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Response of common bean (*Phaseolus vulgaris* L.) plant to foliar spray with some growth activators

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Abstract

Two field experiments were conducted at the experimental Farm Station of Hort. Faculty of Agriculture Moshtohor, Benha University, Qalubia Governorate, Egypt, during the seasons of 2022 and 2023 This study aimed to investigate the effect of foliar spray with some growth activators i.e., benzyladenine at 25 and 50 mg L^{-1}, milagrow at 50 and 100 mg L^{-1}, yeast extract at 50 and100 ml L^{-1} as well as lithovit at 250 and 500 mg L^{-1} on growth, chemical composition, anatomical features as well as yield characteristics of common bean plant.

The obtained results indicated that, significant increases existed in many growth characteristics and bioconstituents level such as photosynthetic pigments, phytohormones, minerals, total carbohydrates as well as crude protein %. Also, results showed that applied treatments enhanced anatomical features of common bean plant. Moreover yeast extract at 100 ml L^{-1} and milagrow at 100 mg L^{-1} treatments caused significant increases in flowering and yield characteristics i.e., number of flowers $plant^{-1}$, number of setted pods $plant^{-1}$, pods yield $plant^{-1}$, weight of seeds pod^{-1}, 100 seeds weight, weight of seeds (g) $plant^{-1}$ in the two growing seasons which were the most effective treatments in this respect compared with control and the other used treatments.

Generally, it could be recommended to spray common bean plants using growth stimulators such as yeast extract at 100 ml L^{-1} or milagrow at 100 mg L^{-1} to improve their growth, productivity and quality.

Keywords: Common bean, benzyladenine, milagrow, yeast and lithovit.

INTRODUCTION

Common bean plant (*Phaseolus vulgaris* L.) is a member of legumes **(Qin *et al*., 2019).** It is considered one of the most important vegetables, belonging to the family Fabaceae. Snap bean is an important economic vegetable crop grown in Egypt for local consumption and exportation. It is utilized for various purposes like fresh bean, dry pulses and edible podded type. It is rich in a variety of macro-and micro-nutrients, including starch **(Punia *et al.,* 2020)**, the average crude protein content of common bean typically ranges from 21 to 25%, carbohydrate content varies between 60 and 65%, fibers content (soluble and insoluble) ranges between 3 and 7% , a very low amount of fat between 0.8 and 1.5% **(Rathna and Manickavasagan, 2020.)**, minerals (P, Ca, K, Fe, and Mg) and vitamins (A, B1, B6, and B12) **(Osorno *et al.,* 2020 and Mohamed *et al*., 2023)** and also source of antioxidant compounds such as phenols and ketones **(Yang *et al.,* 2019)**, which have positive effects in managing diabetes, inhibiting obesity and increasing human metabolism **(Liu *et al.,* 2020; Neil *et al.,* 2019**; **Nolan *et al.,* 2020)**. Egypt production of bean was 144809 tons from total area 90734 acre **(Faostat, 2020**).

Many investigators reported that improving physiological, morphological and anatomical performances of plants could be achieved by the application of different natural and chemical growth substances to enhance and maximize their growth, yield and seed quality characteristics as well.

In this respect, cytokinins are plant growth regulators that regulate plant growth, including cell division and leaf senescence **(Gao, 2020)**. Cytokinins have been shown to have effects on many other physiological and development processes, including leaf senescence, formation and activity of shoot apical meristems, floral development, breaking of bud dormancy and seed germination. Cytokinins also appear to mediate many aspects of light-regulated development, including chloroplast differentiation, development of autotrophic metabolism, leaf and cotyledon expansion **(Ikiba, 2017).**

Benzyladenine (BA) is one of the cytokinins that improve quantitatively and/or qualitatively yield of many plants **(Reda *et al.,* 2007).** Application of benzyladenine is important for increasing plant height, number of leaves and fresh weight of leaves **(Nahed and Aziz, 2007).**

Milagrow is a natural growth promoter extracted from the pollen of cabbage flowers, it has great effectiveness in many field crops. Milagrow has combined effects of auxins, cytokines, gibberellins, ethylene and hydrogen cyanamid. The chemical composition of milagrow is 20% phosphorus, 10% potassium, 3% boron and 0.2% brassinolide **(El-Emary and Abd El-Aal, 2018)**. Brassinolide is a natural plant growth promoter for all crops, which promotes growth, increases yield, improves quality and increases percentage of the fruit setting, spraying before flowering can promote the of flower buds and spraying during the flowering stage, can resist fruits dropping and flowers dropping **(Seadh *et al.*, 2012; Attia *et al.*, 2011).** Milagrow (Brassinosteroids, BRs) has been found for stimulating cell division and elongation, differentiation of flowering buds, carbohydrate assimilation and activity of ATP, subsequently improving vegetative growth as well as enhancing physiological status then directing plant for earlier harvest and increasing fruit yield and quality features **(Gabr *et al*., 2011; Gomes *et al.*, 2006; Symons *et al.*, 2006).** Brassinolide had a wide range of physiological and molecular responses in plants, such as stem elongation, pollen tube growth, leaf bending, photosynthesis, ethylene biosynthesis, proton pump activation, vascular differentiation, gene expression, nucleic acid and protein synthesis **(Sasse, 2003).**

As for yeast extract, it is a natural bio substance contains many nutrient elements and productive compounds of growth regulators like auxins, gibberellins and cytokinins. Dry yeast extract is a source of nutrients for plants because it contains amino acids, plant hormones, sugars, carbon, nitrogen, phosphorus, potassium, calcium, magnesium and micronutrients **(El Sheikha *et al.*, 2022; Manea *et al.*, 2019).** Yeast extract is a natural source of many growth substances (thiamine, riboflavin, niacin, pyridoxine and vitamins B1, B2, B3 and B12), cytokinins and many of the nutrient elements as well as organic compounds i.e., protein, carbohydrates, nucleic acid and lipids. Yeast is the best source of B-complex vitamin and a valuable source of bio-constituents, especially cytokinins **(Amer, 2004 and El Sheikha *et al.*, 2022).** It has been reported to be a rich source of phytohormones (especially cytokinins), vitamins, enzymes, amino acids and minerals **(Khedr and Farid, 2000; Mahmoud, 2001)**. It was reported its stimulatory effects on cell division and enlargement, protein and nucleic acid synthesis and chlorophyll formation **(Khater *et al.*, 2023).** Improving growth and productivity of vegetable crops by the application of active yeast extract were recorded by **(Khater *et al.*, 2023; Amer, 2004; El-Tohamy and El-Greadly 2007)**. It was additionally announced its stimulatory impact on cell division and expansion, protein and nucleic acid synthesis as well as chlorophyll formation **(Khater *et al.*, 2023).**

For lithovit compound, it is containing silica (5%), magnesium carbonate (4%) and calcium carbonate (75%), particles are extremely small, which gives them the ability to enter through the stomata of leaves with foliar spraying **(Abo-Sedera *et al*., 2016; Beinsan *et al*., 2014)**. Lithovit (manufactured by Zeovita-GmbH, Berlin, Germany) and quantitatively analyzed by **Wichmann and Basler (2006)**, who described it as a natural calcium carbonate foliar fertilizer supplemented with 12 different minerals that deliver fine particles (<10 µm) that can be easily adsorbed directly through the stomata of plant leaves. The positive effects of lithovit on plant growth and chemical constituents were reported by **Abu-Shleell (2017).** Lithovit contains several elements or compounds, such as magnesium, which is the central element of the chlorophyll molecule; silica, which plays a vital role in increasing plant tolerance against abiotic stress, mainly concerning water relations and photosynthesis **(Raven, 2003).** The beneficial effect of this compound is being contains calcium carbonate ($CaCO_3$) decomposes to calcium oxide (CaO) and carbon dioxide (CO_2) in leaves stomata, and this Co_2 increases photosynthesis intensity, leading to increased carbon uptake and assimilation, there by increasing plant growth **(Carmen *et al.*, 2014). Bilal (2010)** lithovit is recommended by the European Community for organic farming according to EWG 2092/91. The micronutrients supplied with lithovit such as Mn, Cu, Zn, among others, influence plant physiology and metabolism and cell wall formation **(Morsy *et al.*, 2018).** Lithovit is a foliar fertilizer that improves plant growth and the yield of snap bean plant **(Byan, 2014).** Lithovit with the micronutrients provided an influence on cell wall formation, plant metabolism, and plant photosynthetic activity **(Thorn and Rogan, 2015)**, that it works as an enzyme activator, a constituent of many enzymes, and a carrier of phosphorus in plant **(Allison *et al.*, 2001; Haq and Mallarino, 2005).**

So, this study aimed to investigate the effect of benzyladenine (BA), milagrow, yeast extract and lithovit foliar as spray treatments on growth, chemical compositions, anatomical features as well as yield characteristics of common bean plant (*Phaseolus vulgaris* L.).

2. MATERIAL AND METHODS

Two field experiments were conducted at the experimental Farm Station of Hort. Faculty of Agriculture Moshtohor, Benha University, Qalubia Governorate, Egypt, during seasons of 2022 and 2023. In order to study the effect of benzyladenine (BA), milagrow, yeast extract and lithovit on morphological, physiological, anatomical, flowering and yield characteristics of common bean (*Phaseolus vulgaris* L.).

Seeds of common bean (cv. Nebraska) were sown on the 1^{st} of March during the 2022 and 2023 seasons. Three seeds were sown in hills on one side of the ridge at 15 cm space between the hills, 3 cm deep, after inoculation with root nodules bacteria (*Rhizobium phaseoli*). The standard inoculums contained about 270 spores g^{-1} soil. The inoculums were placed below common bean seeds at sowing time in the soil. After complete germination plants were thinned into two plants per hill. The experimental design was a randomized complete block design (RCBD) with three replicates. Each plot consisted of three rows for each replicate (3m length X 0,7m width). This experiment included 9 treatments. All field practices of growing common bean plants including fertilization, irrigation, manual weed control and so on were carried out as usual according to crop requirement recommendations.

The experimental treatments were as follows: -

Benzyladenine (BA) at 25 and 50 mg L^{-1}, Milagrow at 50 and 100 mg L^{-1}, Yeast extract at 50 and 100 ml L^{-1} and Lithovit at 250 and 500 mg L^{-1}as well as control (tap water).

Through plant growth and development, the growth substance treatments were applied as foliar spray three times starting at 25 days from sowing and repeated two times at 15-day intervals. The plants were sprayed with a hand pump mister. A surfactant (Tween 20) at a concentration of 0.01% was added to all tested solutions including the control. The foliar spraying solution was added to the point of runoff.

Treatments source:

1-Benzyladenine (BA) was exported from Algomhoria Chemical Company, Egypt.

2- Milagrow (Brassinosteroids, BRs) is a registered trademark product of Green India Co., India. It has been obtained from Gaara Company, Cairo, Egypt. The compositions of milagrow are 0.2% brassinolide, 20% phosphorous, 10% potassium, and 3% boron **(Abou Elhassan *et al.*, 2023; Seadh *et al*., 2012)**

3-Yeast extracts were prepared according to **(Abd EI-Rahim *et al.*, 1988).**

4- Lithovit as Nano particles (Ca, Mg and Fe nano or micro particles) containing calcium carbonate (80%), magnesium carbonate (4.6%) and Fe (0.75%) **(Carmen *et al*., 2014)** was obtained from Agro Link Company (3 Ibn- Eyas. St., Roxy, Heliopolis, Cairo).

The analysis of prepared yeast extract stock solution was: total protein (5.3%), total carbohydrates (4.7%), N (1.2%), P (0.13%), K (0.3%), Mg (0.013%), Ca (0.02%), Na (0.01%); micro-elements (mg L^{-1}), Fe (0.13), Mn (0.07), Zn (0.04), Cu (0.04), B (0.016), Mo (0.0003), IAA (0.5 µg ml^{-1}) and GA (0.3 µg ml^{-1}).

Such analysis was according to **(Cotton, 1954)** for N, P, and K determination, the atomic absorption method of **(Nelson, 1944**) for mineral analysis, **(A.O.A.C. 2005)** for carbohydrate determination, the GLC method of **(Vogel, 1975)** for IAA and GAs determination and the method of **(Fletcher and Mccullagh, 1986)** for cytokinins bioassay.

Table (1): Physical and chemical properties of the experimental soil during 2022 and 2023 seasons were as follows.

Soil analysis	Seasons	
	2022	2023
	Pre planting	Pre planting
Soluble cations and anions (mmole L^{-1})		
Ca^{++}	1.3	2.6
Mg^{++}	0.7	1.2
K^{+}	0.4	0.7
Na^{+}	5.1	8.3
Cl^{-}	4.9	10.0
CO_3^{2-}	0.0	0.0
HCO_3^{-}	1.2	2.4
So_4^{2-}	1.4	0.4
Chemical analysis		
E.C* (dS m^{-1})	0.73	1.31
PH	7.92	7.78
Particle size distribution (Mechanical analysis)		
Course sand %	10.5	16.5
Find Sand %	16.1	10.0
Silt %	37.30	36.6
Clay %	36.1	36.9
Soil texture	Clay loam	Clay loam

Sampling and collecting data: -

2.1. Morphological measurements: -

Three plants from each replicate for each treatment were randomly taken at 55 days after sowing during both seasonand then separated into their organs and the following characteristics were recorded:

Plant height (cm), stem diameter (cm), number of branches plant^{-1}, number of leaves plant^{-1}, total leaves area plant^{-1} by using disk methods according to **(Derieux *et al.,* 1973),** shoot fresh as well as dry weight (g) plant^{-1}. The samples of the above ground i.e., vegetative parts were dried in the oven-dried for 48 h in 70°C to a constant weight and then the dry weight per plant was calculated. The dry samples were kept for chemical analysis.

2.2. Photosynthetic pigments determination: -

The photosynthetic pigments (chlorophyll a., b. and carotenoids) were extracted from fresh leaf samples (in the 4th apical leaves) at 55 days after sowing and determined using the methods described by **(Fadeel, 1962; Wettestein, 1957).**

2.3. Anatomical features: -

Specimens of the leaves were taken from the certain leaflet of the third apical leaf on the main stem of common bean plant at 55 days after sowing.

These vegetative specimens were killed and fixed in F.A.A. (10 ml formalin, 5 ml glacial acetic acid and 85 ml ethyl alcohol 70%), washed in 50% ethyl alcohol, dehydrated in a series of ethyl alcohols 70, 90, 95 and 100%, infiltrated in xylene, embedded in paraffin wax with a melting point 60-63°C, sectioned 15 microns in thickness for stem and 20 microns for the leaf **(Sass, 1951),** stained with the double stain method (Erythrosin and crystal violet), cleared in xylene and mounted in Canada balsam **(Johanson, 1940)**. Stem and leaf sections were microscopically inspected to detect histological manifestations of noticeable responses resulting from treatments. Counts and measurements (µ) were taken using a micrometer eye piece. Averages of readings from 2 slides treatment^{-1}were calculated.

2.4. Endogenous phytohormones determination: -

Endogenous phytohormones were quantitatively determined in common bean shoots at 55 days after sowing during the 2023 season. According to the method of **Koshioka *et al.,* (1983)** used for HPLC (High- Performance Liquid Chromatography) for the determination of auxin (IAA), gibberellic acid (GA_3) and abscisic acid (ABA). Meanwhile, cytokinins were determined by HPLC according to **Nicander *et al.,* (1993).**

2.5. Flowering stage measurements: -

At the flowering stage, flowers number, flower setting percentage, flower abscission percentage, pods number plant^{-1} were recorded and calculated.

2.6. Dry pods yield and its components: -

At harvest time (105 days after sowing in 2022 and 2023 seasons) three plants from each replicate were randomly taken to estimate the following characteristics: number of pods plant^{-1}, number of seeds pod^{-1}, pods weight (g) plant^{-1}, seeds number plant^{-1}, seeds yield (g) plant^{-1}, weight of 100 seeds (g), pods yield (kg) fed^{-1} and seeds yield (kg) fed^{-1}.

2.7. Chemical compositions: -

Chemical analysis was carried out on the samples of dry shoots and seeds during the second season (2023)**.**

2.7.1. Determination of certain nutrient elements:

The wet digestion of 0.2 g plant material with sulphoric and perchloric acids was carried out on shoots and dry seeds according to **Piper (1947).**

Total nitrogen and crude protein:

Total nitrogen was determined in the dry matter using microkjeldahil method as described by **Horneck and Miller (1998)**, then calculated as a percentage of dry weight. Then, the crude protein was calculated according to the equation of **A.O.A.C (2005).**

Crude protein = Total nitrogen x 6.25

Phosphorus:

It was determined calorimetrically according to the method of **Sandell (1950)** and calculated as mg g^{-1}dry weight.

Potassium, calcium and sodium:

They were or K, Ca and Na were determined by the flame photometer model Carl-Zeiss according to the method described by **Horneck and Hanson (1998)** and calculated as a percentage of dry weight.

Iron and Manganese.

Fe and Mn were determined using the atomic absorption spectrophotometer (Perkin Elmer 3110).

2.7.2. Total carbohydrates :

Total carbohydrates were determined in the dry shoot at 55 days after sowing and in the seeds at harvest time using the phenol-sulphoric acid method according to **Dubois et al. (1954)** and calculated as mg g^{-1}dry weight.

2.7.3. Determination of total sugars content: -

Total sugars was determined according to the method described by **(Kawamura *et al*., 1966; Tanaka *et al*., 1975 and Dubois *et al*., 1956)**

2.8. Statistical analysis:

Data of morphological, flowering and yield characteristics were statistically analyzed and the means were compared using the least significant differences (LSD) test at a 5% level of significance, according to **Snedecore and Cochran (1989).**

3. RESULTS AND DISCUSSION

3.1. Effect of applied treatments on vegetative growth characteristics:

Data in **Table 2** show that each of plant height (cm), number of branches plant^{-1}, stem diameter (cm), number of leaves plant^{-1} and total leaf area plant^{-1} as well as shoot fresh and dry weights (g) plant^{-1} of common bean plant were increased to reach the 5% level of significance with different applied treatments i.e., benzyladenine at 25 and 50 mg L-1, milagrow at 50 and 100 mg L^{-1}, yeast extract at 50 and 100 ml L^{-1} as well as lithovit at 250 and 500 mg L^{-1}during the 2022 and 2023 seasons compared with the control.

The highest increases existed with yeast extract at 100 ml L^{-1} followed by benzyladenine (BA) at 50 mg L^{-1}, milagrow at 100 mg L^{-1} and lithovit at 500 mg L^{-1} compared with the control.

The prefound effects of foliar-applied benzyladenine on enhanceing plant growth parameters viz., plant height, number of branches and dry matter accumulation were reported by **(Samuel et *al.*, 2000)**. The promoting effects of cytokinins like benzyladenine (BA) on plant growth may be due to their stimulatory effects on cell division, cell elongation, nutrient mobilization, shoot initiation and growth, delay the processes of senescence and apical dominance alternation in plants **(Duck *et al.*, 2004** and **Taiz and Zeiger, 2006).**

The promotive effect of milagrow on vegetative growth parameters may be due to the improvement of cell growth, differentiation, division and enlargement, alteration of membrane potential, and metabolism of nucleic acids and proteins **(Müssig, 2005; Dehghan *et al.*, 2020; Abou Elhassan *et al.*, 2023)**. Milagrow (Brassinosteroids, BRs) has been found to stimulate cell division and elongation, flower bud differentiation, carbohydrate assimilation and ATP activity, subsequently improved vegetative growth, enhanced physiological status and directed trees to earlier harvest as well as increased fruit yield and quality **(Wang *et al.*, 2004, Müssig, 2005, Gomes *et al.*, 2006; Symons *et al.*, 2006**; **Gabr *et al.*, 2011).**

The enhancement effect of yeast extract may be due to its influence on metabolism, biological activity, photosynthetic pigments and enzyme activity which in turn encourage vegetative growth **(Wanas, 2002; El-Sherbeny *et al.*, 2007** and **Adam *et al.*, 2022)**.

The micronutrients supplied with lithovit such as Mn, Cu, Z and among others, influence plant physiology and metabolism and cell wall formation **(Morsy *et al.*, 2018)**. Lithovit contains several elements or compounds, such as magnesium, which is the central element of the chlorophyll molecule and silica, which plays a vital role in increasing plant tolerance against abiotic stress, mainly concerning water relations and photosynthesis **(Raven, 2003)**, calcium carbonate ($CaCO_3$), which is decomposed into calcium oxide (CaO) and carbon dioxide (CO_2) in the leaf stomata, where CO_2 increases the intensity of photosynthesis **(Beinsan *et al.*, 2014**). Moreover, **Ibrahim et al. (2016)** suggested that lithovit at this rate of feeding okra plant leaves with CO_2 gas from inside the leaves at a much higher rate than in the air, thus enhancing the basic process of photosynthesis and prompting assimilates accumulation, which is essential for building up protoplasm and protein, as well as inducing cell division, which resulted in an increase in cell number and cell size with an overall increase in the vegetative growth**.**

3.2. Effect of applied treatments on common bean bioconstituents:

3.2.1 Photosynthetic pigments:

Data presented in Table 3 show that different applied treatments significantly increased the concentration of chlorophyll a, b and carotenoids in common bean leaves at 55 days after sowing during the 2022 and 2023 seasons compared with the control treatment.The maximum significant increase of these pigments existed with yeast extract at 100 ml L^{-1} followed by benzyladenine at 50 mg L^{-1} during the 2022 and 2023 seasons compared with the control treatment.

Herein, the yeast extract's activity as a bio-regulator may be responsible for the enhancement of photosynthetic pigments, because of its efficacy in the balance between photosynthesis and photorespiration in plants **(Olaiya, 2010).** Furthermore, yeast works to improve chlorophyll concentrations due to its rich contents of many essential elements, vitamins, and amino acids **(Abdelaal *et al.*, 2017).** At the same time, yeast extract works on CO_2 release, which is reflected in the elevation of photosynthesis efficiency **(Khalil and Ismael, 2010** and **Mady, 2009).**

Benzyladenine is one of the most active synthetic cytokinins, influencing a wide range of plant developmental processes (i.e., chlorophyll synthesis and delayed leaf senescence) **(Müller and Sheen, 2007).** BA had a favorable effect on chlorophyll synthesis and accumulation in the leaves **(El-Maadawy *et al.*, 2006).**

Brassinosteroids might activate or induce enzymes involved in chlorophyll biosynthesis or might surmount the stomatal limitations, thus escalating the CO2 entry into the leaf and its availability for photosynthetic enzymes, resulting in elevated photosynthetic carbon fixing efficiency **(Holá *et al*., 2010.(**

Raven (2003) and **Beinsan *et al.*, (2014)** stated that lithovit contains several elements, such as magnesium, which is the central element of the chlorophyll molecule, and compounds such as calcium carbonate (CaCO3), which is decomposed to calcium oxide (CaO) and carbon dioxide (CO2) in the leaf stomata; hence, it leads to an increase in CO2 levels within the plant leaf structure and by implication enhances photosynthetic efficiency.

Table (2) Effect of different applied treatments on some morphological characteristics of common bean (*Phaseolus vulgaris* L) plant at 55 days after sowing during the 2022 and 2023 seasons.

Treatment \ Trait	Plant height (cm)		Stem diameter (cm)		No. of leaves plant^{-1}		Total leaf area (cm^2) plant^{-1}		No. of branches plant^{-1}		Shoot fresh weight (g) plant^{-1}		Shoot dry weight (g) plant^{-1}	
	2022	2023	2022	2023	2022	2023	2022	2023	2022	2023	2022	2023	2022	2023
benzyladenine at 25 mg L^{-1}	44.67	47.33	0.77	0.83	31.00	33.33	3177.77	3498.50	7.33	7.67	171.27	169.83	25.18	24.97
benzyladenine at 50 mg L^{-1}	47.33	51.00	0.60	0.67	37.00	38.00	4077.00	4180.27	8.67	8.33	188.80	189.57	27.19	27.31
milagrow at 50 mg L^{-1}	48.00	38.00	0.47	0.47	25.67	26.67	2316.00	2400.77	5.00	5.33	166.23	159.40	24.77	23.76
milagrow at 100 mg L^{-1}	50.33	40.33	0.50	0.40	28.33	30.33	2755.00	3064.00	6.33	6.00	174.70	174.20	25.51	25.43
yeast extract at 50 ml L^{-1}	51.00	43.33	0.57	0.63	34.67	35.67	3707.27	3825.50	6.67	7.00	179.30	181.87	26.06	26.32
yeast extract at 100 ml L^{-1}	53.67	45.00	0.83	0.87	40.33	40.33	4538.00	4546.77	8.00	7.67	198.83	197.43	28.44	28.24
lithovit at 250 mg L^{-1}	41.67	35.33	0.40	0.53	23.00	25.00	2001.50	2158.50	4.33	4.67	162.63	155.77	24.39	23.35
lithovit at 500 mg L^{-1}	43.33	37.00	0.47	0.60	27.33	28.00	2590.03	2717.03	6.00	5.67	168.50	163.53	24.95	24.29
control	37.00	33.00	0.37	0.53	20.00	23.00	1527.00	1720.50	3.67	4.00	156.53	151.17	23.63	22.82
L.S.D. at 5 %	1.82	2.47	0.09	0.09	2.28	2.91	252.90	262.1	0.99	1.22	4.06	3.05	0.57	0.42

Table (3) Effect of different applied foliar treatments on photosynthetic pigments (mg g^{-1} F.W.) of common bean (*Phaseolus vulgaris* L) plant at 55 days after sowing during the 2022 and 2023 seasons.

Treatment \ Trait	Chlorophyll (a)		Chlorophyll (b)		Chlorophyll (a + b)		Carotenoids	
	2022	2023	2022	2023	2022	2023	2022	2023
benzyladenine at 25 mg L^{-1}	0.706	0.540	0.350	0.109	1.056	0.650	0.289	0.279
benzyladenine at 50 mg L^{-1}	0.894	1.026	0.376	0.313	1.270	1.339	0.327	0.439
milagrow at 50 mg L^{-1}	0.603	0.741	0.247	0.150	0.850	0.892	0.219	0.324
milagrow at 100 mg L^{-1}	0.872	0.827	0.276	0.167	1.149	0.994	0.376	0.398
yeast extract at 50 ml L^{-1}	0.376	0.930	0.140	0.270	0.516	1.200	0.173	0.384
yeast extract at 100 ml L^{-1}	1.078	1.133	0.482	0.378	1.560	1.511	0.382	0.478
lithovit at 250 mg L^{-1}	0.695	0.641	0.224	0.098	0.920	0.739	0.272	0.368
lithovit at 500 mg L^{-1}	0.709	0.712	0.270	0.158	0.98	0.871	0.270	0.342
control	0.305	0.382	0.069	0.064	0.374	0.446	0.161	0.232

Table (4) Effect of different applied foliar treatments on some chemical constituents level of common bean shoot (*Phaseolus vulgaris* L) at 55 days after sowing during the 2023 season.

Trait Treatment	N %	P %	K %	Ca %	Na %	Fe mgL^{-1}	Mn mgL^{-1}	Protein %	Total carbohydrates %	Total sugars %
benzyladenine at 25 mg L^{-1}	1.91	0.51	2.99	2.43	1.23	0.33	1.00	11.98	54.91	7.19
benzyladenine at 50 mg L^{-1}	2.38	0.65	2.53	3.10	1.68	0.32	1.20	14.88	54.32	7.68
milagrow at 50 mg L^{-1}	2.80	0.50	2.60	3.47	1.20	0.35	1.62	17.50	55.17	7.80
milagrow at 100 mg L^{-1}	2.80	0.69	2.72	3.27	1.11	0.49	0.60	17.50	56.48	7.73
yeast extract at 50 ml L^{-1}	2.11	0.57	2.79	3.39	1.24	0.50	0.62	13.19	55.41	7.45
yeast extract at 100 ml L^{-1}	2.18	0.53	2.72	2.78	1.49	0.44	0.60	13.66	55.90	7.32
lithovit at 250 mg L^{-1}	2.42	0.51	2.56	2.53	1.35	0.61	0.62	15.16	54.47	7.39
lithovit at 500 mg L^{-1}	2.62	0.48	2.60	2.69	1.46	1.02	1.20	16.38	54.02	7.67
control	1.98	0.43	2.38	1.94	1.08	0.31	0.53	12.38	53.76	7.18

3.2.2.minerals, crud protein, total carbohydrate and total sugars:

Data in Table 4 illustrate that all applied foliar treatments effectively increased the of N, P, K, Ca, Na, Fe, Mn, crude protein, total carbohydrate and total sugars in the shoots of treated plants compared with those of the control during the 2023 season. In this respect the most effective treatments were milagrow at 100 mg L^{-1} and 50 mg L^{-1}followed by yeast extract with its two concentrations, benzyladenine at 50 mg L^{-1} and lithovit at 500 mg L^{-1}, respectively.

In this respect, **El-Emary and Abd El-Aal (2018)** Indicated that foliar spraying of milagrow significantly increased the percentage of nitrogen, crude protein, phosphorus and potassium in treated tomato plantscompared with the untreated plants. The increase may be due to milagrow being a natural growth promoter. Milagrow is a rich source of auxins, cytokines, gibberellins, ethylene and hydrogen cyanamid and its chemical composition is 20% phosphorus, 10% potassium, 3% boron and 0.2% brassinolide. Milagrow stimulate chemical compositions biosynthesis activity by the combined effects of auxins, cytokines, gibberellins, ethylene and hydrogen cyanamid **(Seadh *et al.*, (2012)**

Yeast extract may increase absorption of different elements by roots and also their translocation and accumulation in leaves (**Hammad, 2008**; **Mady, 2009)**. The application of yeast caused a significant increase of N, P and K% in pea leaves which could be attributed to its minerals, carbohydrates and hormonal contents **(Hammad, 2008**). **Taha *et al.*, (2016)** mentioned that yeast also facilitates the growth of plants by improving the uptake of nutrients and production of some phytohormones.

These results of benzyladenine conform with those obtained by **Zewail *et al.*, (2019)**on soybean plants. Also, **Mahmoud *et al.*, (2016)** reported that foliar application with benzyladenine significantly increased lupine plant chemical composition**.**

Lithovit contains several elements, such as magnesium, which is the central element of the chlorophyll molecule, and compounds such as calcium carbonate ($CaCO_3$), which is decomposed to calcium oxide (CaO) and carbon dioxide (CO_2) in the leaf stomata; hence, it leads to increased CO_2 levels within the plant leaf structure and, by implication, enhances photosynthetic efficiency **(Beinsan *et al.*, 2014).** Consequently, chemical bioconstituents increased.

3. 3. Endogenous phytohormones:

Data in **Table (5)** show changes in the levels of endogenous phytohoromones i.e., gibberellins, auxins, cytokinins and abscisic acid, in common bean shoots treated with benzyladenine at 50 mg L^{-1}, milagrow at 100 mg L^{-1}, yeast extract at 100 ml L^{-1} and lithovit at 500 mg L^{-1} (the most effective treatments, which greatly improved the morphological, metabolical performances of common bean plant as previously mentioned) and control at 55 days after sowing during the 2023 season.

Concerning gibberellin, treatment of benzyladenine at 50 mg L^{-1} achieved the highest value followed by milagrow at 100 mg L-1then lithovit at 500 mg L^{-1}, meanwhile yeast extract at 100 ml L^{-1}gave the lowest value compared with the control.

As for auxin level, benzyladenine at 50 mg L^{-1} was the most effective treatment followed by lithovit at 500 mg L^{-1} then yeast extract at 100 ml L^{-1} and the control , respectively , while milagrow at 100 mg L^{-1}ranked last in this respect.

For cytokinins, Lithovit at 500 mg L^{-1} gave the highest value compared with the controlfollowed by benzyladenine at 50 mg L^{-1}, milagrow at 100 mg L^{-1} and yeast extract at 100 ml L^{-1}, respectively.

Generally, phytohormones that promote growth aspects, i.e., growth promoters (gibberellins, auxins and cytokinins), levels in common bean shoots were increased with the assigned treatments during the2023 season compared with the control. Here, lithovit at 500 mg L^{-1} gave the highest value of total promoters followed by benzyladenine at 50 mg L^{-1}, milagrow at 100 mg L^{-1} and yeast extract at 100 ml L^{-1} in descending order. Concerning the growth inhibitor, (abscissic acid) its level was reduced with various assigned treatments during 2023 season compared with the control, but the reduction was more obvious with lithovit at 500 mg L^{-1}.

These increases in the endogenous growth promoters and decreases in growth inhibitor substances in response to applied treatments may be attributed to their effect on enhancing the biosynthesis of growth promoters and decreasing the biosynthesis and action of growth inhibitors (abscisic acid).

Abd El-Aal and Eid-Rania (2018) indicated that application of lithovit at a rate of 500 mg L^{-1}on soybean gave the highest values of phytohormones concentration.

Cytokinins are phytohormones influencing a wide range of plant developmental processes for example shoot branching and flowering **(Buban, 2000** and **Müller and Sheen, 2007).** Foliar application with benzyladenine significantly increased endogenous phytohormones concentration in the shoots of soybean plant (**Zewail *et al.*, 2019**).

Milagrow is a natural growth promoter, it has combined effects of auxins, cytokines, gibberellins, ethylene and hydrogen cyanamid **(El-Emary and Abd El-Aal, 2018; Seadh *et al*., 2012; Attia *et al*., 2011).** Spraying tomato plants with milagrow caused an increase in phytohormones i.e., gibberellins, auxins, cytokinins and salicylic acid whereas reduced abscisic acid level **(El-Emary and Abd El-Aal, 2018).**

Application of yeast extract acts as a a biostimulents that improves growth and yield of different crops and it has beneficial roles due to its content of biologically active substances such as phytohormones, different nutrients, protein, amino acids and vitamin B **(Dawood *et al*., 2013; Abbas 2013; Mahmoud *et al*., 2016;Abdelaal *et al*., 2017; Abdallah 2020). El-Shafey *et al.*, (2016)** Yeast extract foliar spray at 5 g L^{-1} and 10 g L^{-1} increased endogenous phytohormones such as (cytokinin, GA_3 and IAA) of faba bean plant.

3.4. Effect of applied treatments on the anatomical characteristics of common bean:

3.4.2. Effect of applied treatments on leaf anatomy:

Data in Table 6 and Fig.1 indicate that most studied leaf anatomical features were increased with different applied treatments compared with the control. Among these anatomical features were the most important ones, i.e., the thickness of each midrib, lamina, palisade tissue, and spongy tissue, as well as the length and width of the vascular bundle, phloem, and xylem tissues, in addition to number of xylem vessels in vascular bundle.

These increases were more obvious with yeast extract at 50 ml L^{-1} and 100 ml L^{-1} followed by benzyladenine at 25 mg L^{-1} and 50 mg L^{-1} as well as milagrow at 50 mg L^{-1}.

Foliar application with the most effective concentration of active yeast extract (ml L^{-1}) on kidney bean 'Giza 6', increased the thickness of both midvein and lamina of the leaflet due mainly to increments in the thickness of palisade and spongy tissues as well as the main vascular bundle of the midvein **(Nassar *et al.*, 2011).**

The positive effects of benzyladenine on different anatomical traits of stems and leaf blades might be due to its ameliorative effect on endogenous cytokinins **(Gad-Mervat, 2005).**

Hayat *et al.*, (2003) revealed that brassinosteroids regulate metabolism through the signals of auxins for promoting cell division and xylem differentiation. The positive effects of milagrow may be due to the improvement of cell growth, differentiation, division and enlargement **(Müssig, 2005**; **Dehghan *et al.*, 2020).**

Lithovit caused an increase in the thickness of the midvein region, the number of vessels in the midvein bundle and the average diameter of the vessel **(Nawar *et al.*, 2018**). Increasing of leaf anatomy characters may be positively correlated with increasing cell division and elongation **(El-Emary *et al.*, 2018).**

Table (5) Effect of applied treatments on endogenous phytohormones concentration or level in common bean (*Phaseolus vulgaris* L) shoots at 55 days after sowing during the 2023 season.

Plant hormones / Treatments	Gibberellins µg g^{-1} F.w.	Auxins µg g^{-1} F.w.	Cytokinins µg g^{-1} F.w	Total Promoters µg g^{-1} F.w	Abscisic acid µg g^{-1} F.w
benzyl adenine at 50 mg L^{-1}	569.8254	48.4463	449.9522	1068.2239	4.3580
milagrow at 100 mg L^{-1}	544.3310	25.7963	424.8314	994,9587	1.9734
yeast extract at 100 ml L^{-1}	450.0930	37.1409	392.3918	879.6257	3.7936
lithovit at 500 mg L^{-1}	526.1633	44.9678	591.6128	1162.7439	1.5455
Control	519.2139	34.5010	262.7003	816.4152	21.5068

Table (6) Effect of applied treatments on the mean counts and measurements of certain anatomical features of common bean (*Phaseolus vulgaris* L) leaflet at 55 days after sowing during the 2023 season.

Treatments / Characteristics	benzyladenine at 25 mg L^{-1}	benzyladenine at 50 mg L^{-1}	milagrow at 50 mg L^{-1}	milagrow at 100 mg L^{-1}	yeast extract at 50 ml L^{-1}	yeast extract at 100 ml L^{-1}	lithovit at 250 mg L^{-1}	lithovit at 500 mg L^{-1}	Control
Thickness of leaf midrib.	1449.0	1449.0	1746.0	1620.0	1395.0	1593.0	1260.0	1305.0	828.0
Thickness of lamina.	364.95	286.2	396.9	272.7	330.2	275.4	299.7	343.8	238.5
Upper epidermis thickness.	32.85	31.50	33.30	31.50	31.50	26.10	27.00	33.30	25.20
Lower epidermis thickness.	25.20	17.10	27.00	25.20	25.20	18.00	22.50	27.00	18.90
Palisade tissue thickness.	144.0	133.2	189.0	108.0	117.0	117.0	108.0	135.0	90.0
Spongy tissue thickness.	128.7	97.2	117.0	108.0	117.0	90.0	108.0	108.0	81.0
Length of the largest v. bundle	392.3	407.7	497.7	432.0	549.0	450.0	405.0	422.0	171.0
Thickness of phloem.	96.3	53.1	74.7	72.0	90.0	90.0	90.0	71.1	45.0
Thickness of xylem	288.0	261.9	306.0	270.0	378.0	288.0	225.0	270.0	126.0
No. of xylem rows in vascular bundle.	6.0	9.0	6.0	5.0	5.0	7.0	9.0	7.0	4.0
Diameter of the widest xylem vessel.	79.2	52.2	63.0	51.3	60.3	59.4	57.6	49.5	36.9

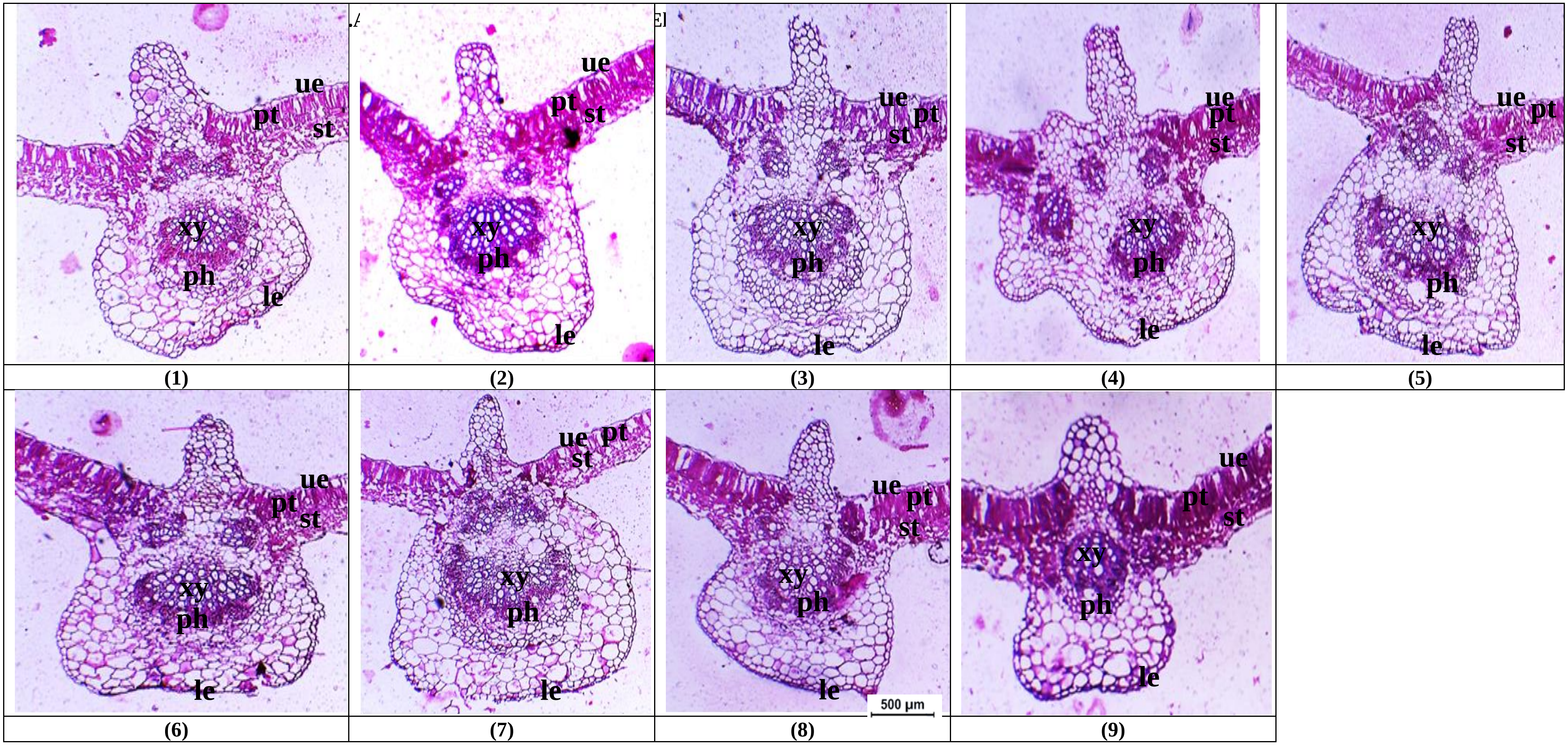

Fig. (1): Transverse sections (X = 40) through the terminal leaflet of the 4th apical leaf of common bean plant at 55 days after sowing as affected by different applied treatments.

Where: (1): benzyladenine at 25 mg L^{-1} (2): benzyladenine at 50 mg L^{-1} (3): milagrow at 50 mg L^{-1} (4): milagrow at 100 mg L^{-1} (5): yeast extract at 50 ml L^{-1} (6): yeast extract at 100 ml L^{-1} (7): lithovit at 250 mg L^{-1} (8): lithovit at 500 mg L^{-1} (9): Control

ue = upper epidermis le = lower epidermis pt = palisade tissue st = spongy tissue ph = phloem tissue xy = xylem tissue

3.5.Effect of applied treatments on flowering characteristics:-

Data in Table 7 as shown in Table 8, different applied spraying treatments had ameliorative effects on flowering characteristics of common bean plants since they caused a significant increase in the number of pods plant $^{-1}$compared with the untreated plants during both seasons of this study. This increase was accompanied by a significant increase in the number of flowers and the percentage of flower set as well as a significant reduction in the flower abscission. In this respect the most efficacious treatment was yeast extract at 100 ml L^{-1}followed by milagrow at 100 mg L^{-1} then lithovit at 250 mg L^{-1} or benzyladinine at 50 mg L^{-1}.

Improving the productivity of some vegetable plants by using a spray application with yeast extract was indicated by **Abou EL-Yazied and Mady (2012); Kamal and Ghanem, (2012); Mahmoud *et al.*, (2013); Zewail *et al.*, (2019)**, who attributed that to its bio-substances contents, such as phytohormones, especially cytokinines, sugars, vitamins, enzymes, amino acids and minerals which reflected in flowering improvement.

Milagrow (Brassinosteroids, BRs) has been found to stimulate flower bud differentiation **(Wang *et al.*, 2004; Mussig, 2005; Gomes *et al.*, 2006; Symons *et al.*, 2006**; **Gabr *et al.*, 2011).** Milagrow is a natural growth promoter, increases fruit setting percentage, promotes flowering buds formation and resists flowers and fruits dropping **(El-Emary and Abd El-Aal, 2018).**

Application of lithovit caused an increase in photosynthetic efficiency which reflected in flowering improvement **(Abass *et al.*, 2022**; **Abd El-baset, 2018).**

3.6. Effect of applied treatments on yield and its components:

Data in Table 8 show the effect of benzyladenine at 25 mg L^{-1} and 50 mg L^{-1}, milagrow at 50 mg L^{-1} and 100 mg L^{-1} ,yeast extract at 50 ml L^{-1} and 100 ml L^{-1} , and lithovit at 250 mg L^{-1} and 500 mg L^{-1} applied as foliar spray treatments on yield characteristics (i.e., No. of pods plant^{-1}, pods weight (g) plant^{-1}, No. of seeds pod^{-1}, No. of seeds plant^{-1}, seeds weight (g) plant^{-1}, 100-seeds weight (g), pods yield fed^{-1} (kg) and seed yield fed^{-1} (kg)) at harvest time during the 2022 and 2023 seasons.

Data indicate that different applied treatments increased yield traits during the 2022 and 2023 seasons compared with the control treatment. Yeast extract at 100 ml L^{-1} followed by milagrow at 100 mg L^{-1} gave the highest significance increases, respectively when compared with the contro and other treatments in both seasons.

The enhancing effect of such treatments on common bean plant (*Phaseolus vulgaris* L.) yield components may be due to their ameliorative effects on flowering and setting percentage, consequently the number of pods and their weight. Also, this could be due to the promotional effects of the same treatments on growth behavior, metabolic activity levels, mineral content and phytohormones level and through increasing the assimilates and their translocations from leaves to the developing seeds in pods all of them positively correlated with yield quantity and quality.

The present results are generally in agreement with those reported by **(Zewail, 2014; El-Shafey *et al.*, 2016**; **Muhammad *et al.*, 2020)** for yeast**; (Ayad and Gamal El–Din, 2011; Mahmoud *et al.*, 2016; Zewail *et al.*, 2019** ; **Shyaa and Kisko, 2023)** for benzyladenine (BA)**; El-Bassiony *et al.*, 2012; Netwal *et al.*, 2018**; **Furio *et al.*, 2022)** for milagrow (Brassinosteroids)**; Abd El-Aal and Eid-Rania, 2018; Byan, 2020** ; **Saad *et al.*, 2021)** for lithovit.

3.7. Effect of applied treatments on chemical constituents of common bean seeds:

As shown in Table 9 different foliar spraying treatments caused an obvious increases in the concentration all determined chemical constituents of common bean seeds , mainly nitrogen, phosphorus, potassium, calcium, sodium, iron, manganese as well as crud protein and total carbohydrate in addition to total sugars % compared with the control during the 2023 season.

In this respect, the most effective treatments were yeast extract at 100 ml L^{-1} followed by benzyladenine at 50 mg L^{-1} then lithovit at 500 mg L^{-1} and milagrow at 100 mg L^{-1}, respectively compared with the control.

Other studies also, reported nearly similar results **El-Shafey *et al.*, 2016** and **Muhammad *et al.*, 2020)** for yeast; **Shyaa and Kisko, 2023)** for benzyladenine ; **Netwal *et al.*, 2018** and **Furio *et al.*, 2022)** for milagrow (Brassinosteroids); **(Abd El-Aal and Eid-Rania, 2018** and **Byan, 2020)** for lithovit

Table (7) Effect of applied treatments on flowering characteristics of common bean (*Phaseolus vulgaris* L) plant at flowering stage during the 2022 and 2023 seasons.

Trait / Treatments	No. of flowers plant^{-1}		No. of pods plant^{-1}		Flowers setting (%)		Flowers abscission %	
	2022	2023	2022	2023	2022	2023	2022	2023
benzyladenine at 25 mg L^{-1}	68.67	73.00	31.67	36.00	46.09	49.31	53.91	50.69
benzyladenine at 50 mg L^{-1}	64.33	65.67	41.33	43.00	64.26	65.53	35.74	34.47
milagrow at 50 mg L^{-1}	66.33	70.00	45.00	48.00	67.84	68.57	32.16	31.43
milagrow at 100 mg L^{-1}	73.33	77.00	51.00	53.67	69.53	69.72	30.47	30.28
yeast extract at 50 ml L^{-1}	68.00	72.00	48.00	51.00	70.57	70.83	29.43	29.17
yeast extract at 100 ml L^{-1}	74.67	79.00	53.33	56.33	71.39	71.34	28.61	28.66
lithovit at 250 mg L^{-1}	70.33	75.33	34.33	40.33	48.76	53.55	51.24	46.45
lithovit at 500 mg L^{-1}	65.67	68.33	43.33	46.33	65.98	67.83	34.02	32.17
Control	59.67	62.00	25.33	29.00	42.39	46.76	57.61	53.24
L.S.D. at 5 %	2.15	1.52	3.09	1.83	3.28	2.84	3.28	2.84

Table (8) Effect of different applied treatments on yield and yield components of common bean (*Phaseolus vulgaris* L) plant at harvest time during the 2022 and 2023 season.

Trait / Treatment	Pods weight (g) plant^{-1}		No. of seeds pods^{-1}		No. of seeds plant^{-1}		seeds weight (g) plant^{-1}		100-seeds weight (g)		Pods yield fed^{-1} (kg)		Seeds yield fed^{-1} (kg)	
	2022	2023	2022	2023	2022	2023	2022	2023	2022	2023	2022	2023	2022	2023
benzyladenine at 25 mg L^{-1}	87.63	94.47	3.91	3.78	123.33	136.00	36.70	45.74	29.75	33.63	1641.7	1808.3	978.6	1093.0
benzyladenine at 50 mg L^{-1}	95.43	102.73	3.79	3.52	132.67	144.33	41.58	51.87	31.35	35.93	1758.3	1941.7	1116.4	1259.4
milagrow at 50 mg L^{-1}	100.73	114.10	3.27	3.19	147.00	153.00	48.09	57.72	32.72	37.74	1950.0	2100.0	1281.8	1401.0
milagrow at 100 mg L^{-1}	108.13	121.57	3.21	3.33	159.33	179.33	58.47	71.07	36.69	39.64	2141.7	2333.3	1480.2	1562.2
yeast extract at 50 ml L^{-1}	102.77	118.67	3.13	3.34	154.00	170.00	52.94	65.91	34.40	38.79	2033.3	2275.0	1375.7	1562.2
yeast extract at 100 ml L^{-1}	112.37	127.93	3.20	3.31	170.33	186.00	63.47	76.90	37.26	41.35	2225.0	2416.7	1584.8	1753.8
lithovit at 250 mg L^{-1}	92.77	98.67	3.21	3.36	129.67	141.67	40.18	49.05	31.00	34.62	1700.0	1875.0	1056.7	1186.2
lithovit at 500 mg L^{-1}	97.97	109.23	3.25	3.26	140.67	150.67	45.87	55.24	32.62	36.66	1891.7	2008.3	1222.0	1320.0
control	83.27	89.47	4.12	3.84	103.67	111.33	30.17	34.80	29.09	31.25	1358.3	1366.7	855.4	872.7
L.S.D. at 5 %	3.37	4.09	N.S.	N.S.	4.38	5.40	2.39	3.23	1.90	2.05	91.8	88.6	55.5	50.8

Table (9) Effect of applied treatments on some bioconstituents of common bean (*Phaseolus vulgaris* L) seeds at harvest time during 2023 season.

Trait / Treatment	N %	P %	K %	Ca %	Na %	Fe mg g^{-1} D.W	Mn mg g^{-1} D.W	Protein %	Carbohydrates %	Total sugars %
benzyladenine at 25 mg L^{-1}	2.22	0.72	1.88	1.12	0.67	0.56	0.77	13.88	63.81	9.48
benzyladenine at 50 mg L^{-1}	2.8	0.73	1.69	1.13	0.82	0.58	0.72	17.5	62.35	9.46
milagrow at 50 mg L^{-1}	2.55	0.70	1.78	1.28	0.89	0.50	0.77	15.94	65.53	9.35
milagrow at 100 mg L^{-1}	2.55	0.69	1.56	1.13	0.78	0.72	0.88	15.94	64.42	9.64
yeast extract at 50 ml L^{-1}	2.82	0.72	1.67	1.41	0.93	0.62	0.82	17.66	63.71	9.86
yeast extract at 100 ml L^{-1}	2.82	0.71	1.71	1.36	0.74	0.60	0.62	17.66	65.34	9.87
lithovit at 250 mg L^{-1}	2.82	0.68	1.57	1.61	0.93	0.89	0.99	17.66	64.49	9.08
lithovit at 500 mg L^{-1}	2.66	0.66	1.53	1.32	0.56	0.92	0.92	16.66	63.46	9.79
control	2.12	0.62	1.48	1.04	0.49	0.93	0.73	13.25	61.27	8.98

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