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EFFECT OF VARIOUS CONCENTRATIONS OF BIO-REGULATORS AND HUMIC ACID ON GROWTH, YIELD AND QUALITY OF FRENCH BEAN (*PHASEOLUS VULGARIS* L.) CV. CONTENDER UNDER SUBTROPICAL CONDITION OF GARHWAL HILLS

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Abstract

This field experiment was carried out at Horticultural Research Centre, Chauras Campus, H.N.B. Garhwal University, Srinagar Garhwal, Uttarakhand, India, during summer season 2013. The experiment was designed in RBD with three replications and sixteen treatments to study the effect of various concentrations of bio-regulators and humic acid on growth, yield and quality of French bean (*Phaseolus vulgaris* L.) cv. Contender under subtropical conditions of Garhwal hills. The treatments used in this study were different concentrations of humic acid and combinations of humic acid with NAA and kinetin. The spraying of all the treatments was done after four weeks from date of sowings. The results were found to be significant in most of parameters except days taken for first flowering and TSS were non-significant at 5% level. Application of Humic acid 10ml (T_1) produced maximum number of nodules per plant (17.7) and fresh weight of nodule per plant (208.2 mg). Application of humic acid 30ml (T_3) recorded highest plant height (36.4cm), leaf area (84.9cm^2) and chlorophyll (0.06mg/g). Dry weight of nodules per plant (51.5mg) was maximum in control (T_{16}). When application of Humic acid 50ml+ Kinetin 100ml (T_{15}) yield of green pods per plant (0.080kg), yield of green pods per plot (2.33kg), pod yield per hectare (60.7q/ha) and number of pods per plant (81.0) were recorded highest. TSS content (5.4 ^{0}brix) was recorded highest in Humic acid 20ml+ NAA 40ml (T_8). The obtained results clearly indicated that combination of humic acid 50ml+ kinetin 100ml (T_{15}) kinetin is best suited for green pod yield.

Key words : French bean, humic acid, NAA, kinetin and bio-regulators.

Introduction

French bean (*Phaseolus vulgaris* L.) 2n=22, locally known as Pharas bean belongs to the family Leguminosae. It is also known as kidney bean, haricot bean, snap bean, navy bean, garden bean. It is one of the important crops of the bean group and forms an important part in our diet. It is world's most important food legume. It is consumed as vegetable when pods are immature, delicate, tender and green shelled. In India, it is grown for tender vegetable, shelled green beans and dry beans (Rajmah), while in USA it is grown in large quantities for processing. It occupies good place among nutritious vegetables as being rich source of protein, carbohydrates and Vitamin A. Dried beans are rich in protein and closely compared with meat. Humic acid, a naturally occurring polymeric organic compound, is a potential natural resource that can be utilized to increase growth, nutrient availability and yield. Humic acid is a commercial product, which is produced by decaying organic compounds. It contains elements that improve soil fertility, reduces soil nutrient deficiency and increases water and nutrient availability by forming chelates of various nutrients. Although, French bean is a leguminous crop, but shows very good response to the humic acid. It adds organic matter to poor soils and increases root vitality. Humic acid helps in improving the nutrient uptake and also favours better seed germination in French bean. It helps to increase the synthesis of chlorophyll. Humic acid increases the yield and quality of beans. Application of growth substances improved the plant growth, flowering and yield of pod in french bean. Spraying bio-regulators on the plants at 50-200 ppm proved very effective in increasing the plant height and number of leaves. The application of exogenous bio-regulators reduce the effects of stress on plants is especially those that delay leaf senescence (cytokinins), to prevent the abortion of fruits (auxins and gibberellins) and increase the area leaf (gibberellins).

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French bean is a short duration leguminous crop being grown as a cash crop in north-west hill region. Hence, it requires a lot of research programmers for finding out quality yield potential and appropriate production technology for the hill regions. No work has so far been done with regard the humic acid together with bio-regulators on this crop in the hill areas. Therefore, a need useful to conduct an investigation on above aspects under valley conditions of Garhwal region to find out the effect of various concentration of humic acid and combination of humid acid with bio-regulators on growth, yield and quality of French bean.

Materials and Methods

A field experiment was conducted during summer season 2013, at Horticultural Research Center, Chauras Campus, H.N.B. Garhwal University, Srinagar (Garhwal), Uttarakhand to evaluate the effect of various concentrations of bio-regulators and humic acid on growth, yield and quality of French bean (*Phaseolus vulgaris* L.) cv. Contender under subtropical conditions of Garhwal hills. The experiment consisting of sixteen treatments consisting of different concentrations of humic acid and combination of humic acid with bio-regulators (kinetin and NAA) *viz.,* humic acid @ 10ml ($\mathbf{T_1}$), 20ml ($\mathbf{T_2}$), 30ml ($\mathbf{T_3}$), 40ml ($\mathbf{T_4}$), and 50ml ($\mathbf{T_5}$), humic acid+NAA @ 10ml+20ml ($\mathbf{T_6}$), 20ml+40ml ($\mathbf{T_7}$), 30ml+60ml ($\mathbf{T_8}$), 40ml+80ml ($\mathbf{T_9}$) and 50ml+100ml ($\mathbf{T_{10}}$), humic acid+kinetin @ 10ml+20ml ($\mathbf{T_{11}}$), 20ml+40ml ($\mathbf{T_{12}}$), 30ml+60ml ($\mathbf{T_{13}}$), 40ml+80ml ($\mathbf{T_{14}}$) and 50ml+100ml ($\mathbf{T_{15}}$) including control ($\mathbf{T_{16}}$), which were arranged in a randomized block design with three replications. Geographically, the Horticultural Research Centre, Chauras Campus, H.N.B. Garhwal University, Srinagar (Garhwal), Uttarakhand, is situated at Alaknanda Valley between 78^0 46' 56" E longitude and 30^0 13' 7" N latitude, right in the heart of Garhwal region 132 km away from Haridwar on Haridwar-Badarinath Dham Highway at an elevation of 540 m above MSL, in the lesser Himalayan region. The experimental site exhibits a semiarid subtropical climate with occasional dense fog in the morning up to 10 AM from October to with not only dry summer and rigorous winter mid February. Except during rainy season, rests of the months are usually dry, with exception of occasional showers during winter or early spring. Treated seeds of French bean cv. Contender were sown in well prepared furrows beds of 3×2 m^2 at 45cm distance and seeds were then placed within the furrows at a distance of 10 cm apart with 2.5 cm depth. All the agronomic practices recommended for the successful crop growth were followed and time to time irrigation was given to maintain the proper moisture in the field for better growth and development of the plants. The spraying of all the treatments was done after four weeks from date of sowings. Five plants from each treatment were randomly selected and tagged for recording the following observations *viz.,* days taken to full germination**,** plant height**,** leaf area**,** number of nodules per plant**,** fresh weight of nodules per plant**,** dry weight of nodules per plant, days taken for first flowering, number of pods per plant, yield of green pods per plant, yield of green pods per plot**,** pod yield per hectare, total soluble solids and chlorophyll content. The data were analyzed according to the procedure of analysis for randomized block design (RBD) given by Cochran and Cox (1992). The significance of variation among the treatments was observed by applying ANOVA and least significant differences (LSD) test at 1% and 5% level was calculated to compare the mean values of treatments for all the characters.

Results and Discussion

Vegetative growth characters

Results in table 1 showed that French bean growth characters were significantly influence by application of different concentrations of humic acid. The minimum days taken to full germination were recorded (4.0) were in $\mathbf{T_9}$ (Humic acid 20ml + Kinetin 40ml) and the maximum days (6.00) were recorded in $\mathbf{T_8}$ (Humic acid 20ml + NAA 40ml) treatments. The highest plant height (36.4 cm) was recorded in $\mathbf{T_3}$ (Humic acid 30ml) while minimum plant height (24.3cm) was recorded in $\mathbf{T_7}$ (Humic acid 10ml+ Kinetin 20ml) treatment. Present finding results are in line with results obtained by Kaya *et al.* (2005), Yildirim (2007), El-Bassiony *et al.* (2010) and Shehata *et al.* (2012). Maximum leaf area (84.9 cm^2) was recorded in $\mathbf{T_3}$ (Humic acid 30ml) treatment and it was statistically at par with $\mathbf{T_8}$ (Humic acid 20ml+ NAA 40ml) treatment. Minimum leaf area (57.5 cm^2) was recorded in $\mathbf{T_6}$ (Humic acid 10ml+ NAA 20ml) treatment. El-Bassiony *et al.* (2010) and Ahmad *et al.* (2013) showed similar result by foliar application of humic acid. Maximum number of nodules per plant (17.7) was recorded in $\mathbf{T_1}$ (Humic acid 10ml) treatment and it was statistically at par with $\mathbf{T_{16}}$ (control) treatment. Minimum number (5.7) was recorded in $\mathbf{T_{10}}$ (Humic acid 30ml + NAA 60ml) treatment. The greater weight of nodules in HA treatment suggests the favourable effect of HA on the nodule formation (Tan & Tantiwira, 1984). Bano *et al.* (1988) and El-Bassiony *et al.* (2010) also found similar result in their research. Maximum fresh weight (208.2 mg) was recorded in $\mathbf{T_1}$ (Humic acid 10ml) treatment and it was

Table 1 : Effect of bio-regulators and humic acid on growth characters of French bean.

Treatment	Days taken to full germination	Plant height (cm)	Leaf area (cm^2)	Number of nodules per plant	Fresh weight of nodule per plant (mg)	Dry weight of nodules per plant (mg)
T_1 (Humic acid 10ml)	5.4	33.7	78.8	17.7	208.2	49.8
T_2 (Humic acid 20ml)	5.3	30.1	61.9	10.0	62.5	15.9
T_3 (Humic acid 30ml)	5.4	36.4	84.9	9.8	124.4	33.7
T_4 (Humic acid 40ml)	4.8	29.8	74.8	6.7	63.9	15.0
T_5 (Humic acid 50ml)	5.3	27.1	69.2	8.3	47.5	10.8
T_6 (Humic acid 10ml+ NAA 20ml)	5.6	31.4	57.5	6.3	48.6	10.5
T_7 (Humic acid 10ml+ Kinetin 20ml)	5.2	24.3	62.1	9.9	105.4	23.1
T_8 (Humic acid 20ml+ NAA 40ml)	6.0	28.3	84.6	7.3	65.3	16.03
T_9 (Humic acid 20ml+ Kinetin 40ml)	4.0	29.0	75.3	6.9	67.4	21.8
T_{10} (Humic acid 30ml+ NAA 60ml)	5.6	28.1	77.9	5.7	53.7	18.1
T_{11} (Humic acid 30ml+ Kinetin 60ml)	4.9	25.8	83.5	9.7	160.5	34.1
T_{12} (Humic acid 40ml+ NAA 80ml)	4.8	34.8	83.3	10.7	122.8	33.2
T_{13} (Humic acid 40ml+ Kinetin 80ml)	4.9	29.3	72.9	6.0	100.5	20.6
T_{14} (Humic acid 50ml+ NAA 100ml)	5.4	28.2	65.8	7.0	108.3	35.2
T_{15} (Humic acid 50ml+ Kinetin 100ml)	4.9	29.7	59.8	6.0	78.1	18.1
T_{16} (Control)	5.3	29.7	65.1	17.4	183.3	51.5
C.D. at 5%	0.5	1.62	0.9	1.5	1.6	2.4
S.Em.±	0.2	0.56	0.3	0.5	0.6	0.8

not statistically at par with any other treatment. Minimum fresh weight (47.5 mg) was recorded in T_5 (Humic acid 50ml) treatment. El-Bassiony *et al*. (2010) showed that foliar application by humic acid (at 1, 2 or 3 g/l) significantly affects the fresh and dry weight of nodules in snap bean plants (*Phaseolus vulgaris* L.) cv. Paulesta. Maximum dry weight (51.5 mg) was recorded in T_{16} (control) treatment and it was statistically at par with T_1 (Humic acid 10ml) treatment. Minimum dry weight of nodules (10.5) was recorded in T_6 (Humic acid 10ml+ NAA 20ml) treatment.

Yield and quality characters

The presented data in table 2 concerning with the yield parameters of French bean are affected by combination of humic acid and kinetin. Most of the yield and quality parameters gave a significant influence except days taken for 1st flowering and TSS were non-significant influence at 5% level. Minimum days taken for 1st flowering (28.0) were recorded in T_3 (Humic acid 30ml), T_6 (Humic acid 10ml+ NAA 20ml) and T_{16} (control) treatments while maximum days (29.3) were recorded in T_2 (Humic acid 20ml) treatment. Maximum pods per plant (81.0) were recorded in T_{15} (Humic acid 50ml + Kinetin 100ml) treatment and it was not statistically at par with any other treatment. Minimum pods (38.0) were recorded in T_{11} (Humic acid 30ml+ Kinetin 60ml) treatment. Ananthi *et al*. (2012) and Rajesh *et al*. (2014) found that the yield and yield components were significantly increased by the application of chemicals, growth regulators and bio-regulators. Maximum weight of green pods per plant (0.080 kg) was recorded in T_{15} (Humic acid 50ml+ Kinetin 100ml) treatment and it was not statistically at par with any other treatments. Minimum weight (0.040 kg) was recorded in T_2 (Humic acid 20ml), T_4 (Humic acid 40ml), T_5 (Humic acid 50ml), T_7 (Humic acid 10ml+ Kinetin 20ml), T_{11} (Humic acid 30ml + Kinetin 60ml) and T_{14} (Humic acid 50ml+ NAA 100ml) treatment. Maximum yield of green pods per plant (2.33 kg) was recorded in T_{15} (Humic acid 50ml+ Kinetin 100ml) treatment and it was statistically at par with T_3 (Humic acid 30ml) treatments. Minimum yield of green pods per plant (1.03 kg) was recorded in T_{14} (Humic acid 50ml+ NAA 100ml) treatment. Maximum pods yield per hectare (60.7 q) were recorded in T_{15} (Humic acid 50ml+ Kinetin 100ml) treatment and it was not statistically at par with any other treatment. Minimum (23.5 q) were found in T_7 (Humic acid 10ml+ Kinetin 20ml) treatment. Ananthi *et al*. (2006) found in their research that the yield and yield components were significantly increased by the application of chemicals and bio-regulators. Maximum TSS (5.4°brix) was recorded in T_8 (Humic acid 20ml + NAA 40ml) treatment and minimum TSS

Table 2 : Effect of bio-regulators and humic acid on yield and quality characters of French bean.

Treatment	Days taken for 1st flowering	Number of pods per plant	Yield of green pods per plant (kg)	Yield of green pods per plot (kg)	Pod yield per hectare (q/ha)	TSS (^{0}brix)	Chlorophyll (mg/g)
T_1 (Humic acid 10ml)	29.0	48.7	0.050	1.50	36.4	4.6	0.04
T_2 (Humic acid 20ml)	29.3	43.7	0.040	1.30	32.9	4.7	0.02
T_3 (Humic acid 30ml)	28.0	74.4	0.073	2.23	55.0	4.3	0.06
T_4 (Humic acid 40ml)	28.3	41.7	0.040	1.20	30.9	4.6	0.03
T_5 (Humic acid 50ml)	29.0	40.3	0.040	1.30	32.4	4.7	0.03
T_6 (Humic acid 10ml+ NAA 20ml)	28.0	52.0	0.060	1.63	42.9	4.2	0.04
T_7 (Humic acid 10ml+ Kinetin 20ml)	28.3	42.7	0.040	1.13	23.5	4.6	0.03
T_8 (Humic acid 20ml+ NAA 40ml)	28.3	65.7	0.067	1.93	48.7	5.4	0.05
T_9 (Humic acid 20ml+ Kinetin 40ml)	28.3	59.7	0.060	1.83	46.9	4.5	0.03
T_{10} (Humic acid 30ml+ NAA 60ml)	29.0	60.0	0.060	1.80	45.0	4.8	0.03
T_{11} (Humic acid 30ml+ Kinetin 60ml)	29.0	38.0	0.040	1.10	29.01	3.4	0.04
T_{12} (Humic acid 40ml+ NAA 80ml)	29.0	62.3	0.060	1.83	47.1	4.8	0.03
T_{13} (Humic acid 40ml+ Kinetin 80ml)	29.0	44.7	0.050	1.37	35.2	4.4	0.02
T_{14} (Humic acid 50ml+ NAA 100ml)	28.7	38.3	0.040	1.03	29.1	4.2	0.03
T_{15} (Humic acid 50ml+ Kinetin 100ml)	28.3	81.0	0.080	2.33	60.7	4.8	0.03
T_{16} (Control)	28.0	71.3	0.070	2.13	55.2	4.2	0.04
C.D. at 5%	1.2	2.8	0.0012	0.11	2.2	1.1	0.2
S.Em.±	0.4	0.9	0.0035	0.039	0.8	0.4	0.6

(3.4 ^{0}brix) was recorded in T_{11} (Humic acid 30ml + Kinetin 60ml) treatment. Maximum chlorophyll content (0.58 mg) was recorded in T_3 (Humic acid 30ml) treatment while minimum 0.02 was recorded in T_2 (Humic acid 20ml) and T_{13} (Humic acid 40ml + Kinetin 80ml) treatments.

Conclusion

A comparative study of the present findings led to the conclusion that concentration of humic acid @ 10ml and 30ml is best suited for vegetative growth parameters while the combination of humic acid 50ml+ Kinetin 100ml is best suited for green pod yield under Srinagar valley conditions (Sub-tropical climate) of Garhwal region, Uttarakhand.

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