



Effect of Foliar Spray of Humic Acid on Root Growth, Yield Components and Quality in Redgram (*Cajanus cajan*)

M. K. Meena^{a*}, M. M. Dhanoji^a and Chandra Naik^a

^a *Department of Crop Physiology, University of Agricultural Sciences, Raichur, 584104, Karnataka, India.*

Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

The present study examined the effect of foliar spray of humic acid on root Growth, yield components and quality in Redgram (*Cajanus cajan*). The study was conducted during Kharif 2015-16 at Main Agricultural Research Station, UAS, Raichur by using randomized block design. The effectiveness of humic acid was studied with different levels as T₁. Humic acid liquid 15% @ 1.0 ml/l of water, T₂. Humic acid liquid 15% @ 1.5 ml/l of water, T₃. Humic acid liquid 15% @ 2.5 ml/l of water, T₄. Humic acid liquid 15% @ 4.0 ml/l of water, T₅. Planofix 4.5 % @ 20ppm and T₆ as a control. Redgram root growth including root length, shoot length, root dry weight, shoot dry weight, leaf area, dry matter production, flower drops, minerals content (quality), and yield components were measured at 60,90 DAS and at harvest, respectively. Significant differences (p<0.05) were observed for all the above mentioned parameters across the humic acid levels. Based on this study, the foliar application T₄. Humic acid liquid 15% @ 4.0 ml/l of water might be recommended to improve growth physiology, quality and yield components of Redgram in similar environmental conditions. Further, research is required in diverse plant environments to determine economically feasible application levels of Humic acid while comparing it with other plant growth regulators sources.

[≡] Assistant Professor;

[°] Professor;

*Corresponding author: E-mail: meenam4565@gmail.com;

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1. INTRODUCTION

Pulses, as one of the most important plant resources, are high in protein and, after grains, are the second most important dietary source for humans. Protein levels in legume grains are twice to three times more than in grain cereals, and 10 to 20 times higher than in tuberous crops such as potatoes [1]. Pigeonpea (*Cajanus cajan*) is cultivated on an about 4.83 million hectares in the world with annual production of 2.98 million tonnes and a productivity of 700 kg ha⁻¹. It is an important pulse crop in India, which accounts for an about 90 per cent (3.88 m ha) of the total world area and production (2.92 m tons) with a productivity of 860 kg ha⁻¹. In Karnataka, pigeonpea occupies second place in area (0.78 m ha) and production (0.38 m tons) with a productivity of 760 kg per ha [2]. Gulbarga called as dalbowl, is a very potential district in the Northern Karnataka state for extensive cultivation of pigeonpea. Pigeonpea is intrinsically perennial, but it is generally grown as an annual crop. The initial vegetative growth take place during the monsoon and floral initiation to end of grain filling phase occurs in winter season; which is generally dry and the pigeonpea crop depend for their continued development on stored moisture. As a result, redgram consumption has risen from 22 percent to 66 percent in most low-income nations, including as India. Despite these advances, because to scant, irregular rainfall and marginal soils, rainfed yields are often low and variable.

Humic acids (HAs) are the most active components of soil and compost organic matter and the main parts of humic substances (HS). They have both indirect and direct impacts on plants [3], and their function is dose-dependent, with high HS concentrations inhibiting nutrient accumulation [4]. Some plant hormone-like chemicals appear to be present in the HS, which could have a growth-stimulating impact [5]. Humic acid is a commercial substance that contains numerous elements that improve soil fertility by improving nutrient availability, which affects plant development and productivity. Humic acid is especially useful for removing or reducing the detrimental effects of chemical fertilisers and other chemicals in the soil. Humic acid has long been known to have a significant impact on plant development. Although there is broad agreement on the benefits of humus, there is considerable disagreement on the benefits of

applying applied humate (the deposits containing the humic acids). Humic acid is derived from soil, humus, peat, oxidised lignite, and coal, among other things. Humic acid promotes plant growth by increasing the growth of shoots and roots, as well as the absorption of nitrogen, potassium, calcium, magnesium, and phosphorus by the plant. Humic acid is found in nature and is not harmful to plants and the environment [6]. According to Abdel Mawgoud et al., [7], humic acid stimulates plant development by chelating multiple minerals to overcome nutritional deficiencies, and has beneficial impacts on agricultural product growth, productivity, and quality enhancement due to the presence of hormone components. Humic acid foliar spray has amazing impacts on plant vegetative growth and boosts photosynthetic activity and leaf area index in legume family plants. In corn, Ghorbani et al. [8]. Masciandaro et al. [9] found that the interaction effect of varying doses of humic acid at three distinct foliar spraying times on leaf area was substantial in wheat. According to Sharif et al. [10], humic acid can support photosynthetic tissues, resulting in an increase in total dry weight. To manage agriculture production in unfavorable soil conditions by enriching their organic matter, various options are found in literature for example, crop rotation, green manures, residue and humic acid application [11], (Selim et al., 2009 in potato; [12] in sweet corn; [13]. Keeping in consideration the magnitude for shipment and universal availability humic acid seems a choice amongst the various options to improve the yield and quality of crop plant with foliar application. Many studies have demonstrated the foliar application importance of humic acid in agriculture for example Nardi et al.,[14] in higher plant, Buyukkeskin & Akinci (2011) in broadbean , Çelik et al.,(2011) in maize, Tahir et al., (2011)in wheat and Humintech [15] have reported beneficial effects of foliar application of humic acid substances on plant growth physiology, mineral nutrition, seed germination, seedling growth, root initiation, root growth, shoot development, yield and the uptake of macro-and microelements. Masciandaro et al., [9] have indicated that humic substances might counteract abiotic stress conditions e.g., unfavorable temperature, pH, and salinity enhancing the uptake of nutrients and reducing the uptake of some toxic elements. However, Hartz &Bottoms [16] have reported that humic acid neither improves crop nutrient uptake nor productivity in vegetable crops. The influence of

humic compounds derived from various organic materials on the growth and nutrient absorption of barley during hydroponic cultivation was studied by Ayuso et al. [17] in barely. They discovered that dosages of less than 10 mg L⁻¹ carbon encouraged plant development, but higher amounts reduced it in several cases. The inclusion of humic compounds had a considerable impact on macronutrient absorption, but the effect varied depending on the nutrient. Tufencki et al. [18] introduced escalating concentrations of humic acids to experimental soil deposited in pots at various intervals before lettuce seedling transplantation, ranging from 500 to 2000 mg per kg. Humic acids, when applied early, had a favourable effect on plant development and nutrient content in lettuce plants with a short growing time. Also, no comprehensive study is available on optimization of humic acid for any crop especially for redgram flower drop management and enhancing the productivity and production. The present study for that reason explore full potential of foliar application of humic acid on growth physiology, mineral content and yield component redgram seed production-with optimization of foliar application levels of Humic acid .The research findings of this study are based on the key parameters necessary for evaluation of redgram growth physiology, quality and yield, and hoped to be valuable information for farmers and researchers.

2. MATERIALS AND METHODS

A field experiment was conducted to find out effect of foliar spray of humic acid on root Growth physiology, yield components and quality in Redgram during Kharif 2015-16 at Main Agricultural Research Station, UAS, Raichur. The data of prevailing climatic parameters were collected from research centre meteorological station which is located within one kilometer from experimental area. The crop was sown on 17th July, 2015 by manual line sowing 90 cm row spacing and 30 cm between plants. The redgram variety selected for the study was TS-3R released by University of Agricultural Sciences, Raichur. It is a high yielding variety. The humic acid was sprayed three times at 60-90 days after sowing, at the time of flowering and pod development stage. The concentration of Humic acid for each treatment was sprayed at different levels as T₁. Humic acid liquid 15% @ 1.0 ml/l of water, T₂ .Humic acid liquid 15% @ 1.5 ml/l of water, T₃ .Humic acid liquid 15% @ 2.5 ml/l of water, T₄ . Humic acid liquid 15% @ 4.0 ml/l of

water, T₅ . Planofix 4.5 % @ 20ppm and T₆ . control. The observations on various root growth physiological parameters viz., root length was measured by meter scale . While the fresh weight and dry weight of roots, the root sample was placed in the oven for 48 hours at 75°C and then it was weight by a digital scale with accuracy of 0.01 g balance. Root volume was measured by the water displacement method. The dried plant seeds material was ground and digested with a diacid 2:1mixture of nitric acid (HNO₃) and perchloric acid (HClO₄) to determine the various macro and micro nutrient content from redgram seeds with Atomic absorption spectroscopy for Fe, Cu, Zn and flame photometry for K.

3. RESULT AND DISCUSSIONS

3.1 Leaf Area (cm² per plant) and Total Dry Matter Production (g/plant)

The data pertains to leaf area total dry weight trend (Fig. 1 & 2) shows that at different growth stages, total dry weight of plant has increased gradually and all the treatments differ significantly to each other. As it is observed, total dry weight of redgram plant in treatment with 4.0 ml /l of water humic acid is more than that of other treatments. This shows that as humic acid concentration increases, total dry weight also increased. The results of this study are conformity with the findings of [6] in Horsegram, [19] in tomato stated that humic acid could improved the activity of photosynthetic tissues in crop plant and thus leaf area & total dry weight would increases at all the stages . All levels of humic acid 98 days after sowing maximized leaf area & dry matter accumulation and then they showed a descending trend. The plantsown its accumulated dry matter into reproductive organs, and the loss of leaves led to decrease of dry matter accumulation. The highest descending trend was observed in control treatments due to lack of absorption of humic acid by the leaves [20]. showed that application of humic acid foliar sprays had a key role in increasing the yield. The results were consistent with the findings of [21] in potato and [22] in maize and [23] in soybean.

3.2 Root Growth Parameters

The data on root development at harvest presented in Table 1 indicated significant differences between the treatments. The all the treatments differed significantly in root length(cm), root fresh weight(mg) , root dry

weight (mg) and T_4 recorded significantly higher root length (cm), root fresh weight (mg), root dry weight (mg) (24.25, 27.12, 9.93, respectively) as compared to all other treatments. While significantly lower root length (cm), root fresh weight (mg), root dry weight (mg) was recorded in control (10.92, 19.7, 4.60, respectively), but it was on par with T_1 . These results are in line with the growth-promoting effects of humic compounds that have been documented for a variety of plant species [24,25]. The favourable results of the potato field trial match the findings of a 2005 study from Finland's Potato Research Institute [26]. Humifirst had a beneficial effect on total tuber yield (+ 17 percent vs. control) and marketable yield (+ 24 percent vs. control) in this study. When Humifirst was given to the soil soon before seed bed tillage, which is identical to our experiment, the best reaction was obtained, as opposed to later applications on planting and hilling. Other positive effects of Humifirst on potato yield were found at Gembloux (+ 25%) and Geer (+ 11%) both located in the southern part of Belgium [27]. Eyheraguibel [28] detected that humic substances accelerated both vegetative and reproductive growth of maize plants and thus stimulated optimal production of plant biomass (shoot and cobs). Root growth was stimulated as well with more fine lateral and secondary roots in the humic substances treatments. In line with these results While, Sharif et al. [10] also reported that sprayed 50 to 300 mg per kg humic acids on the soil in a pot experiment with maize and found that the addition of 50 and 100 mg kg^{-1} caused a significant increase of 20 and 23% in shoot and 39 and 32% in root dry weight. The incorporation of humic substances in the soil stimulated root mass of creeping bent grass with 45% in the 0 to 10 cm depth and with 38% in the 10 to 20 cm depth [3]. Above ground biomass was only slightly promoted and was attributed by the authors to a sufficient nutrient supply.

The data on flower drops (%) at flowering development presented in Table 3 indicated significant differences between the treatments. The all the treatments differed significantly in flower drops and T_4 recorded significantly lower flower drops (45.8 %) as compared to all other treatments. While significantly higher flower drops was recorded in control (65.4%). These results are good agreement with the findings of Haghighi et al., 2011 in horse bean; Hossain et al., [29] in groundnut and Turkmen et al., (2005) in tomato. Similarly, Albairak and Camas [30] said that humic acid stimulates plant

development by chelating multiple minerals to overcome nutritional deficiencies, and that it has beneficial impacts on agricultural product growth, production, and quality enhancement due to its hormonal components. According to Ghorbani et al., [8], humic acid foliar spray has amazing impacts on plant vegetative growth (plant height, number of branches) and enhances photosynthetic activity and leaf area index in legume family plants. Haghighi et al. [6] evaluated the influence of humic acid on cowpea growth characteristics and discovered that humic acid increased leaf area, total dry matter, and leaf area index in horses. Abdel- Al., [31] and Erik et al., [32], on onion plant and Hafez, [33], on squash reported that humic acid applications led to a significant increase in soil organic matter which improves plant growth and crop production. Tahir et al., (2011) with study effects of mineral fertilizers and humic substances on growth and yield of cowpea were reported that, combination of chemical fertilizer with application of humic substances improve growth and yield of cowpea.

3.3 Seed Quality Parameters

The data on seed quality i.e. macro-nutrient (%) and micro-nutrients content (ppm) of redgram seeds at harvest presented in Table 2 indicated significant differences between the treatments. The all the treatments differed significantly in Macro-nutrient (%) and micro-nutrients content (ppm) and T_4 recorded significantly higher Macro-nutrient (4.92, 0.952, 3.80 %, N P K, respectively) and micro-nutrients content (2.98, 10.60, 5.59 ppm Cu, Zn, Fe, respectively) as compared to all other treatments. While significantly lower macro-nutrient (%) and micro-nutrients content (ppm) was recorded in control (1.87, 0.259, 1.13 %, NPK, respectively) and micro-nutrients content (1.50, 6.65, 3.50 ppm Cu, Zn, Fe, respectively), but it was on par with T_1 . Our results are supported by Delfine et al. [11], Morard et al. [34] who have reported that humic substances provoked a better efficiency of plant water uptake and improved the mineral nutrition and grain protein content. Similarly, our results are further supported by Turan et al. [35] that salinity had negative impacts on the dry weight and the N, P, K, Ca, Mg, Fe, Cu, Zn and Mn uptake of maize plants, the humic acid mitigate salinity and increase dry weight and nutrients composition of plants. Similar to this the foliar application of humic acid affected the uptake of P which was statistically significant in the uptake of Na, K, Cu, and Zn. However, its amounts were

Table 1. Effect of foliar application of Humic acid on root characteristics and Flower drops (%) at flowering development in Redgram

Treatments	Root length (cm)	Root fresh weight(g)	Root dry weight (mg)	Root volume (cc)	Flower drops (%)
T ₁ = Humic acid liquid 15% @ 1.0 ml/l of water	15.24	21.67	5.83	45.82	58.2
T ₂ = Humic acid liquid 15% @ 1.5 ml/l of water	18.81	23.58	7.48	48.55	57.4
T ₃ = Humic acid liquid 15% @ 2.5 ml/l of water	21.98	25.64	8.63	49.50	53.2
T ₄ = Humic acid liquid 15% @ 4.0 ml/l of water	24.25	27.12	9.93	52.08	45.8
T ₅ = Planofix 4.5 % @ 20ppm	18.52	24.87	8.78	45.39	55.3
T ₆ = Control	10.92	19.07	4.60	43.80	65.4
S.Em (±)	1.86	1.60	1.59	1.78	2.57
C. D. (5%)	5.60	4.84	4.78	5.38	7.74

*DAS = Days after sowing***Table 2. Effect of foliar application of Humic acid on macro and micronutrient at harvest in Redgram**

Treatments	Macronutrient			Micronutrient		
	N (%)	P (%)	K (%)	Cu (ppm)	Zn (ppm)	Fe (ppm)
T ₁ = Humic acid liquid 15% @ 1.0 ml/l of water	2.69	0.437	1.28	1.93	7.48	3.88
T ₂ = Humic acid liquid 15% @ 1.5 ml/l of water	2.92	0.575	1.37	2.31	7.93	4.55
T ₃ = Humic acid liquid 15% @ 2.5 ml/l of water	3.62	0.765	2.73	2.42	8.78	5.03
T ₄ = Humic acid liquid 15% @ 4.0 ml/l of water	4.92	0.952	3.80	2.98	10.60	5.59
T ₅ = Planofix 4.5 % @ 20ppm	3.75	0.521	1.58	2.35	8.40	4.73
T ₆ = Control	1.87	0.259	1.13	1.50	6.65	3.50
S.Em (±)	0.454	0.147	0.34	0.19	0.67	0.39
C. D. (5%)	1.382	0.444	1.04	0.57	2.02	1.18

DAS= days after sowing

Table 3. Effect of foliar application of Humic acid on yield and yield components at harvest in Redgram

Treatments	Yield components			
	Number of pods per plant	Pod weight (g)	Test weight (g)	Yield (kg/ha)
T ₁ = Humic acid liquid 15% @ 1.0 ml/l of water	95.35	46.65	7.85	1176.98
T ₂ = Humic acid liquid 15% @ 1.5 ml/l of water	102.18	51.60	8.58	1254.30
T ₃ = Humic acid liquid 15% @ 2.5 ml/l of water	116.28	62.38	9.40	1323.02
T ₄ = Humic acid liquid 15% @ 4.0 ml/l of water	126.88	75.45	9.78	1426.12
T ₅ = Planofix 4.5 % @ 20ppm	105.10	61.85	8.40	1288.66
T ₆ = Control	89.38	44.88	7.43	1073.88
S.Em (±)	6.15	6.14	0.52	39.91
C. D. (5%)	18.53	18.49	1.56	120.21

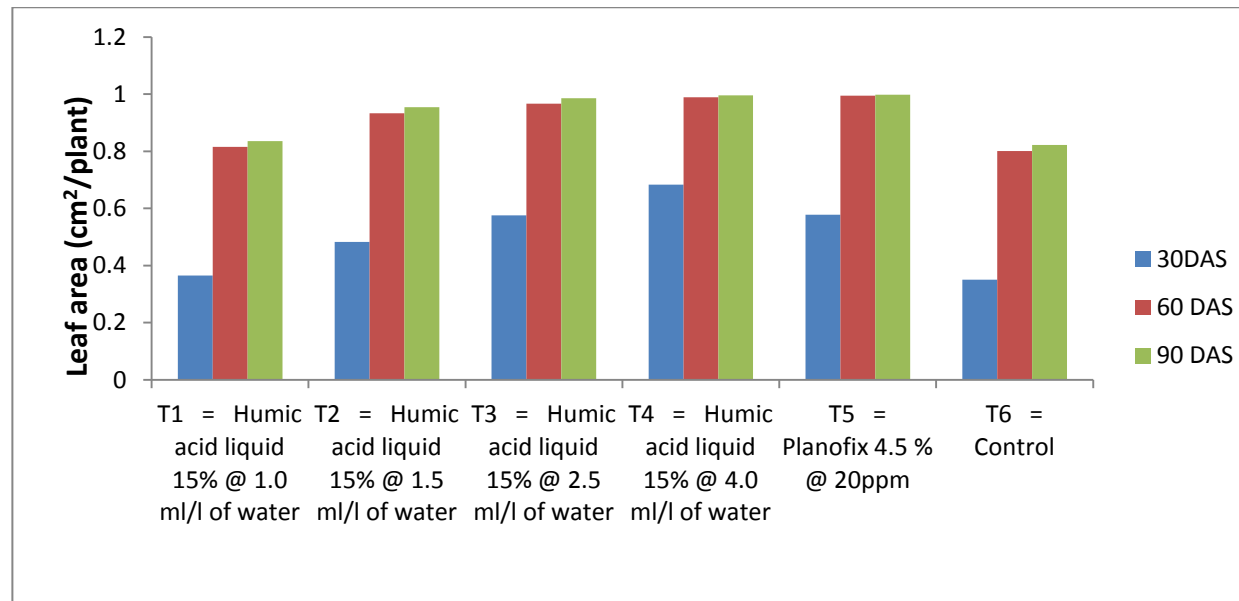


Fig. 1. Influence of foliar application of Humic acid on leaf area (dm²/plant) at different stages of crop growth in Redgram

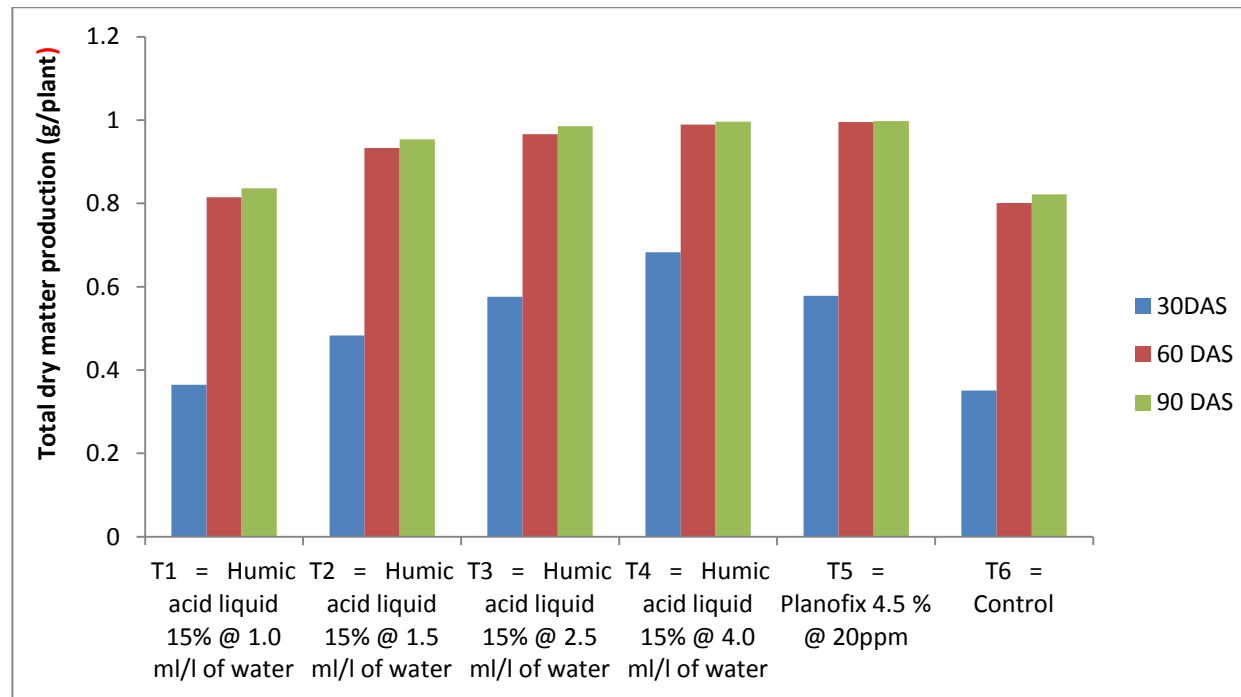


Fig. 2. Influence of foliar application of Humic acid on Total dry matter production (g/plant) at different stages of crop growth in Redgram

not found statistically significant with other nutrients. The highest dry weight and nutrients uptake were obtained with 0.1% dose of humic acid. Nevertheless, the dry weight and nutrients uptake were decreased at 0.2% dose of humic acid, but the amounts except for Fe, Cu, and Mn were found higher than in the control [36]. Similarly, Fernandez-Escobar et al. [37] studied the effect of foliar application of humic acid extracts to young olive plants in greenhouse and infield experiments. Under field conditions, shoot growth and accumulation of potassium (K), boron (B), magnesium (Mg), calcium (Ca), and iron (Fe) in leaves was promoted. The effects of humic substances on plant production and nutrient absorbance generally depends on their origin, type and concentration and on the species and variety of the plant treated [24,4].

3.4 Yield and Yield Components

The data on pods and yield of redgram was significantly influenced by Humic acid Liquid 15% application (Table 3). Significantly higher redgram pod yield was recorded with application of 4.0ml/L of 15% of Humic (2,154 kg/ha) followed by application Humic acid liquid 15% @ 2.5 ml/l of water (1323.02 kg/ha). However, lower pod yield was recorded in untreated control (1073.88 kg/ha) extent of reduction in pod yield was 32 % University check Planofix 4.5 % @ 20ppm (1288.66 kg/ha). Similarly higher number of pods and pods weight were also recorded in T₄ (126.88 and 75.45, respectively) while lower number of pods and pods weight were recorded in control (89.38 and 44.88, respectively). Similar results were obtained by Raj and Rao, [38]; Hafez and. Magda, [33]; Hossain et al., [29], Amiri and Gohari, [39] and Bozorgi et al., [40] in peanut. Khan et al., [41]; Hartz and Bottoms, [16]; Abdzad Gohari and Noorhosseini Niyaki,[42] in peanut.

4. CONCLUSIONS

Application of humic acid substances at the start of the growing season induced an overall positive effect on growth, root development, seed quality and yield of redgram in the field. It was also observed that the foliar application of all the doses of Humic acid Liquid 15% on redgram significantly increased the root length per plant, root dry weight per plant, root volume, number of pods/plant and yield/ha. Further, there was a significant reduction in the flower and pod drop compared to control. The seeds/plant analysis for

quality aspects indicated significantly higher content of macro (N, P,K) and micronutrients (Cu, Mn, Zn, and Fe) with the foliar application of Humic acid Liquid 15% @ 4.0ml/L over the control. The application of Humic acid Liquid 15% @ 4.0ml/L at flower bud formation stage may reduce flower drops in redgram compared to control. Increment in Humic acid concentration increased root growth and quality of redgram in the present study. Based on the present study findings Humic acid Liquid 15% @ 4.0ml/l foliar application to may be recommended. Further research is required in diverse plant environments to determine economically feasible application level of Humic acid while comparing it with other manures and organic fertilizer sources.

DISCLAIMER

The products used for this research are commonly and predominantly use products in our area of research and country. There is absolutely no conflict of interest between the authors and producers of the products because we do not intend to use these products as an avenue for any litigation but for the advancement of knowledge. Also, the research was not funded by the producing company rather it was funded by personal efforts of the authors.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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