2004) and Albayrak (2005)

Hence the results revealed that application of humic acid had a significant influence on growth and yield of the crop. The growth in terms of LAI and aerial dry mass were significantly higher in the treatments where plants got humic acid along with compost. Soil application of humic acid along with compost had significant effect on number of pods (the main yield component). Thus, it may be concluded that application of humic acid had a distinct effect to increase the yield of pigeon pea crop.

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