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Effect of Plant Growth Regulators (Iba and 2,4-D) on the Morphology and Biochemical Characteristics of Radish (*Raphanus sativus L.*)

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Abstract

A study was carried out during the year 2013-2014 at vegetable experimental area, Institute of Horticultural Sciences, University of Agriculture, Faisalabad to investigate the effect of plant growth regulators on certain morphological and biochemical parameters of *Raphanus sativus.* The plant growth regulators IBA and 2,4-D were applied individually in different concentrations; IBA (2 ppm and 4 ppm) and 2,4-D (2 ppm and 4 ppm). Experimental design was randomized complete block design with 3 replications. The results indicated that foliar application of Indole-3-butyric acid and 2,4-Dichlorophenoxyacetic acid with different concentrations led to significant increases in vegetative growth; leaf length, plant height, number of leaves per plant, fresh and dry weight of roots, root diameter and biochemical attributes like total soluble solids, titratable acidity and vitamin C contents of radish. Maximum root length was observed in 2,4-D application with both concentrations (2 ppm, 4 ppm). Root width was maximum in 2,4-D with 4 ppm concentration. TSS was maximum in control and 2 ppm of 2,4-D and these two are at par with each other. Maximum acidity was observed by the application of IBA @ 2 and 4 ppm concentrations. However less acidity was observed in control as compared to others. The recorded data was statistically analyzed using Statistics software at 5% probability level under RCBD. Least Significant Difference (LSD) test was applied for comparing the differences among treatment means.

Keywords: Plant growth regulators; IBA; TSS; Titratable acidity

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Introduction

Radish (*Raphanus sativus* L.), which was originated in Asia, is presently cultivated all over the world. Long and red/spring radishes that are mainly used for salad and decorative purposes have high demand for hotel industry. In addition, radish is used for pickling and other processing industries. It is a good source of vitamin C (ascorbic acid) and minerals like calcium, potassium and phosphorus. It has got refreshing and diuretic properties. In homeopathy, it is used for neurological disorders, headache, sleeplessness and chronic diarrhea. The roots are also useful in urinary complaints and piles. The leaves of radish are good source for extraction of protein on a commercial scale and radish seeds are potential source of non-drying fatty oil suitable for soap making, illuminating and edible purposes. Radishes can be planted in both spring and fall but the growing should be suspended in the warmer months. Plant growth regulators are the chemicals which enhance the plant growth when applied in very minute quantity [1]. Several reports on regulatory effects of growth regulators on plant growth and development show that some of them can be used to enhance crop yield [2-4]. The role of endogenous gibberellins in the regulation of stem elongation and flower formation in radish has not been studied, although Murakami [5] was unable to detect gibberellin-like activity in mature dry seeds of a Japanese radish cultivar. The cytotoxic and mutagenic effects of 2,4-D synthetic auxin were observed both in animals (on hamster fibroblasts, for example) and in root apical meristems [6]. Many investigations showed that pre-sowing treatment of growth regulators could lead to increase in tissue hydration, redistribution of nutrient reserves, higher respiratory activities and enhancement of seedling growth, dry matter production, early flowering and yield [7-10]. The role of

plant growth regulators in fruit development can also be seen from the fact that with their help it is possible to stimulate fruit development without fertilization (parthenocarpic). In brinjal, application of 2,4-D at 0.00025% in lanolin paste to cut end of styles or as foliar sprays to freshly opened flower cluster has been reported to induce parthenocarpy. Ethephon, an ethylene releasing compound, has been reported to induce ripening in tomato and pepper. Field application of ethephon at 1000 mg/l at turning stage of earliest fruits induced early ripening of fruits thus increasing the early fruit yield by 30%-35%. Post-harvest dip treatment with ethephon at 500-2000 mg/l has also been reported to induce ripening in mature green tomatoes (Berleth and Sachs, Campanoni and Nick, Teale et al.).

Indole-3-butyric acid (IBA) is a plant growth promoter, used to regulate and accelerate the formation of roots of young plant clippings, to promote growth development of flowers and fruit and to elevate crop yields. Early rooting initiation was observed by applying IBA as compared to untreated plants of datepalm [11]. Application of IBA gave significant results as compared with control in statistical analysis of all recorded parameters i.e. number of leaves, length of root, fresh and dry weight of root, fresh weight of plant, height of the plant, diameter and length of the bulb, length of the clove, brix, anthocyanin, yield of allicin and total yield of the bulb [12].

2,4-D is a selective herbicide with auxin activity. This herbicide is especially designed to control broad leaf weeds (dicotyledons) in cereal crop fields. It is generally accepted that 2,4-D is an auxin-like herbicide, because at low concentration it has growth promoting properties. The first herbicide reported to improve growth and yield of crops at sub-toxic level was 2,4-D [13]. Studies indicated that 2,4-D is important in tomato production to induce fruit setting and earliness and GA_3 seems to extend fruit maturity and harvest period while the combined applications have intermediate effects. Studies have shown the stimulatory effects of growth regulators in the growth and yield of vegetables. The growth regulators influence plant growth and development at very low concentrations while they inhibit at high concentrations [14].

The present study also contributed to the knowledge of effect of these growth regulators on morphological and biochemical characteristics of radish cultivars.

Material and Methods

The field experiment was carried out at vegetable area, Institute of Horticultural Sciences, University of Agriculture Faisalabad Pakistan, to study the effect of foliar application of different concentration of Indole-3-Butyric acid and 2,4-D on morphological and biochemical parameters of *Raphanus sativus.* Seeds of *Raphanus sativus* cultivar "Mino Early" were sown on 1st November 2013. Sowing was done on ridges of 2.5 ft wide and plant to plant distance was maintained at 6 inches. The experiment included four treatments with one control. Foliar application of 2,4-D (2 and 4 ppm) and IBA (2 and 4 ppm) was done at 2 leaf stage of radish.

Some morphological traits of radish like root width, root length, plant height, leaf width, leaf length, and number of leaves were calculated before harvesting. After 60 days from sowing, crop was harvested and following morphological parameters like fresh weight of root, dry weight of root, root diameter, and biochemical traits like total soluble salts (TSS), vitamin C and titratable acidity were calculated.

Foliar spray of different concentration of IBA and 2,4-D (2 ppm and 4 ppm of each one) were applied at two leaf stage. The experiment was laid out according to Randomized Complete Block Design (RCBD) with five treatments. All the cultural operations were performed as per requirement of the crop.

Treatments to be included in this experiment are given T_0 (Control), T_1 (IBA 2 ppm), T_2 (2,4-D 2 ppm), T_3 (IBA 4 ppm) and T_4 (2,4-D 4 ppm).

Morphological parameters

Data were recorded for the following morphological parameters of the radish. The height of the plant was recorded by adding the root width and leaf length of the randomly selected plants, their average was calculated and analyzed statistically. Leaf length was measured from base of the leaf to the tip of the leaves at 40 days after sowing and at harvest and the leaf length was expressed in cm. Leaf width was measured three different points and their average is calculated expressed in cm. The numbers of the leaves were counted on randomly selected plants at the time of complete maturity their average was calculated and analyzed statistically. Fresh weight of the plant was calculated after harvesting by digital weight balance in grams (gm) from randomly selected plants and their average were calculated and analyzed statistically. Dry weight of the root was calculated after 72 hours drying the roots in an oven at 60°C. Dry weight was calculated by digital weight balance. Their averages were calculated and analyzed statistically. The diameter of the roots of five randomly selected plants after harvesting was measured with the help of Vernier Caliper in cm and mean values were calculated.

Yield hectare^{-1} was calculated by taking the yield from 1 m^2 area of each treatment and then by multiplying with 10000 m^2.

Biochemical parameters

Total soluble solids were determined by using Refractometer. Five roots were taken from each treatment. Drop from the representative sample of root juice was placed on prism and readings were noted. Titratable acidity (mg/L) was measured by determining the concentration of titratable hydrogen ions in juice. It depends upon the concentration of tartaric acid and bitartratemalic acid. Vitamin C (mg/L) was measured by DCPIP (dichlorophenolindophenol) method. The principle of this method is a titration with dichlorophenolindophenol (or phenol-indo-2,6-dichlorophenol, also known as DCPIP). Ascorbic acid reacts with DCPIP, changing the color from blue to colorless. They react in a 1:1 fashion, so if a known quantity of DCPIP solution reacts with the plant tissue extract, the quantity of DCPIP used gives a direct measure of the quantity of ascorbic acid present.

Statistical analysis

The experiment was executed in open field conditions according to Randomized Complete Block Design (RCBD) having five treatments of various concentrations of IBA and 2,4-D. Each treatment was replicated for five times. Data was subjected to analysis of variance technique and difference among treatments was determined by (LSD) test at 5% probability level [15].

Results and Discussion

Two concentrations (2 ppm, 4 ppm) of IBA and Two concentrations (2 ppm, 4 ppm) of 2,4-D were used to observe their effects on various morphological and biochemical parameters of radish.

Morphological parameters

In **Table 1**, 2,4-D at 2 ppm showed maximum height (62.10 cm) and its results were at par with other applications of 2,4-D and IBA including control. However, less height was shown by 2 ppm IBA (56.60 cm). Maximum number of leaves (27) was observed in control and significantly different from all other applications. IBA concentration @ 2 ppm shows minimum number of leaves (18) whereas 2,4-D at 2 ppm and at 4 ppm shows non-significant results with each other. It means 2,4-D concentrations did not affect the number of leaves. Leaf length in control was significantly higher (28.10 cm) from all other concentrations while leaf width was maximum (9.5 cm) in 2 ppm concentration of 2,4-D. The concentration of 2,4-D at 2 ppm and at 4 ppm shows results at par with each other but significantly different from all other treatments for the character fresh weight of root.

Maximum root length was observed in 2,4-D application with both concentrations (2 ppm and 4 ppm) 34.3 cm and 33.7 cm respectively. For the trait root width, 2,4-D application with both concentrations (2 ppm and 4 ppm) showed significant increase (5.59 and 5.9 cm respectively) with respect to other treatments. Root width was reduced in control which concluded that any of the concentration of these plant growth regulators led to enhancement of root width. All treatments including control shows non-significant results with each other in dry weight of root (**Figures 1 and 2**).

Biochemical parameters

Among biochemical parameters of radish, in **Table 2**, maximum TSS was observed in control (6.4 brix) and 2 ppm concentration of 2,4-D (6.1 brix) and these two are at par with each other. Control shows significantly higher value of vitamin C (69.3 g/L) and minimum value were observed in treatment 2 ppm of 2,4-D (43 g/L). In case of titratable acidity, all the four applications of 2,4-D, IBA and control showed significant difference with each other. Maximum acidity (0.077 g/L) was observed by the application of IBA @ 2 ppm and 4 ppm concentrations. However less acidity was observed in control (0.05 g/L) as compared to others.

Conclusion

The results showed that all the studied characters were statistically significant except one character i.e. dry weight of

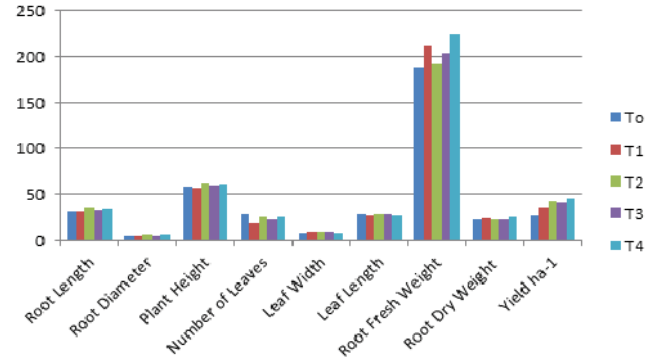

Figure 1 Graphical representation of means of morphological traits recorded in the experiment showing comparisons of means using LSD Test.

To: Control, T1: IBA (2 ppm), T2: 2,4-D (2 ppm), T3: IBA (4 ppm), T4: 2,4-D (4 ppm).

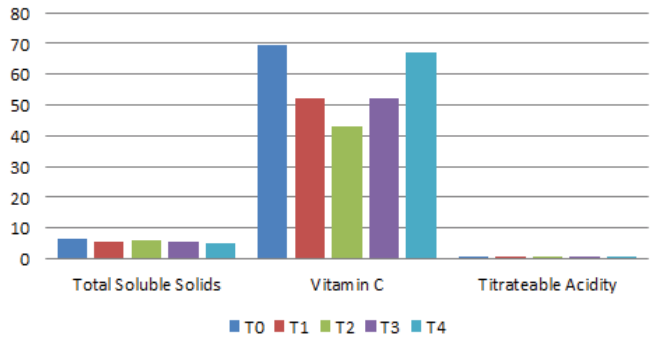

Figure 2 Graphical representation of means of biological traits recorded in the experiment showing comparisons of means using LSD Test

To: Control, T1: IBA (2 ppm), T2: 2,4-D (2 ppm), T3: IBA (4 ppm), T4: 2,4-D (4 ppm).

Table 1 The means of morphological traits recorded in the experiment showing comparisons of means using LSD Test.

T	R. L	R. W	PH	N. L	L.W	L.L	F. Wt.	Dry Wt.	Yield ha^{-1}
T0	30c	4.80c	58.10bc	27a	7c	28.10a	188.20e	21.90b	26.66d
T1	30.5c	5.18c	56.60c	18b	9a	26.6b	212.7b	23.4a	34.33c
T2	34.3a	5.59b	62.10a	25a	9.5a	27.8ab	192.2d	21.3b	42.33ab
T3	31.5bc	5.07bc	58.73bc	22ab	8.33ab	27.23ab	203.2c	21.7b	40.00b
T4	33.7ab	5.90a	60.40ab	25a	7.3bc	26.7ab	225a	24.3a	45.00a

T: Treatments; R. L: Root Length (cm); R. W: Root Width (cm); PH: Plant Height (cm); N. L: Number of Leaves; L. W: Leaf Width (cm); L. L: Leaf Length (cm); F. Wt: Fresh Weight of Root (g); Dry Wt: Dry Weight of Root (g); Yield ha^{-1} (ton)

Table 2 The means of biochemical traits recorded in the experiment showing comparisons of means using LSD Test.

T	TSS	Vit. C	Acidity
T0	6.4a	69.3a	0.05d
T1	5.4b	52c	0.077a
T2	6.1a	43d	0.07b
T3	5.3b	52c	0.077a
T4	5.2b	67b	0.064c

T: Treatments; TSS: Total Soluble Salts (brix); Vit. C: Vitamin C (g/L); Acidity (g/L)

root which suggested that this specific character was largely influenced by environment. The growth regulator 2,4-D was found prominently effective in enhancement of the characters plant height, leaf width, fresh weight of root, root length and TSS. IBA proved important in the development and improvement of root width and titratable acidity while some traits were not dependent on any of the concentration of both growth regulators which were number of leaf, leaf length and vitamin C. The results will provide useful information about these plant growth regulators for radish.

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