Impact of foliar spraying by using some stimulative substances on growth, green pods, dry seed yield, its components and some chemical constituents of pea plants (*Pisum sativum* L.) under high temperature stress conditions

ABSTRACT

This current study was carried out during the two winter seasons of 2020/2021 and 2021/2022 at Qaha Vegetable Research Farm (Qalubia Governorate), Horticulture Research Institute, Agriculture Research Center (A. R. C.), Egypt. The objectives of this study were to investigate the effect of foliar spraying with some stimulative substances *i.e.* Green Miracle at the rate of 3 cm^3 / L, Kaolin (Aluminum silicate) at the rate of 20 g/ L, Selenium element at the rate of 12 mg /L, Megacal Hort at the rate of 2.5 cm^3/L, Super Grow Hortic at the rate of 0.75 cm^3 /L and High Harvest at the rate of 0.75 cm^3/L beside the control treatment (spraying with tap water) on vegetative growth, green pods, dry seed yield, its components as well as seed quality of pea Master B cv. under high temperature stress conditions. The experimental design was a randomized complete block containing seven treatments with three replicates. Seeds of peas were sown in the 2nd week of September during the two winter growing seasons.

The results showed that, the most estimated parameters were significantly affected with all tested treatments as foliar applications; the superiority effect of the treatments was recorded by using kaolin (Aluminum silicate) followed by selenium element and green miracle which led to obtain the highest significant increase in all the previous studied traits *i.e.* the vegetative growth, green pods, dry seed yield and its components as well as seed quality under high temperature stress conditions.

Keywords: Peas, High temperature stress, Green Miracle, Kaolin, Selenium, Megacal Hort, Super Grow Hortic, High Harvest, Dry seeds, Carbohydrates and Protein.

INTRODUCTION

The field pea (*Pisum sativum* L.) is a cultivated species of the genus *Pisum* family Fabaceae and is widely cultivated as a cool season crop in most temperate climates and at high elevations in tropical countries throughout the world. Peas is one of the popular vegetable crops and grown as a winter crop in Egypt. Pea plants suffer from yield losses due to early planting which is very important for both of early fresh marketing and exportation. Pea is a highly nutritional crop and a cheap source of protein (23-33 %) to supplement meat protein. It is also rich in amino acids *i.e.* tryptophan and lysine, complex carbohydrates, high fiber (soluble and insoluble), B vitamins, folate, minerals content, such as calcium (Ca), iron (Fe), potassium (K). Pea is a high carbohydrate, very low in sodium and fat content, pea seeds are widely used in soups, breakfast cereals, processed into pea flour, starch or pea protein concentrates (**Fikreselassie, 2012**).

Concerning the effect of sowing pea plants under high temperature stress conditions:-

Peas are planted in Egypt as a winter crop; it requires low temperature ranged from 15 to 24 ˚C. Heat stress has a significant impact, during September and October months of year (with prevailing temperature >30-32°C) as shown in meteorological data in **Table 1.** In peas, the heat stress could be sub-categorized into two phases *i.e*. heat stress at vegetative stage and heat stress at reproductive stage. Field pea is very sensitive to high temperatures and seed production starts to decline when the maximum daytime temperature increases to above 25 to 30 °C.

In addition, when the temperature is over 35ºC, it is considered more severe for pea seed production. Heat stress at early vegetative or reproductive growth stage decreases all the yield components as hot dry weather interferes with optimum plant growth, pollination and seed setting, thereby reduces the number of pods /plant and pod weight. Heat stress conditions, similar to many other abiotic stresses, could result in deleterious effects on physiological processes including cell proliferation, photosynthesis, respiration and membrane stability and increase protein denaturation and the accumulation of reactive oxygen species (ROS) leading to cell death, damaged chloroplast, reduced carbohydrate synthesis and exportation and hasted oxygen senescence, attack cell membranes, led to their degradation and leakage of cell solutes, damage of nucleic acids, degradation of chlorophyll and suppression of all metabolic processes and finally senescence and death of cells and tissues **Lamichaney *et al*. (2021)**. The excess production of Reactive Oxygen Species results in cellular damage that manifest as degradation of biomolecules including pigments, proteins, lipids, carbohydrates and deoxyribonucleic acid, resulting in plant cellular death **(Medina *et al*., 2021).** Pea early seedling establishment and development stages resulted in thermal damage on poor emergence and vegetative growth of pea that includes reduction in shoot growth, root number, root diameter, reduced stomatal conductance and leaf water content, leaf curling, wilting and yellowing. Heat stress conditions cause severe yield losses by adversely affecting several traits in peas. High-temperature stress (30.5-33°C) especially during reproductive phase is known to drastically reduce seed yield. Furthermore, reproductive phase is more prone to the heat stress conditions than the vegetative phase **(Devi *et al*., 2023)**.

Concerning, the favorable effects of green miracle and kaolin (Aluminum silicate), both are considered antitranspiration. The positive role of green miracle (specially under heat stress conditions) on increasing the vegetative growth, green pod yield, dry yield, its components and pod quality of pea plants may be is attributed to that it contains total amino acids not less than 3 % and fatty alcohol 80 %. The aromatic amino acids (tyrosine, phenylalanine and tryptophan) serve as precursor for numerous metabolites involved in stress defense, including auxin, melatonin, phenolic compounds and alkaloids. Glycine is known to be the substrate for respiration and also serve as a precursor for the glycine betaine, which is a well known stress protector **(Dixon, 2001)**. Free amino acids are constituents of proteins and play regulatory roles in abiotic stress responses as signaling molecules, precursor for numerous secondary metabolites, protein chaperone and osmotic protectants. For example, proline protects plants from stress damage by serving as compatible osmolyte, regulator for redox homeostasis and molecular chaperone. In this concern, heat stress was found to decrease the accumulation of proline. Proline accumulation is considered as an adaptive mechanism under heat stress **(Szabados and Savoure, 2010)**.

One of the great importance is the contribution of silicon in reinforcement of cell walls by deposition of solid silica. Silicon application, therefore, improves plant architectures *i.e.*, making it more erect, improving the angle of leaves and light interception, avoiding excessive self shading, increasing the structural rigidity of plant tissues, reducing lodging and delaying senescence on wheat leaves in field under drought conditions **(Gong and Chen, 2012)**. Silicon can increase plant tolerance to different abiotic and biotic stresses, such as salt, drought stress, extreme temperature stress, nutrient deficiency, aluminum toxicity, disease resistance and pest resistance, during stress, silicon stimulates multiple response pathways, thereby activating antioxidants, enhancing mineral uptake and organic acid anions, exuding phenolic compounds and regulating hormonal production **(Kim *et al.*, 2017).**

Kaolin as an antitranspirant that was sprayed on surfaces of transpiring plants to reduce water use by suppressing transpiration enhance the disease resistance, physiological processes, decrease leaf temperature due to increase leaf reflectance, reduce transpiration rate and improve metabolic processes in plants, yield and quality aspects in many vegetable crops especially under dry conditions **(Koteswara *et al*., 2018)**. **Ahmed (2019)** revealed that kaolin is a reflective antitranspirant material, when it sprays on the plants induce covering the leaves and fruits with thin films of nano particles as a white color and increasing their reflectance properties of light. Foliar spraying with kaolin as a particle film at the rate of 5 % which reflects photo synthetically active, ultraviolet and infrared radiations thus reduce high temperatures stress of treated the plant organs *i.e.* leaves, fruits and mitigating environmental stresses, increasing the vegetative growth, yield, its components and fruit quality. Thus the kaolin has been used to prevent fruit sunburn damage as well as suppress diseases, protect crops from insect pests and save water by reducing transpiration of tomato plants. **Ahmed *et al.* (2019)** assumed that foliar spraying by kaolin at the rate of 2 % /L and green miracle at the rate of 3 cm^3/ L led to enhance the vegetative growth characteristics, dry seeds yield (kg /fed.) weight of 100 seeds (g), germination percentage and some chemical composition of dry seeds on the squash plants during the both seasons as compared with the control treatment especially under dry conditions. **Ismail and Fayed (2020)** working on broad bean plants and indicated that foliar spraying with the green miracle at the rate of 3 cm^3/L markedly improved the vegetative growth characteristics, dry seeds yield, its components and some chemical composition of dry seeds.

As regard to the beneficial effects of using selenium element under high temperature stress conditions, Egypt is a country with a low content of selenium in its soil, which is quite low, causing a selenium deficiency in the human diet (**Tapiero *et al.*, 2003**). Cultivation of plants enriched with selenium element could be an effective way of producing Se- rich foodstuffs and thereby increase health benefits, selenium element plays a role in the prevention of atherosclerosis, specific cancers, heart disease, arthritis and altered immunological functions.

Furthermore, selenium element plays an important regulatory role in improving the tolerance of plant to high temperature stress through increasing chlorophyll content and activating antioxidant enzymes. Also, where selenium is an antioxidative function, it may delay plant senescence and to promote plant growth **(Shang *et al.*, 2005)**. Selenium regulates the reactive oxygen species (ROS) concentrations in pepper plant cells by stimulating spontaneous dismutation of O_2^- to H_2O_2 by superoxide dismutase (SOD). Moreover, selenium regulates the amount and activity of antioxidant enzymes *i.e.* glutathione peroxidase (GSH-Px), Glutathione reductase (GR), Superoxide dismutase (SOD), Ascorbate peroxidase (APX), catalase (CAT) and metabolites such as Glutathione (GSH), ascorbate and decreased lipid peroxidation resulting in higher reactive oxygen species scavenging capacity of plants **(Feng *et al.*, 2013)**. In addition, selenium application enhance the plant metabolism leading to the vegetative growth characters, green pods, dry seeds yields and its components as well as seed quality increments on common bean plants (**Wathiq *et al*., 2022).**

Regarding to the effect of Megacal Hort, Super Grow Hortic and High Harvest as foliar spraying which they contained macronutrients and micronutrients, cetric acid, ascorbic acid cytocinine, gebrilic acid, naphthalene acetic acid, free amino acids and polysaccharides (**Table 3)**, the beneficial effects of using the previous compounds under high temperature stress conditions can successfully mitigate the adverse effects of heat stress conditions. In this connection, nitrogen (N) is one of the most important plant nutrients, in almost all types of crop plants, it is linked to higher chlorophyll biosynthesis, greater photosynthetic activity and efficient solar radiation utilization. The amount of stress relief was shown to be controlled by the type of nitrogen supplied, either ammonium (NH_4^+) or nitrate (NO_3^-). *Phaseolus vulgaris* plants fertilized with NO_3^- showed a stronger tolerance to heat stress than those fertilized with NH_4^+, according to **(Zhu *et al*., 2000)**. Furthermore, foliar application of nitrogen fertilizers at the reproductive stage, particularly in leguminous crops under drought conditions, significantly slows abscisic acid synthesis while accelerating cytokinin production, which promotes nodulation, cell elongation, apical dominance, shoot development, photosynthetic activity and assimilates translocation to the sink organs. Stress alleviation helps to improve the yield or helps in yield reduction **(Banerjee *et al*., 2019)**.

Boron plays an important role in increasing the level of carbohydrates transported to the effective growth areas during the reproductive plant stage as well as protecting and moving the IAA, which encourages the increasing of cell division and expansion and thus gives an increment in vegetative growth **(Barker and Pilbeam, 2006)**. Magnesium increases the root growth and root surface area which helps to increase uptake of water and nutrients by root. Magnesium being a constituent of chlorophyll increases the amount of sucrose and enhances the transport of sucrose from leaves to roots. Magnesium improves carbohydrates translocation by increasing phloem export and reduces reactive oxygen species generation and photo-oxidative damage to chloroplast under temperature stress (high or low) conditions. Maintenance of chloroplast structure by improving Magnesium nutrition enhances the photosynthetic rate under temperature stress which in turn improves the productivity **(Waraich *et al,* 2011)**. Sulphur (S) is the fourth most important plant nutrient after nitrogen, phosphorus and potassium is an essential macronutrient in plants that serves various functions. Many sulphur containing chemicals play protective functions in abiotic stress response, cellular acclimatization and adaptability in the adverse conditions. An exogenous supply of sulphur has been shown to benefit plants survival in stressful conditions by maintaining their normal metabolic processes and also improving crop yield **(Hasanuzzaman *et al*., 2012)**. Calcium (Ca) plays a vital role in regulating a number of physiological processes in plants at tissues, cellular and molecular levels that influence both growth and responses to environmental stresses calcium is an essential secondary nutrient, mediating the cell and plant development processes. It also improves plant response to different stress conditions by regulating many physiological aspects. Calcium is also important for nutrient uptake, hormonal enzymatic regulations and stabilisation of cellular membranes to mitigate abiotic stress in plants. There are reports that Ca reduces yield loss in different crops under diverse abiotic stress conditions, including salt, drought, flooding, heat, chilling and heavy metal stress (**Parvin *et al*., 2019)**.

Additionally, many small molecules like anthocyanins, glutathione, ascorbic acid and tocopherols secure the plant by scavenging active oxygen species during oxidative stress. Various phytohormones were produced under stress conditions *i.e.* heat stress act as signaling molecules and activate the systematic defense system in plants. The exogenous application of amino acids on plants controls membrane permeability and ion uptake; thus enabling plants to withstand severe stress. The amino acid content also helps in stress tolerant, through regulating the intracellular pH, osmotic adjustment and detoxification of reactive oxygen species **(Shulaev *et al*., 2008)**.

Phyto-hormones such as auxin, gibberellin (GA) and cytokinin (CK) are positively involved in regulating plant reproductive tolerance under heat stress **(Liu *et al.*, 2019)**. Foliar application of auxins 4-chloroindole-3-acetic acid (4-Cl-IAA) at early reproductive stage of pea can increase seed yield under heat stress **(Abeysingha, 2015)**.

The aim of this investigation was to study the impact of spraying pea plants with some stimulative substances to protect plants from heat stress and reflect that on invigoration the growth, enhancing green pod yield productivity, dry seed yield, its components and chemical properties of dry seeds as well as dry seeds quality.

MATERIALS AND METHODS

This study was conducted during the two winter seasons of 2020/2021 and 2021/2022 at Qaha Vegetable Research Farm (Qalubia Governorate), Horticulture Research Institute, Agriculture Research Center (A. R. C.), Egypt. It was initiated to investigate the influence of some stimulative substances on vegetative growth, green pods, dry seeds yields and its components as well as seed quality of pea Master B cv. under high temperature stress conditions. The meteorological data for the experimental area has been obtained from Central Laboratory for the Agricultural Climate (CLAC), Agricultural Research Center (ARC), Ministry of Agricultural and Land Reclamation, the values were recorded during the two growing seasons as shown in **Table(1)**.

Table (1): Meteorological data at Kaha, Qalubia Governorate during the two winter seasons of 2020/2021 and 2021/2022.

Months	Temperature ^{o} C			
	2020/2021		2021/2022	
	Maximum	Minimum	Maximum	Minimum
September	39.4	22.3	36.9	21.7
October	34.8	19.9	32.7	18.6
November	25.9	14.9	28.7	16.1
December	23.6	11.3	20.6	10.0
January	22.3	9.3	17.6	6.3

The soil type of this experimental field was clay loam. Soil samples were taken randomly of each year before planting at the depth of 0-30cm to determine the physical and chemical analysis of soil which determined according to **Jackson (1973)** as shown in **Table (2)**.

Table (2): Physical and chemical analysis of soil before planting during the two winter seasons of 2020/2021 and2021/2022.

Seasons	1st season	2nd season
Soil texture	Clay	Clay
Clay %	51.0 %	50.0 %
Coarse sand %	14.2 %	14.0 %
Fine sand %	8.3 %	8.6 %
Silt %	25.0 %	26.0 %
Organic Matter %	1.5 %	1.4 %
pH	7.8	8.0
Electrical conductivity dS/m	2.64	2.37
Available N (ppm)	53.3	51.8
Available P (ppm)	4.2	3.9
Available K (ppm)	60.3	60.1

The experiment included seven treatments of foliar spraying by using some stimulative substances as follows:

1- Control (tap water).

2- Green Meracle at the rate of 3 cm^3/L.

3- Kaolin (Aluminum silicate) at the rate of 20 g/L.

4- Selenium element at the rate of 12 mg/L.

5- Megacal Hort at the rate of 2.5 cm^3/L.

6- Super Grow Hortic at the rate of 0.75 cm^3/L.

7- High Harvest at the rate of 0.75 cm^3/L.

The experimental design was complete randomized block with three replicates. Seeds of peas were sown in the 2nd week of September during the two winter growing seasons of 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 150 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. Seeds were sown in hills on one side of ridges at 10 cm apart, between hills in 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 seeds yield components. The different stimulative substances treatments using in this investigation were applied at four times; the 1st foliar spraying started after 15 days from sowing date and was repeated every 10 day intervals during the growth period of the two winter seasons, respectively.

Guard rows were set between the experimental units to avoid drifting to the adjacent plots. The treatments included the compounds names, its composition, sources and concentration/ L beside the control treatment are shown in **(Table 3)**.

Table (3): The compounds names, its composition, sources and concentration/ L which it's used as a foliar spraying during the two growth periods of the two winter seasons of 2020/2021 and 2021/2022.

Compounds names	Composition	Sources	Concentration/ L
Green Miracle®	Total amino acids not less than 3 %, Fatty alcohol 80 %, other neutral alcohol 10 %, emulsifier and stabilizers 7 %, used as a liquid form.	Gaara establishment for import and export T-Stanes and Company Limited – India	3 cm^3/ L
Kaolin® (Aluminum silicate)	Kaolin clay particle film (Aluminum silicate - $Al_2O_7Si_2$). Concentration of Al at 0.7 % and Si at 48.8 mg/kg, used as a powder form.	Manufactured by Green Way Naturals Co., Ltd. Ismailia – Egypt.	20 g/ L
Selenium element®	Sodium selenate (Na_2 SeO_4), used as a powder form.	Imported from Germany	12 mg /L
Megacal Hort®	N 13.7 %, Ca 10 %, Mg 5 %, B 2.5 % Cetric acid 5 %, Polysaccharides 2.5 % and ascorbic acid 0.5 %, used as a liquid form.	Agriculture Horticulture Company (AHC)	2.5 cm^3 /L
Super Grow Hortic®	Cytocinine 3.5 %, NAA 0.1 %, Gebrilic acid (GA_3) 0.3 %, Vitamine C 0.8 %, Vitamin E (α–Tocopherol) 0.8 % and Polysaccharides 10 % used as a liquid form.	Agriculture Horticulture Company (AHC)	0.75 cm^3 /L
High Harvest®	Free amino acids 15 % (Glycine 0.38 %, Cereine 0.32 %, Valine 0.45 %, Isoluecine 0.29 %, Thrionine 0.23 %, Histedine 0.19 %, Arginine 0.23 %, Aspartic 1.36 %, Alanine 1.84 %, Phenylalanine 0.29 %, Lysine 0.42 %, Leucine 0.45 %, Tyrosine 0.25 % and Glutamic 8.3 %), Proteins 0.28 %, N 8 %, S 1.5 %, Mg 1 %, Fe 0.2 %, Zn 0.1 % and Polysaccharides 2.5 %, used as a liquid form.	Agriculture Horticulture Company (AHC)	0.75 cm^3 /L
Control	Spraying with tap water		

The recommended agricultural practices of pea 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.

Data recorded:

1- Vegetative growth characters:

A random sample of three plants from each experimental plot was taken at flowering and pod development stages (50 - 55 days after sowing), after seven days from the last foliar spray to evaluate the vegetative growth characteristics *i.e.* plant height (cm), number of leaves, branches, fresh and dry weights/ plant (g).

2- 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; average each of pod length and diameter (cm), green pod weight (g), number of green seeds/ green pod and green seeds weight/ green pod. Mature green pods were harvested at suitable maturity stage in tree picking and calculated as total green pods yield in (ton/ fed.).

3- Total dry seeds yield and its components:

A random sample of ten dry pods at the end of harvesting date (after the physiological mature stage) from each plot were taken to determine the following data *i.e.* number of dry seeds /dry pod, dry seeds weight / dry pod (g), shell out % of dry pods, seed index (the dry weight of 100 seeds), dry seeds yield (g/plant) and total dry seeds yield (kg/fed.).

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

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

4-Chemical composition of pea dry seeds:

4-1- Minerals content: dry samples of pea seeds were dried in an electric forced-air oven at 70°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).** 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:

Random samples (100 dry seeds each) were used from each treatment for calculating the following records; germination ratio (%), germination rate (days) and sprout length (cm). Germination rate was calculated according to the following equation:

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

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 Whatman 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 was 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, method described by (**Bricker, 1991**).

RESULTS AND DISCUSSION

1- Vegetative growth characters:

With regard to the effect of foliar spraying with various stimulative substances treatments on pea plants subjected to heat stress conditions on vegetative growth characters *i.e.* plant height, number of leaves and branches, fresh and dry weights/ plant, data registered in **Table (4)** showed clearly that, foliar spraying of pea plants with all used treatments significantly enhanced plant height, number of leaves and branches, fresh and dry weights /plant as compared with the control treatment. Whereas, foliar spraying with kaolin was significant only on number of branches in the first season as well as non-significant values were obtained with foliar spraying using Megacal Hort, Super Grow Hortic and High Harvest on dry weight (g/plant) only in the 2^{nd} season as compared to the control treatment.

The most effective treatments produced the tallest plants with more branches, leaves, heaviest fresh and dry weights of pea plant were obtained from plants treated with kaolin at 20 g/ L followed with selenium element at 12 mg/ L and green miracle at 3 cm^3/ L, respectively above the control.

Concerning to the effect of foliar spraying with green miracle and Kaolin on pea plants, these positive results on the vegetative growth characters with foliar spraying by using green miracle treatment may be attributed to the role of amino acids which play an important role in plant resistance to biotic and abiotic stresses. Also, amino acids increase the content and activity of endogenous plant growth regulators, which promote growth of plant organs due to the conversion into indol acetic acid **(Rouphael *et al*., 2018)**.

Additionally, kaolin treatment on pea plants may be due to that, silicon plays significant roles in an increment growth and development as well as acts as a defense system thereby neutralizing the extremities of various biotic stresses especially in heat stress. In this concern, silicon deposition in the cell wall of xylem vessels prevents compression of the vessels under the condition of high transpiration caused by heat stress. The kaolin also prescience in cellulose membrane of epidermal tissue protects the plants against excessive loss of water by transpiration. A reflective kaolin spray was found to decrease leaf temperature by increasing leaf reflectance and this reduce transpiration rate which enhance the efficiency of photosynthesis in many plant species grown at high solar radiation levels leading to promote the vegetative growth of processing tomato plants (**Pace *et al*., 2007)**.

In addition, accumulation of silicon will produce a thick silicate layer on the leaf surface which effectively reduces cuticular transpiration up to 30 % as well as a thick layer of silica gel is associated with cellulose in the epidermal cell wall but less silica gel will allow water to escape at an accelerated rate. Under normal light, silica deposited in stomatal guard cells could serve as windows allowing more light to pass through the epidermis to the photosynthetic mesophyll tissue, thus enabling higher rates of photosynthesis. Silicon is considering as an antitranspirant which ascribed to the important role of blocking stomata without causing any inferior effects on photosynthesis, which retards normal moisture loss without interfering with plant growth or normal respiration (**Vashi *et al.*, 2020)**.

Table (4): Vegetative growth characteristics of pea plants as affected by foliar spraying with different stimulative substances during the two winter seasons of 2020/2021 and 2021/2022.

Treatments	Plant height (cm)/plant		Number of leaves/plant		Number of branches/plant		Fresh weight (g/plant)		Dry weight (g/plant)	
	1st Season	2nd Season	1st Season	2nd Season	1st Season	2nd Season	1st Season	2nd Season	1st Season	2nd Season
Control	38.3	38.8	11.2	11.6	1.41	1.74	21.1	23.3	5.1	5.6
Green Miracle	47.5	48.1	14.1	14.8	2.33	2.54	29.8	30.4	7.3	7.8
Kaolin	52.7	53.2	15.2	15.8	2.71	2.92	32.1	33.1	9.4	9.7
Selenium	50.1	51.2	14.3	15.2	2.43	2.57	30.4	31.6	7.9	7.2
Megacal Hort	41.1	42.1	12.5	12.1	2.22	2.51	24.3	26.4	6.3	6.6
Super Grow Hortic	45.7	46.1	13.8	13.2	1.74	1.81	28.1	28.7	6.4	6.6
High Harvest	43.8	44.2	13.3	13.7	1.46	1.55	26.8	27.2	6.8	6.2
L.S.D. at 0.05	**1.2**	**1.1**	**0.3**	**0.4**	**1.20**	**N.S**	**1.1**	**1.0**	**1.2**	**1.1**

These results were in conformity with those obtained by the finding of **Abdel-Aziz (2007)** who pointed out that foliar application of the raw silicon and sodium meta silicate at a rate of 1 g/ L of each other occurred an increment in vegetative growth of tomato plants under high temperature stress conditions. **Kamal (2013)** mentioned that spraying kaolin at a rate of 4 % and potassium silicate at a rate of 1.5 kg/ fed. obtained an increasing in vegetative growth characteristics of sweet pepper plants.

In addition, **Abdel-Aziz and Geeth (2018)** showed that foliar applications with kaolin at the rate of 20 g/ L led to obtain the highest significant increasing in all vegetative growth parameters of sweet pepper under high temperature stress conditions. **Ahmed (2019)** on tomato concluded that foliar spraying with kaolin at the rate of 5 % which a processing technology plays a key role in reducing plant transpiration, the treated plants became more cooler than the control plants by 2 - 3 °C as well as its reflect the harmful of solar radiation with reflection *i.e.* infrared and ultraviolet radiation resulted an increasing in the plant growth. Kaolin foliar application was reported to improve CO_2 assimilation under high temperature stress and this is enhancing photosynthesis. **Ahmed *et al.* (2019)** revealed that kaolin at the rate of 2 % and green miracle at the rate of 3 cm^3/L had a significant increasing in fresh and dry weights, plant length, number of leaves and leaf area of squash plant during the both seasons especially under dry conditions.

Regarding for using selenium element as foliar spraying, selenium is an essential micronutrient that plays multiple roles in wide variety of physiological processes and improves crop quality and nutritional value. Selenium element plays an important regulatory role in improving the tolerance of plant to high temperature stress conditions through increasing chlorophyll content and activating antioxidant enzymes. Also, the enhancement in the vegetative growth parameters, yield and yield quality may be attributed to the role of selenium at regulating the levels of reactive oxygen species accumulated in the plant cells especially in mitochondria and chloroplasts at the sites of electron transport under heat stress conditions **(Zorov *et al*., 2014)**. Moreover, selenium as an antioxidant activity improvement leads to photosynthesis amelioration in its turn, carbon assimilation increased on lentil plants **(Ekanayake *et al.*, 2015).** Our results in this study confirmed with the previous results like, **Abdel-Aziz and Geeth (2017)** concluded that the foliar spraying pea plants with selenium at a rate of 10 mg/ L significantly increased plant height (cm), number of branches and dry weight of foliage/ plant (g) under cold stress conditions for two peas cultivars *i.e.* Entsar 1 and Master B. **El-Sawy *et al.* (2019)** illustrated that pea plants which received Nano bio-selenium at 30 ppm, mineral selenium at 40 ppm and ascorbic acid at 200 ppm produced the highest significant values of plant length, number of leaves, branches, stems fresh and dry weights per plant as compared to the control treatment. **Wathiq *et al.* (2022)** declared that foliar application of selenium at level of 20 µmol revealed the highest significant values of number of branches, number of leaves/plant and leaf area in the both growing seasons. However foliar application of selenium at 10 µmol on common bean plants showed the highest significant values of plant length.

On the other hand, **Abdel-Aziz and Geeth (2017)** postulated that foliar spraying pea plants with green miracle at a rate of 3 cm^3/ L was the best stimulant substance markedly improved plant height (cm), number of branches and dry weight of foliage/ plant (g) under cold stress conditions for two peas cultivars *i.e.* Entsar 1 and Master B. Also, **Ismail and Fayed (2020)** working on broad bean and indicated that foliar spraying with the green miracle at the rate of 3 cm^3/L was among best stimulant substance, since, markedly improved the vegetative growth.

Regarding to the effect of Megacal Hort, Super Grow Hortic and High Harvest, the beneficial effects of using the previous compounds can mitigate the adverse effects of heat stress conditions also, can help to activate the metabolic and biological processes that help to maintain the high water potential of tissues and therefore increase the heat stress tolerance. The application of plant nutrients like N, Ca and Mg has also been found to reduce toxicity to reactive oxygen species by increasing the amount of antioxidant enzymes such as superoxide dismutase (SOD).

In addition, Zn mediated regulation of water relations confers heat tolerance by sustaining cell water and osmotic potential under stress conditions. Zinc deficiency inhibits plant development and limits photosynthesis in many plant species. Iron (Fe) is required for various plant metabolic reactions and helps during stress. Boron (B) is essential for plant reproduction, growth, root elongation, cell wall formation and metabolism of deoxyribonucleic acid under stressful conditions. Boron is an important nutrient for carbohydrate and hormone metabolism and translocation. Moreover, B is involved in potassium transport into guard cells and thus stomatal opening in stressed environments. Combined application of Zn, Fe and B spray treatments improved chlorophyll biosynthesis, photosynthetic rate, and gaseous exchange regulation, might modulate biochemical changes through antioxidant enzymes **(Waraich *et al*., 2012)**. Also, improving plant growth aspects by vitamin C. treatment may be through enhancing the accumulation of chlorophyll and its act as a co-factor for synthesis of gibberellins and the control of cell growth. Furthermore, vitamin C is an important buffer against the high oxidative load that accompanies rapid metabolism, also it plays a more active role in which tissue contents affect development via hormonal signaling path ways and modulation of defense networks **(Gabriela *et al*., 2003)**. Increasing of α-tocopherols level contributes to plant stress tolerance, while decreasing its level favor oxidative damage **(Munne, 2005).**

These results were in conformity with those obtained by **Shokr and Abdelhamid (2009)** demonstrated that foliar application of vitamins C at 250 ppm/ L, E (α–Tocopherol) at 150 ppm/ L, calcium (in form of Ca-citrate, 25 % Ca) at 2000 ppm/ L and zinc (in form of Zn EDTA, 12 % Zn) at 100 ppm/ L significantly increased plant height, number of leaves and branches/plant, fresh and dry weights/plant of pea plants Master-B cv. under local environmental conditions of the two early summer seasons. **Mona and Karima (2019)** indicated that foliar spraying with amino acids at the rate of 1000 ppm recorded the highest values of the vegetative growth *i.e.* plant length, number of leaves, fresh and dry weight of leaves on squash plants under high temperature conditions. **Ismail and Fayed (2020)** reported that foliar spraying with, naphthalene acetic acid (NAA) at the rate of 0.6 gm / L, potassium silicate at the rate of 3cm / L, boron at the rate of 1.5 gm / L, zinc at the rate of 1.5 gm / L and (zinc+ boron) at the rate of (1.5+1.5) gm / L. significantly enhanced all growth parameters expressed as plant height, number of leaves, branches / plant and stem diameter as well as fresh and dry weights/ plant as compared to the control treatment (tap water) on broad bean plants. **Naz *et al*., (2022)** generalized that growth parameters of pea plants *i.e.* plant height, fresh, dry plant biomass, number of branches/ plant, number of leaves/ plant and leaf chlorophyll content were significant increased with foliar application of three micronutrients *i.e.* zinc sulphate ($ZnSO_4$), copper sulphate (Cu_2SO_4) and boric acid (H_3BO_3) were sprayed alone as well as in combinations, each at the level of 3 mg/ L.

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

Regarding to the effect of foliar spraying with some stimulative substances treatments on pea plants subjected to heat stress conditions on total green pods (ton/ fed.), dry seeds yields (g/ plant and kg/ fed.) and its parameters expressed as pod length and diameter (cm), green pod weight (g), number of green seeds/ green pod, green seeds weight/ green pod, total green pods yield (ton/ fed.), number of dry seeds/dry pod, dry seeds weight/ dry pod, shell out % of dry pods, seed index and dry seeds yield (g/plant and kg/ fed.) of pea plants are presented in **Tables 5 and 6**. It is evident that all different stimulative substances treatments on pea plants led to enhancing of total green pods yield as well as dry seed yield and its parameters. Whereas, foliar spraying of Megacal Hort obtained non significant increasing on pod diameter and dry seeds yield only in the 2^{nd} season. The most effective treatments were produced the highest total green pods yield, dry seed yield and its components by spraying pea plants with kaolin at 20 g/ L followed with selenium element at 12 mg/ L and green miracle at 3 cm^3/ L respectively. The total green pods yield (ton/ fed.) under kaolin, selenium element and green miracle treatments application occurred higher values by 36.8, 33.6, 32.7, 29.4, 27.4 and 25.1 %. The total dry seeds yield (kg/fed.) values recorded 34.2, 32.3, 26.5, 24.3, 21.8 and 18.5 % as an average over the control treatment (the untreated plants) in the 1^{st} and 2^{nd} winter seasons, respectively. These results were considered highly superior for producing total green pods and dry seed yield of pea plants under high temperature stress condition. These positive results of total green pods, dry seed yield and its parameters with foliar spraying by using green miracle treatment on pea plants under high temperature stress conditions may be due to that, the application of amino acids which can be alleviate the negative effects of heat stress on the production and quality. These positive effects of amino acids may be because they are biostimulants, mitigating abiotic stress injuries and serving as hormone precursors **(Rouphael *et al.*, 2018)**. **Al-Said and Kamal (2008)** decided that the main source of protein in plant tissues is the amino acids. The requirement of nitrogen of amino acids in essential quantities is known as a mean to increase growth and yield for all crops. Furthermore, amino acids are the fundamental ingredients for the process of protein synthesis. The important of nitrogen or amino acids came from their widely use for the biosynthesis of large variety of non protein nitrogenous materials; pigments, vitamins, coenzymes, purine and pyrimidine bases. Studies have proved that amino acids can directly or indirectly influences the physiological process in plant growth and development caused an enhancement in fruit yield and its components of sweet pepper plants.

As for, using Kaolin treatment under high temperature stress conditions, these remarkable results of treated pea plants with kaolin could be explained the role of silicon on plants, suggesting they improved silicon uptake and played a role in heat stress tolerance. This role might be attributed to the accumulation of silicon in the shoots, providing additional strength to the leaf and stem structure to minimize the adverse effects of heat and drought stress, hence leading to higher tolerance. In this respect, silicon deposited in cell walls forms a protective layer reducing transpiration through the outer cells under the conditions of high transpiration caused by drought or heat stress contributing in the enhancement of photosynthesis and dry matter content. Furthermore, silicon in plants can increase the thickness and hardness of fruit because of the accumulation of silicon on the epidermal tissues, silicon has been found more tolerant against pests which it is considered to be due either to accumulation of absorbed silicon in the epidermal tissue or expression of pathogenesis induced host defense responses, in this concern, kaolin which a processing technology plays an important role in the ability of the final product to reflect on reducing harmful solar radiation stress in the crop by lowering temperatures inside the plants or around vegetative growth as a result of spraying the plant organs which protect the growth and the fruits from damaging by ultraviolet and infrared radiation while photosynthesis still occurring (**Vashi *et al.*, 2020)**. Foliar spraying with kaolin treatment lead to healthy pea plants as well as vigour of vegetative growth and subsequence leading to increasing total green pods, dry seeds yields and its parameters.

Table (5): Green pods parameters of pea plants as affected by foliar spraying with different stimulative substances during the two winter seasons of 2020/2021 and 2021/2022.

Treatments	Pod length (cm)		Pod diameter (cm)		Green pod weight (g)		No. of green seeds/ green pod		Green seeds 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
Control	9.1	9.5	1.11	1.23	6.34	6.41	7.11	7.32	4.11	4.18	2.452	2.523
Green Miracle	10.6	10.8	1.37	1.39	7.56	7.62	8.23	8.36	4.88	4.92	3.124	3.156
Kaolin	11.7	11.9	1.44	1.46	8.11	8.23	9.11	9.24	5.22	5.31	3.354	3.371
Selenium	11.2	11.6	1.41	1.44	7.77	7.81	8.67	8.88	5.01	5.12	3.253	3.266
Megacal Hort	9.6	9.9	1.22	1.29	6.77	6.85	7.46	7.65	4.43	4.52	2.736	2.761
Super Grow Hortic	10.2	10.5	1.31	1.34	7.21	7.33	7.81	7.92	4.71	4.85	2.951	3.111
High Harvest	9.9	10.3	1.28	1.31	6.83	7.01	7.63	7.77	4.62	4.71	2.865	2.887
L.S.D. at 0.05	**0.4**	**0.3**	**N.S**	**0.07**	**0.22**	**0.18**	**0.21**	**0.24**	**0.11**	**0.13**	**0.066**	**0.078**

The previous results are in agreement with those reported by **Abdel-Aziz (2007)** who declared that foliar application of the raw silicon and sodium meta silicate at a rate of 1 g/ L of each other occurred increasing on average fruit set %, fruit weight, early and total yield/ fed. of tomato plants under high temperature stress conditions. Also, **Abdel-Aziz and Geeth (2018)** working on sweet pepper and pointed out that foliar applications with kaolin at the rate of 20 g/ L led to obtain the highest values of fruit yield and its components under high temperature stress conditions. Similar results were concerning the favorable effect of kaolin and potassium silicate was reported by **Kamal (2013)** on sweet pepper. **Abdel-Aziz and Geeth (2017)** mentioned that the foliar spraying pea plants with the green miracle at a rate of 3 cm^3/ L was the best stimulant substance markedly improves all pea green pods parameters.

Moreover, **Ahmed *et al.* (2019)** revealed that foliar spraying of squash plants with kaolin at the rate of 2 % and green miracle at the rate of 3 cm^3 /L were superior treatments *i.e.* dry seeds yield/ plant (g), dry seeds yield/ plot (g), dry seeds yield kg/fed.), average weight of 100 seeds (g) and seed germination (%) during the both seasons as compared with the control treatment especially under dry conditions. **Ismail and Fayed (2020)** proposed that foliar spraying broad bean plants with the green miracle at the rate of 3 cm^3/ L gave the highest values of dry seed yield components *i.e.* number and weight of seeds/dry pod, seed index 100 seeds weight (g), seed yield (g/plant) as well as seed yield (Kg /fed.) as compared to the control treatment.

Table (6): Dry seed yield and its components of pea plants as affected by foliar spraying with different stimulative substances during the two winter seasons of 2020/2021 and 2021/2022.

Treatments	No. of dry seeds/ dry pod		Dry seeds weight (dry pod/g)		Shell out % of dry pods		Seed index (the dry weight of 100 seeds) (g)		Dry seeds yield (g/plant)		Dry seeds yield (kg/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
Control	5.11	5.25	1.02	1.21	75.2	76.3	16.1	17.2	16.8	17.6	622.1	653.6
Green Miracle	6.14	6.34	1.81	1.92	81.3	82.4	20.6	21.1	20.7	21.8	757.6	774.6
Kaolin	7.16	7.26	2.34	2.41	84.7	86.1	22.7	23.4	24.1	24.8	835.1	864.7
Selenium	6.58	6.72	2.11	2.24	82.4	83.6	21.4	22.3	22.4	23.4	786.7	812.4
Megacal Hort	5.47	5.63	1.31	1.47	77.4	78.6	18.3	18.8	18.1	18.6	663.4	683.4
Super Grow Hortic	5.89	5.94	1.67	1.76	79.6	80.1	19.4	20.1	19.2	19.8	623.4	733.7
High Harvest	5.74	5.82	1.56	1.62	78.8	79.3	18.8	19.3	18.7	19.2	682.3	700.1
L.S.D. at 0.05	**0.33**	**0.26**	**0.16**	**0.12**	**1.1**	**1.2**	**1.0**	**1.1**	**1.1**	**1.2**	**40.2**	**37.6**

With regard to the stimulatory effect of selenium element as foliar application under heat stress conditions may be due to mitigated the deleterious effects of heat temperature stress on antioxidant enzymes activity by markedly improving their activities and it can enhance reactive oxygen species scavenging content in leaves and roots, decrease membrane damage capacity of plants subjected to various stresses included high temperature stress. Foliar application of selenium significantly palliated heat induced injurious effects on growth, yield and its characteristics by improving the above-indicated growth and productivity parameters. Selenium not only provides protection but also enhances chloroplast size under stressed conditions and can partially neutralize the toxicity caused by stress **(Feng *et al*., 2013)**.

The present investigation is in agreement with the previous reports of **El-Sawy *et al.* (2019)** illustrated that foliar application using Nano bio-selenium at 30 ppm, mineral selenium at 40 ppm and ascorbic acid at 200 ppm produced the highest significant values of pod weight, yield (g/ plant), shelling (%) and yield (ton/fed) on pea plants as compared to the control treatment. **Wathiq *et al.* (2022)** revealed that selenium at the rate of 20 µmol gave the highest significant value in dried pods weight/ plant and weight of 100 seeds.

Regarding to the effect of Megacal Hort, Super Grow Hortic and High Harvest as foliar spraying, the results also are in conformity with the findings of **Shokr and Abdelhamid (2009)** proposed that foliar application of vitamins C at 250 ppm/ L, E (α–Tocopherol) at 150 ppm/ L, calcium (as form of Ca-citrate, 25 % Ca) at 2000 ppm/ L and zinc (as form of Zn EDTA, 12 % Zn) at 100 ppm/ L significantly increased pod length, number of seeds/pod, weight of 100 green seeds, fresh pods and dry seeds yields (ton/ fed.) of pea plants Master-B cv. under local environmental conditions of the two early summer seasons. **Kadam *et al.* (2016)** demonstrated that foliar spraying of different nutrients; (DAP) Diammonium phosphate (1.0 %), $MgSO_4$ (0.5 %), KH_2PO_4 (0.5 %), $FeSO_4$ (0.5 %), $ZnSO_4$ (0.5 %), Boric acid (0.2 %) recorded significantly increased on average each of pod length, pod breadth, pod weight, number of pods /plant, number of grains /pod, shelling percentage and green pods yield (q/ ha). The higher treatment was foliar sprays of (0.5 %) $MgSO_4$ followed by foliar sprays of 0.2 % boric acid of pea plants. **Mona and Karima (2019)** pointed out that fruit length, fruit diameter, fruit shape, fruit weight, number of fruits/plant, early and total yield (ton/fed.) were significantly influenced by foliar spraying with amino acid at 1000 ppm on squash plants under high temperature conditions. **Ismail and Fayed (2020)** mentioned that foliar spraying with naphthalene acetic acid (NAA) at the rate of 0.6 g / L, potassium silicate at the rate of $3cm^3$ / L, boron at the rate of 1.5 g / L, zinc at the rate of 1.5 g / L and (zinc+ boron) at the rate of (1.5+1.5) g / L. significantly enhanced dry seed yield and its components *i.e*. number of seeds/ dry pod, seed weight/ dry pod (g), seed index 100 seeds weight (g), seed yield (g/plant) as well as seed yield (kg / fad) as compared to the control treatment (tap water) on broad bean plants. **Muhsen and Jasim (2022)** found that foliar spraying with boron (ethanolamine boron 11 %) at the rate of 2 mg/ L, potassium silicate (a water solution of 35 % $K_2O.4SiO_2$ and 12 % K_2O) at the rate of 3 mg/ L and amino acids (aminoacids, free amino acids: 24.8 %) at the rates of 3 mg/ L, showed significant effect on number of pods, 300 seeds weight (g) and dry seeds yield (ton/ ha.) of pea plant. **Naz *et al*. (2022)** decided that days to first pod formation, number of pods/ plant, fresh weight of pods/ plant (g), dry weight of pods/ plant (g), pod length (mm) and number of seeds/ pod, 100 seeds weight (g) of pea plants were significant increased with foliar application of three micronutrients *i.e.* zinc sulphate ($ZnSO_4$), copper sulphate (Cu_2SO_4) and boric acid (H_3BO_3) were sprayed alone as well as in combinations, each at the level of 3 mg/ L.

3-Chemical composition of pea dry seeds:

Data on the effect of foliar application with some stimulative substances treatments on pea plants subjected to heat stress conditions on some chemical constituents of dry seeds *i.e.* nitrogen, phosphorous, potassium and crude protein as well as carbohydrates content % are presented in **Table (7)**, data obviously showed that all foliar application treatments led to significant increases in N, P, K and crude protein as well as carbohydrates content %. The results generally reached that pea plants which received kaolin at 20 g /L followed with selenium element at 12 mg/ L and green miracle at 3 cm^3/ L recorded the highest values of N, P, K and crude protein as well as carbohydrates content % of pea dry seeds than the other treatments or the control, as a general trend in the both seasons.

Regarding to the enhancing results of chemical composition of dry pea seeds with foliar spraying by using kaolin treatment on pea plants under high temperature stress conditions may be due to that, silicon deposited in plant tissues helps to alleviate water stress by decreasing transpiration and improves light interception by keeping leaf blade erect in position and subsequent increasing photosynthetic pigments activity with an indirect action. Silicon reduced leaching of nitrogen, phosphorous and potassium lead to increases in minerals uptake and improved soil texture. For silicon influence, the increment of vegetative growth, yield and mineral content parameters may be as a result of the silicon role in enhancing transpiration and stomatal conductance, photosynthetic efficiency, net CO_2 assimilation rate, antioxidant capacity and improving plant cells water **(Pavlovic *et al*., 2021)**.

Concerning the favorite results of chemical composition of pea dry seeds with foliar spraying by green miracle on pea plants under high temperature stress conditions may be due to the possible effect of amino acids on root development and function **(Halpern *et al*., 2015)** can be the reason for improving nutrient content in pea dry seeds, which was reflected in total plant production and quality in the current study.

Table (7): Chemical constituents of dry pea seeds as affected by foliar spraying with different stimulative substances during the two winter seasons of 2020/2021 and 2021/2022.

Treatments	Nitrogen (%)		Phosphorous (%)		Potassium (%)		Crude protein (%)		Carbohydrates (%)	
	1st Season	2nd Season	1st Season	2nd Season	1st Season	2nd Season	1st Season	2nd Season	1st Season	2nd Season
Control	2.88	2.91	0.561	0.574	1.11	1.23	18.00	18.18	13.7	14.3
Green Miracle	3.64	3.74	0.853	0.876	1.74	1.78	22.75	23.37	17.4	17.7
Kaolin	3.86	3.92	0.975	0.982	1.91	1.96	23.93	24.50	18.4	18.6
Selenium	3.77	3.86	0.914	0.942	1.83	1.90	23.56	24.12	17.9	18.1
Megacal Hort	3.21	3.44	0.647	0.687	1.34	1.48	20.06	21.50	15.4	15.8
Super Grow Hortic	3.51	3.62	0.741	0.756	1.61	1.77	21.93	22.62	16.8	17.1
High Harvest	3.42	3.57	0.689	0.714	1.47	1.53	21.37	22.31	16.3	16.8
L.S.D. at 0.05	**0.08**	**0.06**	**0.042**	**0.031**	**0.04**	**0.03**	**0.32**	**0.27**	**0.3**	**0.4**

Corresponding the pronounced promotional effect of foliar application with kaolin and green miracle treatments, the previous findings coincided with **Abdel-Aziz (2007)** who pointed out that foliar application of the raw silicon and sodium meta silicate at a rate of 1 g/ L of each other occurred an increment in nitrogen, phosphorus and potassium content (%) of tomato leaves under high temperature stress conditions. **Kamal (2013)** reported that spraying kaolin at a rate of 4 % and potassium silicate at a rate of 1.5 kg/ fed. significantly enhanced N, P and K (%) uptake of sweet pepper plants in both seasons. **Abdel-Aziz and Geeth (2017)** illustrated that foliar spraying pea plants with the green miracle at a rate of 3 cm^3 / L was the best stimulant substance markedly improved nitrogen, phosphorus and potassium content of pea. Additionally, **Abdel-Aziz and Geeth (2018)** mentioned that foliar applications with kaolin at the rate of 20 g/ L led to obtain the highest values of chemical composition contents of sweet pepper *i.e.* total sugars, proline (mg/g), N, P and K (%). **Ahmed *et al.* (2019)** found that Kaolin at the rate of 2 % and green miracle at the rate of 3 cm^3/ L had a significant increase in squash chemical constitutes of nitrogen, phosphorus and potassium percentage during the both seasons as compared with the control treatment especially under dry conditions. Furthermore, **Ismail and Fayed (2020)** indicated that foliar spraying with the green miracle at the rate of 3 cm^3/ L was among best stimulant substance, since, markedly improved nitrogen, phosphorus, potassium and crude protein content of broad bean dry seeds.

Concerning the favorable effect of foliar spraying with selenium element under heat stress conditions, many reports suggested that foliar spraying of selenium can stimulate the growth and improve the photosynthesis rate. In this respect, selenium supplement increased the osmotically active molecules such as total free amino acids and protein. Also, selenium enhances the uptake of nutrients as well as it increases starch accumulation in chloroplasts and improves the root activity and consequently stimulates water uptake **(Feng *et al*., 2013)**. It could be concluded that selenium application on pea plants increased total carbohydrates and protein as well as enhanced the mineral compositions in dry seeds, the results supported with **Abdel-Aziz and Geeth (2017)** verified that foliar spraying pea plants with selenium at a rate of 10 mg/ L significantly increased N, P, K and protein in dry seeds (%) under cold stress conditions for two peas cultivars *i.e.* Entsar 1 and Master B. **El-Sawy *et al.* (2019)** concluded that foliar application using Nano bio-selenium at 30 ppm, mineral selenium at 40 ppm and ascorbic acid at 200 ppm produced the highest significant values of nitrogen, phosphorus and potassium content both in dry seeds and leaves on pea as compared to the control treatment.

On the contrary, **Chuntao *et al.* (2022)** revealed that spraying pea sprouts with selenium at the concentrations of 0.625, 1.25 and 2.5 mg/ L were significantly superior in the soluble sugar, fructose, glucose and soluble protein contents mg/ g fresh weight as compared with control treatment (pure water). Also, **Wathiq *et al.* (2022)** elucidated that the highest significant values of nitrogen, phosphorus and potassium % content were obtained with selenium at the rates of 20, 10 and 30 µmol, respectively in common bean leaves and seeds.

As regard to the effect of Megacal Hort, Super Grow Hortic and High Harvest as foliar spraying, the direction of these results is confirming by **Shokr and Abdelhamid (2009)** mentioned that foliar application of vitamins C at 250 ppm/ L, E (α–Tocopherol) at 150 ppm/ L, calcium (as form of Ca-citrate, 25 % Ca) at 2000 ppm/ L and zinc (as form of Zn EDTA, 12 % Zn) at 100 ppm/ L significantly increased reduce and none-reduce sugars (mg/100 g fresh weight) of pea plants cv. Master-B under local environmental conditions of the two early summer seasons. **Mona and Karima (2019)** proposed that the highest significant values of nitrogen, phosphorus and potassium % content of leaves obtained by foliar spraying with amino acid at 1000 ppm on squash plants under high temperature conditions. Moreover, **Ismail and Fayed (2020)** referred that foliar spraying with naphthalene acetic acid (NAA) at the rate of 0.6 g / L, potassium silicate at the rate of $3cm^3$ / L, boron at the rate of 1.5 g / L, zinc at the rate of 1.5 g / L and (zinc+ boron) at the rate of (1.5+1.5) g / L. significantly enhanced nitrogen, phosphorus and potassium and crude protein content (%) in dry seeds of broad bean as compared to the control treatment (tap water).

4- Seed germination tests:

It can be mentioned that the quality of pea dry seeds produced from plants sprayed with kaolin at 20 g/ L followed with selenium element at 12 mg/ L and /or green miracle at 3 cm^3/ L were enhanced in terms of germination ratio (%), germination rate (days) and sprout length (cm). Data in **(Table 8)** illustrated that all seed quality terms recorded the highest values in both seasons compared with the other treatments or the control. Generally, it could be stated that, germination ratio (%), germination rate (days) and sprout length (cm) of pea were greatly enhanced where the plants sprayed with kaolin at 20 g/ L followed with selenium element at 12 mg/ L and /or green miracle at 3 cm^3/ L as than the control (untreated plants). These obtained results were in conformity with those of **Marcela *et al.* (2018)** detected that spraying pea plants with selenium concentration of 50 $mg.dm^{-3}$ affected significantly germination %.

Table (8): Germination ratio (%), germination rate (days) and sprout length (cm) of pea plants as affected by foliar spraying with different stimulative substances during the two winter seasons of 2020/2021 and 2021/2022.

Treatments	Germination ratio (%)		Germination rate (days)		Sprout length (cm)	
	1st Season	2nd Season	1st Season	2nd Season	1st Season	2nd Season
Control	77.3	78.4	3.90	3.96	22.4	23.8
Green Miracle	85.1	85.6	2.88	2.81	31.8	32.4
Kaolin	89.1	90.1	2.36	2.28	34.8	35.1
Selenium	87.4	87.7	2.64	2.57	33.1	33.5
Megacal Hort	80.4	81.6	3.42	3.33	25.9	27.2
Super Grow Hortic	83.7	84.1	3.04	3.14	30.4	30.7
High Harvest	81.6	82.3	3.11	3.07	27.8	39.3
L.S.D. at 0.05	**1.6**	**1.14**	**0.07**	**0.08**	**1.22**	**1.48**

Also, **Ahmed *et al.* (2019)** reported that Kaolin at the rate of 2 % and green miracle at the rate of 3 cm^3/ L had a significant increase in germination ratio (%) of squash dry seeds during the both seasons as compared with the control treatment especially under dry conditions. Also, **Ismail and Fayed (2020)** recorded that sprayed broad bean plants with green miracle at the rate of 3 cm^3/L was the best treatment to obtain the highest values of germination ratio (%), germination rate (days) and sprout length (cm) in dry seeds.

CONCLUSIONS

As a general recommendation from this study it can recommended that, foliar spraying pea plants with kaolin (Aluminum silicate) at 20 g/ L followed with selenium element at 12 mg/ L and green miracle at 3 cm^3/ L were the superior treatments to obtain the maximum values of the vegetative growth, total green pods (ton/ fed.), dry seeds yields (kg/ fed.), its components as well as some chemical constituents of dry pea seeds which the treatments applied after 15 days from sowing date and were repeated every 10 day intervals at three times during the growth period of the two winter seasons, respectively.

Results of this study highlighted the role of the kaolin closely followed by selenium element as well as green miracle treatments on pea plants Master B cv. for alleviating the pad effects of high temperature stress conditions especially in the earlier planting date *i.e.* at the middle of September in the two winter growing seasons.

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