Influence of foliar spraying by using paclobutrazol and pinching technique on the growth, green pods, dry seed yields, its components and some chemical constituents of broad bean (*Vicia faba* L.) plants.

ABSTRACT

This current study was conducted at Qaha Vegetable Research Farm (Qalubia Governorate), Horticulture Research Institute, Agriculture Research Center (A. R. C.), Egypt, during the two winter seasons of 2020/2021 and 2021/2022 on broad bean (*Vicia faba* L.) plants Weaam cv. The aim of this work was to investigate the influence of foliar application of paclobutrazol (PBZ) at three different doses *i.e.* 25, 50 and 75 mg/ L at three times; at the vegetative growth, at the peak flowering and at the pod setting stages *i.e.* at 60, 80 and 100 days after sowing (D.A.S.), respectively as well as pinching technique treatments which was done at three times; the 1st one at plants had 60 cm, the 2nd at 80 cm and the 3rd at 100 cm from the plant height per plant by removing the tip of the main stem of broad bean plants, under the two winter seasons condition on the vegetative growth characteristics, total green pods, dry seed yields and its constituents as well as the quality of the dry seed of broad bean plants. The experimental design was arranged in a complete randomized block design with three replications.

The results indicated that, all the tested treatments significantly affected increased the vegetative growth characteristics (with the exception of the plant height in the two winter seasons, respectively), total green pods, dry seed yields, its components and chemical constituents in dry seeds as compared with the control treatment. In this case, among the different concentrations of foliar spraying paclobutrazol treatment at the rate of 50 mg/ L shows the best result as compared with the other two treatments *i.e.* 75 and 100 mg/ L. With regard to the stimulatory effects of broad bean plants with pinching technique treatments either at flowering stage or at the pod setting stage, which were the best treatments and markedly improved the most of all the pervious studied characters of broad bean plants and dry seed quality as compared with the other pinching technique treatment *i.e.* at the vegetative growth stage and no pinching treatment.

Keywords: Broad bean, Paclobutrazol, Pinching technique, Green pods, Dry seeds, Carbohydrates and Protein content (%).

INTRODUCTION

Broad bean (*Vicia faba* L.) is a significant legume crop that is a member of the Fabaceae family. It is one of the most important popular winter crops in Egypt. Broad bean is useful for both human and animal foods, its seeds are consumed both fresh green and dry seeds because of their high nutritional value, which includes high protein contents ranging from 25 to 40%, starch, cellulose, vitamin C and a good source of many nutrients, such as K, Ca, Mg, Fe and Zn based on dry matter, also it contains several other bioactive compounds, such as polyphenols, carotenoids and carbohydrates. When compared to pricey meat and fish protein, its protein is thought to be a viable substitute. But the entire output of this crop is still insufficient to meet local demand **(Alghamdi, 2009)**. Broad bean plant plays an essential role in the biological fixation of aerial nitrogen, which can be used to restore fertility in crop rotations and is capable of satisfying its nitrogen requirements largely from the atmosphere (**Jelenic *et. al*., 2000**).

Regarding the thermal requirements of broad bean plants, it is a cool season legume crop that grows best in temperatures ranging from 15.5 °C to 18 °C but it can grow in conditions as low as 4.4 °C and as high as 21 °C. Broad bean germinates and grows well under cool soil conditions. The optimal temperature for the plant growth is 15 – 20 °C, especially during the stages of flower and pod development. Broad bean flowers will abort if temperatures exceed 26.5 °C and they are particularly sensitive to hot and dry conditions during pod development. Thus, prolonged cool weather in the winter is ideal for development of pods (**Etemadi *et. al*., 2015).**

With respect to the effect of using foliar application of paclobutrazol, it belongs to triazolic group of fungicides which have as the plant growth regulators properties. The application of paclobutrazol has no harmful effects on human health and it enhances the production and increasing yield of several crops. It can induce several growth regulation properties such as morphological and biochemical changes, like reduction in shoot elongation, stimulation of rooting, changes in stem length and weights of seedlings, inhibition of gibberellins synthesis, increase in chlorophyll and carotenoid content, improvement of the carbohydrate metabolism, ascorbic acid, increase in cytokinin synthesis, improvement of photosynthetic activity and water balance, increase in the proline content, soluble sugars and stimulation of antioxidative enzyme systems **(Unyayar and Ozlem, 2005)**. It was found that triazole compounds protect the plants under either normal or stressful circumstances which play a crucial role in controlling numerous development and behavioral processes from various environmental stresses, including chilling, drought, heat, waterlogging, air pollutants and heavy metals **(Tesfahun and Yildiz, 2018).**

Corresponding pinching, it is a technique for breaking apical dominance and redirecting energy to increase blossom production. Apical pinching also known as a topping is one of the techniques employed to enhance the vegetative growth and yield. Pinching involves the removal of the apical bud of a stem to encourage the development of lateral branches. Pinching affects the growth of the plants in height as auxin (plant hormone responsible for elongation growth) is redirected to other buds to induce lateral shoot and pinching provides a wider surface area for bigger photosynthetic activities which in turn enhances other growth characteristics and yield. This increases the potential fruit points on the plant thereby increasing the number of fruit produced of okra plants **(Marie *et. al*., 2007)**. Pinching operation lessens apical dominance, which stops vertical growth and speeds up the growth of productive branches. The goal of this operation, according to its physiology, is to change the source-link connection by reducing the vegetative development, which boosts photosynthetic activity, photosynthesis accumulation, fruit formation and fruit production and yield of fenugreek plants **Lakshmi *et. al.* (2015).** Pinching is a horticultural practice that diverts the flow of energy and nutrients from a single stem system to a multi stem system. Pinching affects a variety of physiological processes in the plant, including vegetative growth arrest and increased deposition of a photosynthetic chemical, resulting in an increase in yield of okra plants **(Priyanka and Biswal, 2017)**.

The goal of this research was to ascertain the effects of paclobutrazol foliar spraying and pinching operation on broad bean growth characteristics, green pod yield and related parameters, dry seed yield components, and dry seed quality.

Materials and Methods

This field experiment was conducted at the Experimental Farm of Qaha Vegetable Research, Qalubia Governorate, Horticulture Research Institute, Agriculture Research Center, Egypt during the two winter seasons of 2020/2021 and 2021/2022 to investigate the influence of applied paclobutrazol (PBZ) as foliar spraying [(Paclobutrazol (PP_{333}) (2RS,3RS) - 1-(4-chlorophenyl) - 4,4 -dimethyl-2-(1H-1,2,4 triazole-1- yl) pentan-3-ol] $C_{15}H_{20}ClN_3O$ - F W 293.79, used as a powder form at the rates of 25, 50 and 75 mg/ L at three times *i.e.* at the vegetative growth, at the peak flowering and at the pod setting stages *i.e.* 60, 80 and 100 days after sowing (D.A.S.), respectively as well as pinching technique is a manual technique done by removing the tip of the main stem of broad bean plants with a sharp cutter at three times; the 1^{st} one at plants had 60 cm, the 2^{nd} at 80 cm and the 3^{rd} at 100 cm from the plant height per plant while the control plants treatment were sprayed with tap water or no pinching, on the vegetative growth, total green pods, dry seed yield and its components as well as quality of the dry seeds in broad bean. Weaam cv. (recorded by Horticulture Research Institute). The experimental design was complete randomized block design with three replicates. The dry seeds of broad bean were sown in the last week of October during the two winter growing seasons 2020/2021 and 2021/2022, respectively. The experimental units were fertilized at the time of the soil preparation with calcium superphosphate (15.5 % P_2O_5) at the rate of 150 kg/ fed. Nitrogen in the form of ammonium sulfate $(NH4)_2SO_4$ - 21 % N at the rate of 100 kg/ fed. and potassium sulfate (48-50 % K_2O) at the rate of 50 kg/ fed. which added to the soil in the two equal portions, before the first and second irrigations. The plot area was (11.2 m^2) and included 4 ridges each of (0.7 m) width and (4.0 m) length. The dry seeds were sown in hills on one side of ridges at 20 cm apart, between hills in the both winter seasons. The 1st two rows were used for fresh green pods characters and the rest of the two rows were deposed for dry seed yield components. Guard rows were set between the experimental units to avoid drifting to the adjacent plots. The recommended agricultural practices of broad bean plants in this area such as irrigation, fertilization, fungal diseases and pest management were applied during the two winter growing seasons according to the recommendations of Egyptian Ministry of Agriculture.

The experiment was contained seven treatments as following:

T1: The control treatment (spraying with tap water or no pinching).
T2: Foliar spraying with paclobutrazol at 25 mg/L.
T3: Foliar spraying with paclobutrazol at 50 mg/L.
T4: Foliar spraying with paclobutrazol at 75 mg/L.
T5: Pinching technique at the growth stage (at 60 cm of the plant height).
T6: Pinching technique at the peak flowering stage (at 80 cm of the plant height).
T7: Pinching technique at the pod setting stage (at 100 cm of the plant height).

The meteorological data for the experimental area obtained from Central Laboratory for Agricultural Climate (CLAC), Agricultural Research Center (ARC), Ministry of Agricultural and Land Reclamation, values were recorded during the two winter growing seasons as shown in **Table 1**.

Table (1): Meteorological data at Qaha Vegetable Research Station, Qalubia Governorate region during the two winter seasons of 2020/2021 and 2021/2022.

Months	Temperature ^{o} C			
	2020/2021		2021/2022	
	Maximum	Minimum	Maximum	Minimum
October	34.83	19.89	32.68	18.63
November	25.94	14.92	28.71	16.05
December	23.63	11.25	20.57	10.02
January	22.29	9.27	17.58	6.33
February	22.54	9.13	20.24	7.25
March	23.98	9.87	22.32	8.04
April	30.72	12.01	32.83	13.85

Sample of the soil at the depth of 50 cm from the soil surface was taken to determine the physical and chemical properties which determined according to **(Black, 1965 and Page *et. al.*, 1982)** were shown in **Table (2)**.

Table (2): Physical and chemical analysis properties of the experiment soil.

PH	E.C. (dSm^{-1})	$CaCO_3$ %	Soluble cations (M/L)				Soluble anions (M/L)				Macro elements (ppm)			Micro elements (ppm)			
			Ca^{+2}	Mg^{+2}	Na^{+}	K^{+}	CO_3^{-2}	HCO^{-3}	Cl^{-2}	SO_4^{-2}	N	P	K	Fe	Cu	Zn	Mn
7.7	2.64	3.4	6.08	3.88	15.6	0.19	3.2	1.9	9.3	13.4	38	6.5	57.8	3.2	6.6	2.21	2.22

Data recorded:

1- The vegetative growth characteristics:

At 110 days after sowing (at the flowering and the pod setting stages) a random sample of three plants from each experimental plot was collected to measure each of the plant height (cm), the number of branches, the fresh and dry weights of the foliage per plant (g). The foliage of plants was dried at 70 C^{o} until they reached to a constant weight as well as the dry weight per plant was calculated.

2- Total green pods yield and its parameters:

At suitable maturity stage in the 2^{nd} picking, random samples of ten green pods from each plot were taken to determine the following data *i.e.* average each of the pod length, pod diameter (cm), green pod weight (g), number and weight of green seeds/ green pod. Mature green pods were harvested at suitable maturity stage in four picking and the rate of the total green pods yield was measured by estimating the yield of the plants for each experimental unit and then converted in to the yield per ton/ fed.

3-Dry seed yield and its components:

A random samples of ten dry pods at the end of harvesting date (after the physiological mature) from each plot were taken to determine the following data *i.e.* average each of number, weight of dry seeds/dry pod (g), seed index (the dry weight of 100 seeds) and shell out % of dry pods. Plot threshing and cleaning was done and total dry seed yield was recorded after thorough drying and is expressed in ton/ fed.

Shell out % of dry pods was calculated using the following equation:

$$\textbf{Shell out \%} = \frac{\text{Weight of dry seeds}}{\text{Weight of dry pods}} \times 100$$

4- Chemical composition of dry seeds:

4-1- Minerals content: dry samples of broad bean seeds were dried in an electric forced-air oven at 70^{o}C to constant weight then fractionated and sifting. The fine powder (at 0.2 g) of each dry sample was digested in a mixture of sulphuric and perchloric acids, as wet digestion according to **Piper (1947),** to determine: total nitrogen, phosphorus and potassium (%) content were according to **Bremner and Mulvaney (1982), Olsen and Sommers (1982), Horneck and Hanson (1998)**, respectively.

4-2- Protein content (%): In the dried seeds were determined through the determination of seeds, total nitrogen and a factor of 6.25 was used for conversion of total nitrogen to protein percentage according to **Kelly and Bliss (1975)**.

4-3- Total carbohydrates content (%): In the dried dry seeds were determined according to **(Dubois *et. al.,* 1975)**.

5- Seed germination tests:

Dry seeds of broad bean were treated with Tobsen fungicide then put it in filter paper inside germination incubator at 25 C^{o} and the germination tests were calculated *i.e.* Germination % and Germination rate as follows:

$$\textbf{Germination rate} = \frac{(G_1 \times N_1) + (G_2 \times N_2) + \ldots\ldots\ldots\ldots (G_n \times N_n)}{G_1 + G_2 + \ldots\ldots\ldots\ldots\ldots\ldots G_n} = \text{days}$$

Where, G = Number of germinated seeds in certain day, N = Number of this certain day. Sprout length (cm), 25 seeds were distributed on watered sheets of filtrated papers No.1 that had been thoroughly moistened with water and incubated at 25 ^{0}C for 14 day. Sprout length (cm) was taken after germination beginning for 2 day intervals until finishing the incubation period.

6-Statistical analysis:

All obtained data of the present study were subjected to the analysis of variance techniques according to the design used by the MSTATC computer software program variance and the mean of treatments were compared according to the Least Significant Differences (L S D) test at the 0.05 probability level, the method described by **(Bricker, 1991)**.

RESULTS AND DISCUSSION

I- The Vegetative growth characteristics:

Concerning to the effect of foliar spraying with paclobutrazol and pinching technique treatments on the vegetative growth characteristics of broad bean plants *i.e.* the plant height, number of branches, fresh and dry weights / plant, the data registered in **Table (3)** showed clearly that, all tested treatments significantly increase the vegetative growth characteristics with the exception of the plant height in the two winter seasons, respectively as compared with the control treatment. Foliar application of paclobutrazol treatment at the rate of 50 mg/ L as compared with the other two rates of 25 and 75 mg/ L as well as pinching technique treatments *i.e.* at the flowering and pod setting stages, respectively obtained the most effective treatments producing the significantly increased of the growth parameters on broad bean plants as compared with the control treatment.

Referring to the plant height under the condition of this experiment, data registered in the same table indicated that foliar spraying with paclobutrazol at all the different doses as well as pinching technique treatments affects the growth of the plants in height obtained non significant increase in the plant height as compared with the control treatment (spraying tap water or no pinching) which obtained the tallest plant height (110.3 and 113.0 cm) while the plants that were not pinched obtained the lowest lateral branches (6.3 and 6.8) as well as the lightest fresh and dry weights (117.6, 20.2, 121.5 and 24.7 g) in the both winter seasons, respectively this trend was true during the two experimental seasons.

Table (3): The vegetative growth characteristics of broad bean plants as affected by foliar spraying with paclobutrazol and pinching technique treatments during the two winter seasons of 2020/2021and 2021/2022.

Treatments	**Plant height (cm)/plant**		**Number of branches/plant**		**Fresh weight /plant**		**Dry weight /plant**	
	1st Season	**2nd Season**	**1st Season**	**2nd Season**	**1st Season**	**2nd Season**	**1st Season**	**2nd Season**
T1	110.3	113.0	6.3	6.8	117.6	121.5	20.2	24.7
T2	67.0	69.7	7.6	7.7	150.1	159.4	24.6	28.1
T3	72.7	74.7	8.8	9.0	174.7	183.4	35.7	36.1
T4	63.7	68.5	7.5	7.8	139.2	148.1	25.9	28.6
T5	60.0	60.0	6.8	7.3	156.7	166.1	27.6	30.7
T6	80.0	80.0	8.1	8.4	166.3	174.5	30.3	33.3
T7	100.0	100.0	8.3	8.6	170.3	180.9	32.4	34.5
L.S.D. at 0.05	**N.S**	**N.S**	**1.1**	**0.7**	**6.1**	**5.2**	**1.1**	**1.5**

Treatments consisted of, **T1**: The control (spraying with tap water or no pinching).**T2**: Foliar spraying with paclobutrazol at 25 mg/L. **T3**: Foliar spraying with paclobutrazol at 50 mg/L. **T4**: Foliar spraying with paclobutrazol at 75 mg/L. **T5**: Pinching at 60 cm of the plant height. **T6**: Pinching at 80 cm of the plant height. **T7**: Pinching at 100 cm of the plant height.

Respecting to the enhancing effects of the paclobutrazol, paclobutrazol triazole-type plant growth regulator, is well known as antigibberellins. Paclobutrazol can block the conversion of *ent*-kaurene to *ent*-kaurenoic acid during the gibberellin biosynthesis pathway by inhibition of kaurene oxidase which is an enzyme in the GA biosynthetic pathway that catalyzes the oxidation of ent-kaurene to entkaurenoic acid **(Kondhare *et. al.*, 2014)**. Paclobutrazol on the plant growth could be related to its effect on increasing internal carbon dioxide concentration and leaf thickness, enhancing plant cell water retention and increasing water use efficiency (**Kamran *et. al*., 2020)**.

Additionally, the mode of action of paclobutrazol may include the inhibition of gibberellic acid synthesis in the plants, which reduces gibberellins level, slows cell division and elongation (without causing toxicity to cells) and increases cytokinin content, as well as the root activity and C: N ratio. Therefore, paclobutrazol can delay senescence and extend the juvenility of plants. paclobutrazol increased the resistance against most of pathogens in the nursery. Paclobutrazol is improving the levels of chlorophyll, root growth, corresponding dry or fresh weight, antioxidants and proline contents in tomato plants under various biotic and abiotic stresses (**El-Beltagi *et. al*., 2022).**

As mention before, the decreasing of the height of broad bean plants which spraying with paclobutrazol at all the different doses may be attributed to the mode of action of paclobutrazol which include the inhibition of gibberellic acid synthesis in the plants, which reduces gibberellins level, slows cell division and elongation. The obtained results are consistent with those observed by **Amira and El-Shraiy (2007)** mentioned that paclobutrazol at 10 and 20 ppm enhanced the vegetative growth characteristics *i.e.* the plant height, number of branches, leaves and dry weight of common bean plants. **Madhumita and Pal (2008)** also, confirmed the result in chrysanthemum. Increase in number of branches may be due to suppression of vertical growth resulting in translocation of photosynthates of leaf axil thus encouraging the lateral branches of chrysanthemum plants. **Yadava (2012)** who assumed that foliar application of paclobutrazol at a rate of 50 ppm/ L led to significant increases on growth rate and cumulative growth of Cape gooseberry plants. **Mahmoud *et. al.* (2020)** reported that spraying paclobutrazol at the rate of 200 mg/L increase the shoot length, shoot fresh and dry weights under normal or salinity conditions at 0, 50, 100 mM NaCl affected pea plants compared to nonsprayed plants.

As for, the encouragement role of pinching technique treatments, when the terminal bud was removed from the plants during the pinching process, the plants became stressed and the plants required time to recover from this situation, causing growth to be impeded. Pinching momentarily decreases auxin, removing apical dominance which encourages the plant to generate lateral branches and become bushy because the majority of the nutrition is dislocated from the apical region of the plant when it is pinched, no pinched plants have fewer branches than pinched of lisianthus plants **(Uddin *et. al*., 2015)**. Such increment in plant growth could be referred to the role of pinching technique which mostly decreases the apical dominance there by arrests the vertical growth and hastens the growth of productive branches. The physiology behind this operation is to alter the source link relationship by curbing the vegetative growth thus it increases the photosynthetic activities, accumulation of photosynthates, pinching stimulates cell division, cell size, leaf area and photosynthetic compound production, which affects branch formation, fruit formation fruit production and yield plants utilized the produced photosynthetic compound as a result there occurs more lateral growth in the form of side branches of sesame plants **(Biswas *et. al*., 2019)**. Pinching technique affects the growth of plants in the height as auxins (plant hormone responsible for elongation growth) by removing the terminal buds, auxin concentration is reduced, which inhibits upward the plant growth resulting in an increase in the number of branches per plant are redirected to other buds to enhance branches per plant and thus reduced the plant height of zinnia plants **(Ali *et. al*., 2021)**. The cytokinin is stimulated when the apical bud is removed, which encourages lateral branching of bottle gourd plants **(Naafe, 2022)**.

The results also, are in conformity with the findings of **Olfati and Malakouti (2013)** pointed out that number of shoots per plant of faba bean was significantly increased by pinching technique. **Lakshmi *et. al.* (2015)** in fenugreek plants demonstrated that plants without apical pinching recorded higher the plant height at 60 days after sowing. **Katsumi and Ikeda (2017)** on processing tomato found that the effects of pinching treatments carried out at the 3 and 6 true leaf gave the maximum number of leaves/plant as compared with those in the untreated control. **Priyanka and Biswal (2017)** on okra plants indicated that the growth parameters in terms of the height of plant was recorded maximum in un pinched plant, whereas, the maximum number of leaves and number of branches were recorded with terminal bud pinching. **Prakash *et. al.* (2022)** verified that the height of the unpinched plant was found to be 25% higher than that of the pinched. Pinching technique resulted in the highest increase in the number of branches on marigold when compared to no pinching.

2- Total green pods, dry seed yields and its parameters:

Regarding to the effect of foliar spraying with paclobutrazol and pinching technique treatments on the total green pods, dry seed yields (ton/ fed.) and its parameters of broad bean plants are presented in **(Table 4 and 5)**. It is evident that all tested treatments led to a significant increases on the total green pods, dry seeds yields and its parameters at the same time. The data also, demonstrated that foliar spraying with paclobutrazol at the rate of 50 mg/ L followed by pinching technique treatments *i.e*. at the flowering and pod setting stages, respectively significantly sufficient to produce the superiority values of the total green pods, dry seeds yields and enhanced green and dry pods components as compared to the other treatments or the control treatment. The increment in total green pods and dry seed yields may be due to directly to the increment in the vegetative growth characteristics **(Table 3)**. The acquired results may be related to foliar spraying with paclobutrazol as well as pinching technique treatments give raise to that more number of branching, flowers setting, faster maturity, number of green pods and dry seed yields, these results are in agreement in the two winter seasons, respectively under this investigation.

Table (4): Total green pods yield and its components of broad bean plants as affected by foliar spraying with paclobutrazol and pinching technique treatments during the two winter seasons of 2020/2021and 2021/2022.

Treatments	Pod length (cm)		Pod diameter (cm)		Green pod weight (g)		No. of green seeds/green pod		Green seed weight (g)/ green pod		Total green pods yield (Ton/ fed.)	
	1st Season	2nd Season	1st Season	2nd Season	1st Season	2nd Season	1st Season	2nd Season	1st Season	2nd Season	1st Season	2nd Season
T1	14.38	15.81	1.68	1.73	17.69	18.33	4.90	5.21	2.90	3.00	8.253	8.918
T2	16.11	17.47	1.75	1.89	20.34	20.95	5.80	5.93	3.69	3.74	9.188	9.461
T3	20.54	20.48	2.30	2.36	23.61	24.53	6.52	6.65	3.95	4.00	10.380	10.890
T4	15.78	16.31	1.81	1.86	19.45	19.91	5.73	5.81	3.57	3.64	9.048	9.328
T5	16.07	17.00	1.94	2.00	20.19	21.06	6.00	6.22	3.65	3.68	9.998	9.670
T6	17.96	18.36	2.00	2.16	21.36	21.89	6.06	6.34	3.71	3.80	9.836	10.170
T7	18.51	19.60	2.14	2.22	22.48	22.42	6.30	6.40	3.81	3.86	10.120	10.430
L.S.D. at 0.05	**0.45**	**0.36**	**0.08**	**0.11**	**0.38**	**0.31**	**0.20**	**0.14**	**0.11**	**0.04**	**0.109**	**0.113**

Treatments consisted of, **T1**: The control (spraying with tap water or no pinching).**T2**: Foliar spraying with paclobutrazol at 25 mg/L. **T3**: Foliar spraying with paclobutrazol at 50 mg/L. **T4**: Foliar spraying with paclobutrazol at 75 mg/L. **T5**: Pinching at 60 cm of the plant height. **T6**: Pinching at 80 cm of the plant height. **T7**: Pinching at 100 cm of the plant height.

As mentioned before in meteorological data (**Table 1)** at the region of Qaha Vegetable Research Station, we find that, the requirements of the maximum and minimum temperatures for the growth, flowers and pod set of the broad bean plants are very suitable for obtaining vigour vegetative growth characteristics as well as the highest total green pods, dry seed yields and its parameters especially in the second winter season.

Concerning the favorite foliar application of paclobutrazol treatment especially at the moderate rate *i.e.* 50 mg/L on total green pods, dry seed yields and its parameters attributed to the increase in canopy size which, in turn, improves light interception and increases photosynthetic rate and reduces senescence processes, the maintenance of higher rates of photosynthesis with relatively high fluorescence ratio and water use efficiency. The most prominent and likely hypothesis on increasing plant production and stress tolerance induced by paclobutrazol has been attributed to it sustaining the endogenous cytokinin concentration, promoting antioxidant capacity, protection against numerous abiotic stresses such as chilling, water deficit stress and heat stress **(Kamran *et. al*, 2020).**

Similar results were reported by many workers concerning the effect of paclobutrazol, **Yadava (2012)** who decided that foliar application of paclobutrazol at a rate of 50 ppm/ L led to significant increases on flowering, fruit maturity, fruit weight and recorded the highest percentage of fruit set of cape gooseberry plant. Furthermore, **Abdel-Aziz and Geeth (2018)** showed that paclobutrazol was applied at the rate of 50 mg/ L to sweet pepper plants significantly increased yield (ton/ fed) and its components, including fruit length, fruit diameter (cm) and fruit dry weight (%). **Mahmoud *et. al.* (2020)** noted that paclobutrazol foliar spraying greatly increased the number of pods per plant, the number of seeds per pod and the weight of 100 green seeds of pea plants under normal or salinity conditions at 0, 50, 100 mM NaCl affected pea plant as compared to nonsprayed plants.

Table (5): Total dry seeds yield and its components of broad bean plants as affected by foliar spraying with paclobutrazol and pinching technique treatments during the two winter seasons of 2020/2021and 2021/2022.

Treatments	No. of dry seeds /dry pod		Dry seed weight dry pod (g) /		Seed index (g)		shell out % of dry pods		Total dry seeds yield (Ton/fed.)	
	1st Season	2nd Season	1st Season	2nd Season	1st Season	2nd Season	1st Season	2nd Season	1st Season	2nd Season
T1	3.8	4.1	3.9	4.1	90.9	94.1	71.0	72.8	0.745	0.766
T2	5.0	5.0	5.6	5.7	123.6	125.7	76.8	77.1	0.866	0.863
T3	5.8	5.9	6.5	6.7	138.5	139.5	81.7	82.3	1.016	1.000
T4	5.5	5.6	5.7	5.8	128.5	130.5	77.2	78.2	0.890	0.899
T5	5.1	5.2	5.8	6.0	128.1	130.4	78.1	79.5	0.922	0.938
T6	5.3	5.5	5.9	6.0	130.2	131.7	79.2	80.4	0.900	0.906
T7	5.5	5.6	6.1	6.2	132.0	134.7	81.0	81.7	0.980	0.974
L.S.D. at 0.05	**0.1**	**0.1**	**0.1**	**0.2**	**1.2**	**1.0**	**0.5**	**0.5**	**0.071**	**0.048**

Treatments consisted of, **T1**: The control (spraying with tap water or no pinching).**T2**: Foliar spraying with paclobutrazol at 25 mg/L. **T3** Foliar spraying with paclobutrazol at 50 mg/L. **T4**: Foliar spraying with paclobutrazol at 75 mg/L. **T5**: Pinching at 60 cm of the plant height. **T6**: Pinching at 80 cm of the plant height. **T7**: Pinching at 100 cm of the plant height.

With regard to the positive effect of pinching technique treatments on broad bean plants, the effectiveness of pinching may probably be due to the change induced in the rate of cell division in the meristematic region thereby reducing the plant height promoting the development of increased number of healthy branches and flower resulting in an increase in the pod number. Further, the effectiveness of chemicals on pod production might be due to their retarding effect on apical growth, which in turn encouraged side branches of carnation plants **(Ahmad *et. al*., 2007)**. Pinching affects a variety of physiological processes in the plant, including vegetative growth arrest and increased deposition of a photosynthetic chemical, resulting in an increase in yield of okra plants **(Priyanka and Biswal, 2017)**. **Prakash *et. al.* (2022)** indicate that pinching resulted in the highest increase in number of flowers per plant and bloom size and yield when compared to no pinching of marigold.

These findings are consistent with **Olfati and Malakouti (2013)** on faba bean research, which found that pinching treatment had an impact on the number of pods/plant and overall output. Additionally, **Priyanka and Biswal (2017)** mentioned that pinching treatment increased the values of number of pods/plant, pod weight/plant and pod girth (cm), 100 seed weight (g), number of seeds per pod and yield/plot (kg) of okra plants. **Ghurbat and Abdul Jebbar (2020)** pointed out that apical pinching of okra plants significantly increased fruit numbers and total yield (ton/ ha.).

3-Chemical constituents of dry seeds:

Data in **Table (6)** made it abundantly evident that foliar spraying with paclobutrazol and pinching technique treatments on broad bean plants significantly improved the elemental components of the seeds *i.e.* the proportion of nitrogen, phosphorus, potassium, crude protein and carbohydrates in the dry seeds as a result of giving the plants all tested treatments in comparison to the control treatment in the both winter seasons. All of the aforementioned therapies significantly outperformed

Table (6): Nitrogen, phosphorus, potassium, crude protein and carbohydrates (%) of broad bean plants as affected by foliar spraying with paclobutrazol and pinching technique treatments during the two winter seasons of 2020/2021 and 2021/2022.

Treatments	**Nitrogen (%)**		**Phosphorus (%)**		**Potassium (%)**		**Crude protein (%)**		**Carbohydrates (%)**	
	1^{st} Season	**2^{nd} Season**	**1^{st} Season**	**2^{nd} Season**	**1^{st} Season**	**2^{nd} Season**	**1^{st} Season**	**2^{nd} Season**	**1^{st} Season**	**2^{nd} Season**
T1	2.99	3.11	0.36	0.42	1.42	1.33	14.75	14.7	18.7	19.4
T2	3.36	3.47	0.54.	0.59	1.61	1.65	17.18	17.3	21.0	21.7
T3	3.87	3.91	0.85	0.94	1.93	1.95	21.06	21.21	24.2	24.4
T4	3.48	3.51	0.63	0.66	1.66	1.71	18.44	19.2	21.8	21.9
T5	3.51	3.60	0.65	0.71	1.66	1.76	19.43	19.62	21.9	22.5
T6	3.60	3.66	0.75	0.76	1.73	1.79	19.77	20.0	22.5	22.9
T7	3.74	3.80	0.81	0.83	1.84	1.86	20.25	20.61	23.4	23.8
L.S.D. at 0.05	**0.17**	**0.09**	**0.03**	**0.04**	**0.05**	**0.06**	**0.41**	**0.24**	**0.47**	**0.33**

Treatments consisted of, **T1**: The control (spraying with tap water or no pinching).**T2**: Foliar spraying with paclobutrazol at 25 mg/L. **T3**: Foliar spraying with paclobutrazol at 50 mg/L. **T4**:

Foliar spraying with paclobutrazol at 75 mg/L. **T5**: Pinching at 60 cm of the plant height. **T6**: Pinching at 80 cm of the plant height. **T7**: Pinching at 100 cm of the plant height.

the control treatment. The best value for nitrogen, phosphorus, potassium, crude protein and carbohydrates (%) in the dry seeds was obtained by foliar spraying with paclobutrazol at the rate of 50 mg / L followed with pinching technique treatments *i.e*. at the flowering and pod setting stages, respectively.

On the other hand, the positive effect of obtained result may be due to that foliar application with paclobutrazol enhanced branching, flowers setting, earlier maturity and yield of plants which led to enhance chemical contents in dry seeds as well as pinching technique treatments increased the photosynthetic products and mineral nutrient uptake by increasing the lateral shoot, leaf areas and also likely lead to increasing numbers of flowers that give rise to more number of green pods. The positive of the pervious results are true in the two winter seasons, respectively.

Regarding to the superior effect of using foliar application of paclobutrazol especially at the moderate rate *i.e.* 50 mg/ L may be attributed to the maintenance of higher rates of photosynthesis with relatively high fluorescence ratio and water use efficiency, developed root system that determines water, ion uptake, their utilization, carbohydrate synthesis, improving chlorophyll biosynthesis and promoting antioxidant capacity **(Kamran *et. al*, 2020).** The pervious aspects are confirmed by **Amira and El-Shraiy (2007)** revealed that paclobutrazol at 10 and 20 ppm positively effect on protein content of common bean seeds. **Yadava (2012)** who regarded that foliar application of paclobutrazol at a rate of 50 ppm/ L significantly increased total soluble solids (%) of Cape gooseberry fruit. **Abdel-Aziz and Geeth (2018)** showed that paclobutrazol was applied at the rate of 50 mg/ L significantly increased nitrogen, phosphorus, potassium (%) in the dry leaves of sweet pepper plants, dry weight, total soluble solids and total sugars (%) in dried fruit. **Mahmoud *et. al.* (2020)** elucidate that paclobutrazol foliar spraying greatly increased the ions percentage of nitrogen, phosphorus, potassium in shoots, as well as carbohydrate and protein concentration in seed of pea plants under normal or salinity conditions at 0, 50, 100 mM NaCl affected pea plant compared to non sprayed plants.

As for, role of pinching technique treatments, the obtained results are consistent with those observed by **Katsumi** and **Ikeda (2017)** demonstrated that the effects of pinching technique treatments carried out at the 3 and 6 true leaf gave the maximum values of nitrogen, phosphorus, potassium, calcium and magnesium mg/ plant content in dry weight of processing tomato. **Priyanka and Biswal (2017)** investigated that terminal bud pinching recorded significant higher values for total soluble solids of okra fruits as compared to the other treatments and un pinched plant.

4- Seed germination tests:

As for to the behavior of seed germination tests *i.e.* seed germination ratio (%), germination rate (days) and sprout length (cm) as affected by foliar spraying with paclobutrazol and pinching technique treatments on dry seeds of broad bean are shown in **Table (7)**. Such data showed clearly that, all tested treatments significantly increased seed germination ratio (%), germination rate (days) and sprout length (cm) as compared with the control treatment. In this concern, the most effective treatments produced the highest seed germination tests values were by pinching technique treatments at the flowering and pod setting stages followed by foliar spraying with paclobutrazol at the rate of 50 mg/ L as compared with the other treatments or the control treatment.

Table (7): Germination ratio (%), germination rate (days) and seedling length (cm) of the dry seeds of broad bean plants as affected by foliar spraying with paclobutrazol and pinching technique treatments during the two winter seasons of 2020/2021and 2021/2022.

Treatments	Germination ratio (%)		Germination rate (days)		Sprout length (cm)	
	1st Season	2nd Season	1st Season	2nd Season	1st Season	2nd Season
T1	77.1	80.1	6.62	6.84	26.4	26.6
T2	83.4	84.3	5.11	5.88	29.6	30.0
T3	88.7	91.5	4.41	4.14	33.6	37.3
T4	83.7	85.6	4.91	4.88	30.2	32.0
T5	83.3	84.8	5.54	5.67	28.0	30.4
T6	84.1	87.2	4.86	4.73	31.2	33.6
T7	86.4	90.1	4.55	4.60	31.8	36.7
L.S.D. at 0.05	**1.4**	**1.1**	**0.07**	**0.05**	**1.2**	**0.5**

Treatments consisted of, **T1**: The control (spraying with tap water or no pinching).**T2**: Foliar spraying with paclobutrazol at 25 mg/L. **T3**: Foliar spraying with paclobutrazol at 50 mg/L. **T4**: Foliar spraying with paclobutrazol at 75 mg/L. **T5**: Pinching at 60 cm of the plant height. **T6**: Pinching at 80 cm of the plant height. **T7**: Pinching at 100 cm of the plant height.

Conclusion

According to the pervious results, foliar spraying the broad bean plants by using paclobutrazol compound at the rate of 50 mg/ L at three times *i.e.* 60, 80 and 100 days after sowing as well as from an applied point of view, pinching technique treatments at the peak flowering and pod setting stages led to vigour growth, the highest total green pods, dry seed yields and its parameters with the best quality of the dry seeds of Weaam cv. during the two winter seasons.

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