Foliar application of triacontanol and salicylic acid improves the performance of peas grown in the summer season

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ABSTRACT

Summer production of pea is significantly low because pea is an essential winter season vegetable crop. Therefore, there is a dire need to explore novel strategies to increase the production of pea in the summer season. Triacontanol is a plant growth promoter that is well-known to increase crop production. Salicylic acid is the most widely recognized plant growth regulator against abiotic stresses. Hence the current research was conducted to study the effect of triacontanol levels (control, 25, 50, 75 uM L^{-1}) and salicylic acid concentrations (control, 75, 150, and 225 mg L^{-1}) on the performance of peas (cultivar Climax) grown in the summer season. The research was carried out in Randomized Complete Block Design (RCBD) having two factors and three replications. Maximum plant height, primary branches $plant^{-1}$, number of leaves $plant^{-1}$, leaf chlorophyll content, number of pods $plant^{-1}$, seeds pod^{-1}, pod length, and yield ha^{-1} were recorded in plants treated with 50 µM L^{-1} triacontanol. Regarding salicylic acid concentrations maximum plant height, primary branches $plant^{-1}$, number of leaves $plant^{-1}$, leaf chlorophyll content, number of pods $plant^{-1}$, seeds pod^{-1}, pod length, and maximum yield ha^{-1} were recorded in 225 mg L^{-1} of salicylic acid concentration. The interaction effects reported best results at the Triacontanol level of 50 µ M and Salicylic acid concentration of 225 mg L^{-1} for the studied attributes. It is concluded that pea cultivar Climax treated with 50 µM L^{-1} triacontanol concentration and 225 mg L^{-1} salicylic acid concentration could be grown for better growth and yield in the summer season in the agro-climatic conditions of Peshawar.

KEYWORDS: Triacontanol, Salicylic acid, Climax, Yield, *Pisum sativum*, summer.

1. Introduction

Pea is belonging to the family leguminacea and is botanically known as *Pisum sativum L*. Peas are cool winter season vegetable generally grown in cool season to get various types of edible seed and seedpods (Elzebroek and Wind, 2008). In Pakistan, many varieties of peas are grown but the climax variety is very famous for late sowing. It gives more production in the later months i.e. March to April and can tolerate a little higher temperature but not too much warmer temperature. In Pakistan, it is grown in many areas. In plain areas, peas are grown in winter, while in hilly areas it is grown in summer (Khitchi *et al.,* 2016). When peas are harvested then plants are also used for animal feeding (Acıkgoz *et al.,* 1985). The area occupied by pea is 528.71 thousand hectares in the world with an annual production of 441.53 thousand tons, while in Pakistan pea is grown under 10 thousand hectares of the area which produce 82 thousand tons (Ashraf *et al*., 2011). Peas maintain blood sugar levels and keep them normal (Dahal *et al.,* 2014). In hundred grams of pea 7.2 g protein, 139 IU vitamin A, 14.5-gram carbohydrates, 9 mg vitamin C, 139 mg phosphorous and 20 mg calcium is present.

Triacontanol is a plant growth promoter found in epicuticle waxes which is well-known to increase crop production. Mostly used for the appropriate growth of rice, wheat, peanut, cotton, tea, sugarcane, tobacco, vegetables, and fruits. It is the primary alcohol of a long 30-carbon chain [CH3 (CH2)28 CH2OH], extracted from the waxes of plants and used for positively improving plant production (Skogen *et al*., 1982). It has been identified that triacontanol can improve both the qualitative and quantitative characteristics of plants (Ries and Wert, 1988). Triacontanol enhanced the growth of many plants and promoted the physiological activities of the plant in different mechanisms. It plays role in the improvement of physicochemical characteristics in various crops. Triacontanol affects the taste, color, size, and shape of the plant for better quality and quantity of plants and increases cell growth in roots. It is used to produce thicker foliage. It also helps plants to uptake nutrients and water. It can increase crop yield up to 40% by improving nutrient availability and promoting chlorophyll pigments (Khandaker *et al.,* 2013).

Salicylic acid is a plant growth regulator and regulates various functions in plants such as vegetative growth, photosynthesis, thermogenesis¸ thermogenesis, bud formation, seed germination, and senescence. In plants' defense salicylic acid is an important component. When plants are grown in abiotic strains such as heat, drought, salinity, heavy metals and cold stress then plants performance is negatively affected. When salicylic acid is applied to such plants grown in stress then it activates several defensive enzymes in the plants which mediate the negative effects of such particular stresses. Salicylic acid not only mediates the negative effects of the stresses but also promotes plant growth and yield (War *et al.,* 2011). It is also used as a food preservative and bactericidal. It is reported that salicylic acid is naturally found in some plants and plays a key role in the development of plants (Raskin, 1992). It is used as a foliar spray on plants both under normal and stress conditions to improve crop productivity (Pancheva *et al.*, 1996). Salicylic acid not only improves plant growth and production but also enhances the resistance of plants to the pathogen (Enyedi *et al.*, 1992; Durner, *et al.* 1997).

The present study was carried out to investigate the role of triacontanol and salicylic acid on the performance of pea grown in the summer season. It is worth mentioning that this research is among the first studies to consider the combined effect of triacontanol and salicylic acid on the performance of vegetables in Pakistan.

2. Materials and methods

2.1 Experimental site and procedure:

The research entitled "foliar application of triacontanol and salicylic acid improves the performance of peas grown in summer season" was performed at Horticulture Research Nursery, Department of Horticulture, The University of Agricultural Peshawar in 2020. The research was planned in Randomized Complete Block Design (RCBD) having two factors replicated three times. Two factors i.e. triacontanol (0, 25, 50, and 75 µ ML^{-}) and salicylic acid levels (0, 75, 150, and 225 mg L^{-1}) were tested in this research. Distances between rows were 50 cm while distances between plants were kept 20 cm. Climax variety of pea was used in this research. Phosphorus and potassium @ 50 25 kg ha^{-1} and nitrogen @ 25 kg ha^{-1} in two split doses were applied. Foliar application of triacontanol was sprayed after one month of sowing of peas climax seeds. Foliar application of salicylic acid was applied at a stage of one month of cultivation of pea's seeds in a field.

2.2 Triacontanol solution preparation

Triacontanol powder of 12 mg was dissolved in 1000 ml of distilled water to make 25 µM L^{-1} triacontanol solution. For 50 µM L^{-1} triacontanol solution preparation, 24 mg triacontanol powder was dissolved in 1000 ml of distilled water to make 50 µM L^{-1} triacontanol solution. Similarly, for 75 µM L^{-1} triacontanol solution preparation dissolved 36 mg triacontanol powder was dissolved in 1000 ml of distilled water to make 75 µM L^{-1} triacontanol solution. Before the solution preparation triacontanol was dissolved in 5 ml ethanol and then dissolved in distilled water because triacontanol is not easily soluble in distilled water.

2.3 Salicylic Acid Solution Preparation

Salicylic acid powder of 75 mg was dissolved in 1000 ml of distilled water to make 75 mg L^{-1} salicylic acid solution. For 150 mg L^{-1} salicylic acid solution preparation 150 mg salicylic acid powder was dissolved in 1000 ml of distilled water to make 150 mg L^{-1} salicylic acid solution. Similarly, for 225 mg $L^{-1,}$ salicylic acid solution 225 mg salicylic acid powder was dissolved in 1000 ml of distilled water to make 225 mg L^{-1} salicylic acid solution.

2.4 Morphological parameters

Plant height (cm) (measured for five randomly selected plants in each replication from the base to the top of the plant using a measuring tape), Number of primary branches plant^{-1}, Number of leaves plants^{-1}, Number of pod plant^{-1}, Pod length (cm), Total seed per pod, and Yield ha^{-1}(kg).

2.5 Biochemical parameters

Leaf chlorophyll content (SPAD) (It was determined with spade meter for five randomly selected leaves in each treatment and each replication). Poly phenol Oxidase Activity (The PPO activity was estimated by following the methodology of Jiang et al. (2002) with slight modification). Ascorbate Peroxidase Activity (APX activity was recorded by the Asada (1992) method).

2.6 Statistical Analysis

To find the difference between treatments and their interactions the experimentally recorded data were analyzed with Statistical software STATISTIX 8.1 for calculating ANOVA and LSD at a 1 % level of significance (Steel *et al.*, 1997).

3. Results

3.1 Plant Height (cm)

The data analysis (Table 1) showed that the plant height of pea was significantly affected by different levels of triacontanol and salicylic acid and their interaction was found significant (Fig: 3). The highest plant height (62.03cm) was found in plants applied with 50 μM L^{-1} triacontanol concentration, while minimum plant height (54.33 cm) was found in 75 μM L^{-1} triacontanol concentration which is followed by (55.32 cm) at 25 μM L^{-1} concentration. In the case of salicylic acid levels, maximum plant height (71.72 cm) was noted in plants applied with 225 mg L^{-1} salicylic acid concentration, while minimum plant height (46.25 %) was found in control plants. The combined effect of triacontanol and salicylic acid concentrations showed that maximum plant height (78.44 cm) was noted in plants sprayed with 50 μM L^{-1} triacontanol and 225 mg L^{-1} salicylic acid concentration, while minimum plant height (42.99 cm) was observed in control plants. The plant height of peas was significantly enhanced by triacontanol and salicylic acid concentrations.

3.2 Number of primary branches plant^{-1}

The results presented in Table 1 indicated that there is a significant difference between triacontanol and salicylic acid levels alone and in their interaction (Fig 3). The maximum number of primary branches (2.96) was found in plants applied with 50 μM L^{-1} triacontanol concentration, while minimum primary branches (1.78) were found in the control treatment. Compared with the means of triacontanol, the maximum number of primary branches (3.68) was noted in plants applied with 225 mg L^{-1} salicylic acid levels, while minimum primary branches (1.30) were found in control plants. The interaction of triacontanol and salicylic acid concentration revealed that the maximum number of primary branches (4.90) was noted in plants sprayed with 50 μM L^{-1} triacontanol and 225 mg L^{-1} salicylic acid interaction, while minimum primary branches (42.99 cm) was observed in plants applied with 75 μM L^{-1} triacontanol and control treatment of salicylic acid.

3.3 Number of leaves plant^{-1}

It is obvious from Table 1 that there is a highly significant difference among the triacontanol levels, salicylic acid, and their interaction (Fig 3). Maximum leaves plant^{-1} (276.05) were noted in plants sprayed with 50 μM L^{-1} triacontanol concentration, while minimum leaves plant^{-1} (232.50) were found in plants applied with control treatment of triacontanol. In the case of salicylic acid concentrations, maximum leaves plant^{-1} (273.47) were recorded in plants sprayed with 225 mg L^{-1} salicylic acid level, while minimum leaves plant^{-1} (226.33) were noted in plants sprayed with control treatment of salicylic acid. The interaction of triacontanol and salicylic acid concentration revealed that maximum leaves plant^{-1} (309.44) were noted in 50 µM L^{-1} triacontanol and 225 mg L^{-1} salicylic acid concentration treated plants, while minimum leaves plant^{-1} (211.44) were noted in the control treatment.

3.4 Number of pods plants^{-1}

Variation in the number of pods plant^{-1} was observed in triacontanol and salicylic acid levels except for their interaction which had a non-significant influence on the number of pods plant-1 (Table 1). Maximum average pods plant^{-1} (50.16) were found in plants applied with 50 µM L^{-1} triacontanol concentration, while minimum pods plant^{-1} (33.66) were found in plants applied with control treatment of triacontanol concentration. Regarding salicylic acid foliar application, maximum pods plant^{-1} (52) were noted in plants treated with 225 mg L^{-1} salicylic acid level, while minimum pods plant^{-1} (28.83) were noted in plants treated with control treatment.

3.5 Pod length (cm)

Mean data revealed that pod length of pea was affected significantly by different triacontanol, salicylic acid concentrations and their interaction (Table 1, Fig 3). Average maximum pod length (12.52 cm) was found in plants applied with 50 µM L^{-1} triacontanol concentrations, while minimum pod length (7.99 cm) was found in plants applied with control treatment of triacontanol concentration. Data regarding salicylic acid concentrations, maximum pod length (10.91 cm) was noted in plants applied with 225 mg L^{-1} salicylic acid level, while minimum pods length (8.66 cm) was noted in plants applied with control treatment of salicylic acid. The combined effect of triacontanol and salicylic acid concentration determined that maximum pod length (14.33 cm) was noted in 50 µM L^{-1} triacontanol and 225 mg L^{-1} salicylic acid concentration sprayed plants, minimum pod length (6.88 cm) was noted in plants in the control treatment.

3.6 Seeds pod^{-1}

Variation in seeds pod^{-1} was observed in triacontanol and salicylic acid levels except for their interaction which had a non-significant influence on the number of seeds pod^{-1} (Table 1). Maximum seeds pod^{-1} (10.10) were noted in plants sprayed with 50 µM L^{-1} triacontanol concentration, while minimum seeds pod^{-1} (8.19 cm) were found in plants applied with control treatment of triacontanol which is followed by (8.66 cm) at 25 μM L^{-1} treatment. Regarding SA, maximum seeds pod^{-1} (10.60) were noted in plants sprayed with 225 mg L^{-1} salicylic acid level, while minimum seeds pod^{-1} (7.41) were noted in plants at control treatment of salicylic acid.

3.7 Yield ha^{-1} (kg):

Triacontanol, salicylic acid levels, and their interaction had resulted in significant differences in Yield ha^{-1} (Table 1, Fig 3). Maximum yield ha^{-1} (2655.8 kg) was observed in plants sprayed with 50 μM L^{-1} triacontanol concentration, while minimum yield ha^{-1} (1826.2 kg) was found in plants applied with control treatment of triacontanol concentration. Regarding Salicylic acid, maximum yield ha^{-1} (2363.7 kg) was recorded in plants sprayed with 225 mg L^{-1} salicylic acid concentration, while minimum yield ha^{-1} (1841.2 kg) was observed in the control treatment. Different triacontanol and salicylic acid concentrations revealed that maximum yield ha^{-1} (3018.3 kg) was found in 50 μM triacontanol and 225 mg L^{-1} salicylic acid concentration treated plants, while minimum yield ha^{-1} (1716.7 kg) was noted in plants sprayed with distilled water (control treatment).

3.8 Chlorophyll content (SPAD):

Table 1 revealed that the chlorophyll content of pea was noticeably affected by different triacontanol and salicylic acid levels and their interaction was noted significant. Maximum chlorophyll content (59.49 SPAD) was noted in 50 μM L^{-1} triacontanol treated plants, while minimum chlorophyll content (49.30 SPAD) was found in plants sprayed with control treatment of triacontanol concentration. Regarding SA, maximum chlorophyll content (54.84 SPAD) was noted in 225 mg L^{-1} salicylic acid level treated plants, while minimum chlorophyll content (48.87 SPAD) was noted in plants at control treatment of salicylic acid. The combined effect of triacontanol and salicylic acid levels revealed that maximum chlorophyll content (63.11 SPAD) was found in 50 μM L^{-1} triacontanol and 225 mg L^{-1} salicylic acid concentration treated plants, while minimum chlorophyll content (46.77) was noted in plants sprayed 75 μM L^{-1} triacontanol concentration and distilled water (control treatment) of salicylic acid.

3.9 Polyphenol oxidase activity (PPO):

Table 2 revealed that the polyphenol oxidase activity of pea was noticeably affected by different triacontanol and salicylic acid levels while their interaction was noted non-significant. Maximum polyphenol oxidase activity (0.035 O.D/g) was noted in 75 μM L^{-1} triacontanol treated plants, while minimum polyphenol oxidase activity (0.008 O.D/g) was found in plants sprayed with control treatment of triacontanol concentration. Regarding SA, maximum polyphenol oxidase activity (0.034O.D/g) was noted in 225 mg L^{-1} salicylic acid level treated plants, while minimum polyphenol oxidase activity (0.009 O.D/g) was noted in plants at control treatment of salicylic acid.

Table 1 Plant height, number of primary branches plant^{-1}, and number of leaves plant^{-1}, pod length, and total seeds pod^{-1}.

Treatments	Plant height	Number of Primary Branches plant^{-1}	Number of Leaves plant^{-1}	Pod Length	Total Seeds Pod^{-1}
Triacontanol Levels (uML^{-1})					
0 (Control)	55.63^{b}	1.78^{c}	232.50^{d}	7.99^{c}	8.19^{b}
25	55.32^{b}	2.07^{b}	250.69^{b}	9.10^{b}	8.66^{b}
50	62.03^{a}	2.96^{a}	276.05^{a}	12.52^{a}	10.10^{a}
75	54.33^{b}	1.98^{bc}	240.88^{c}	9.44^{b}	8.69^{cb}
Salicylic Acid Levels (mg.L^{-1})					
0	46.25^{d}	1.30^{d}	226.33^{d}	8.66^{d}	7.41^{d}
75	49.21^{c}	1.60^{c}	243.39^{c}	9.38^{c}	8.30^{c}
150	60.13^{b}	2.20^{b}	256.94^{b}	10.10^{b}	9.32^{b}
225	71.72^{a}	3.68^{a}	273.47^{a}	10.91^{a}	10.60^{a}
Factors					
Triacontanol Levels (T)	*	*	*	*	*
Salicylic-Acid Levels (SA)	*	*	*	*	*
T x SA	*	*	*	Ns	Ns

Means followed by different letters are significantly different at P≤0.05

Ns nonsignificant,

LSD least significant difference *P≤0.05

Table 2 Yield ha^{-1}, Leaf chlorophyll content, polyphenol oxidase activity and ascorbate peroxidase activity.

Treatments	Yield ha^{-1}	Leaf Chlorophyll Content	Polyphenol oxidase activity[1]	Ascorbate peroxidase activity
Triacontanol Levels (uML^{-1})				
0 (Control)	1826.2^{c}	49.30^{b}	0.008^{c}	1.009^{c}
25	1982.7^{b}	50.88^{b}	0.021^{b}	1.345^{b}
50	2655.8^{a}	59.49^{a}	0.031^{a}	1.446^{a}
75	2013.8^{b}	50.14^{b}	0.035^{a}	1.567^{a}
Salicylic Acid Levels (mg.L^{-1})				
0	1841.2^{d}	48.87^{d}	0.009^{c}	1.008^{d}
75	2069.4^{c}	51.95^{b}	0.022^{b}	1.346^{c}
150	2204.2^{b}	54.16^{a}	0.032^{a}	1.456^{b}
225	2363.7^{a}	54.84^{a}	0.034^{a}	1.568^{a}
Factors				
Triacontanol Levels (T)	*	*	*	*
Salicylic-Acid Levels (SA)	*	*	*	*
T x SA	*	*	*	*

Means followed by different letters are significantly different at P≤0.05

Ns nonsignificant,

LSD least significant difference *P≤0.05

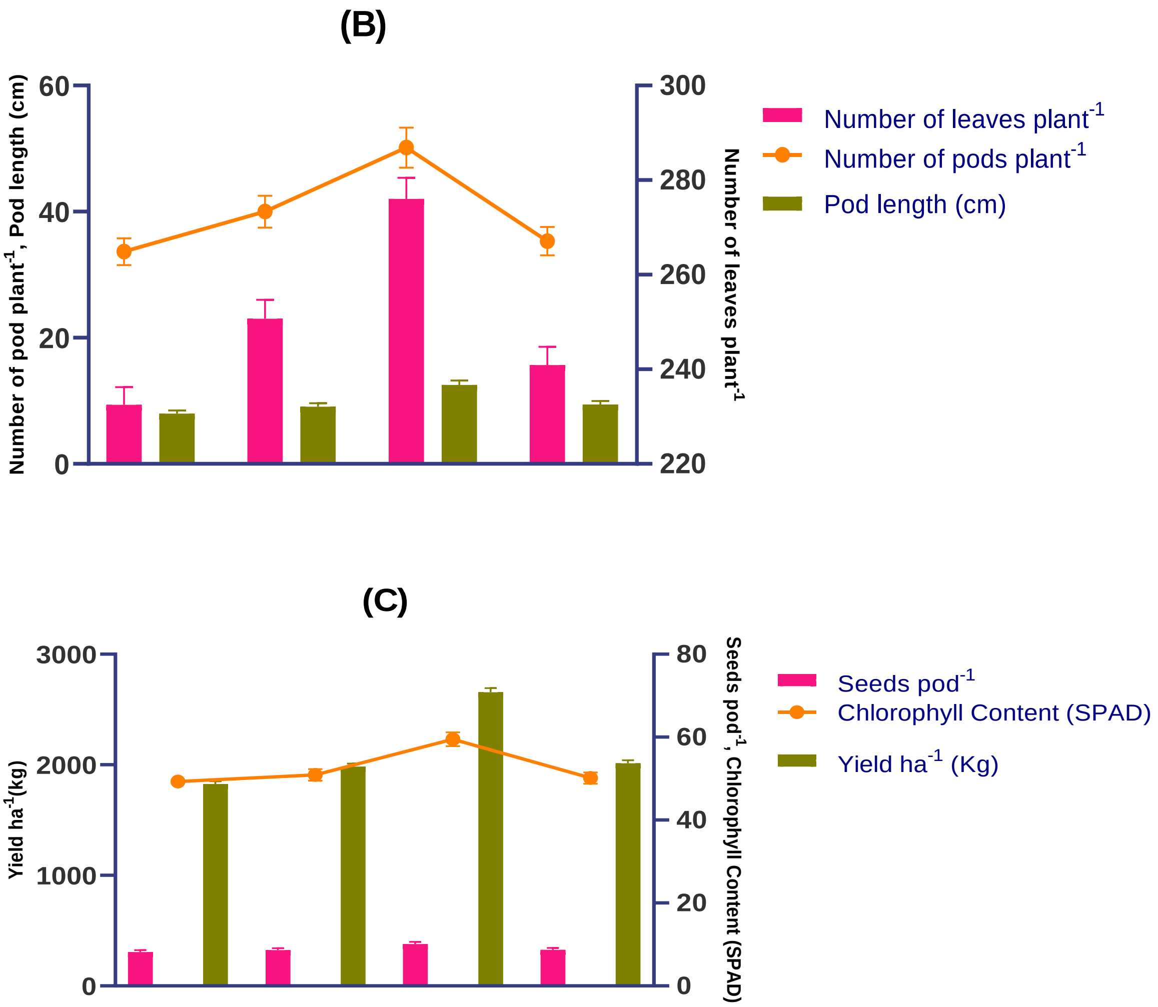


Figure 1. Growth and yield-related attributes of *Pisum sativum* as influenced by foliar application of Triacontanol.

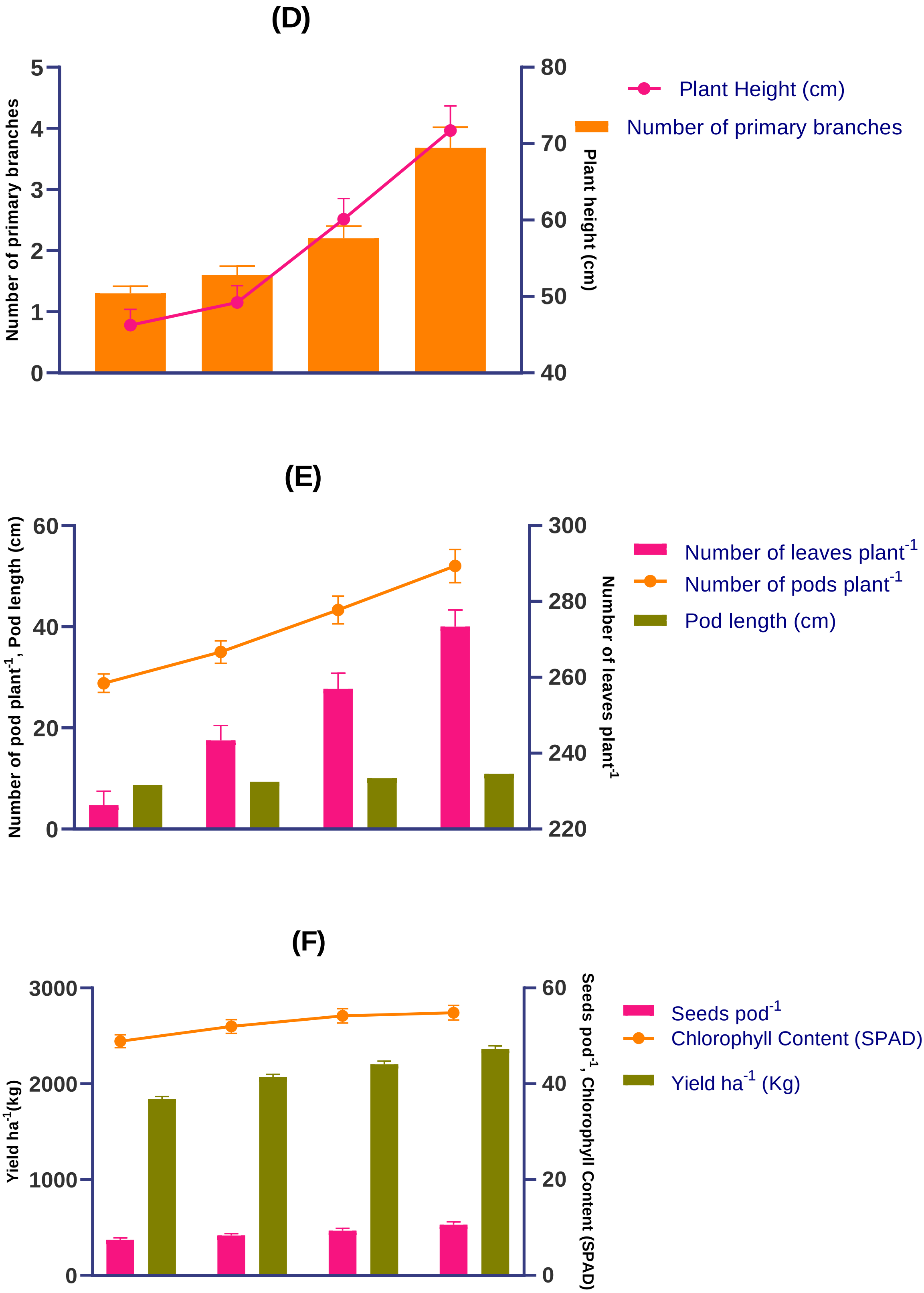
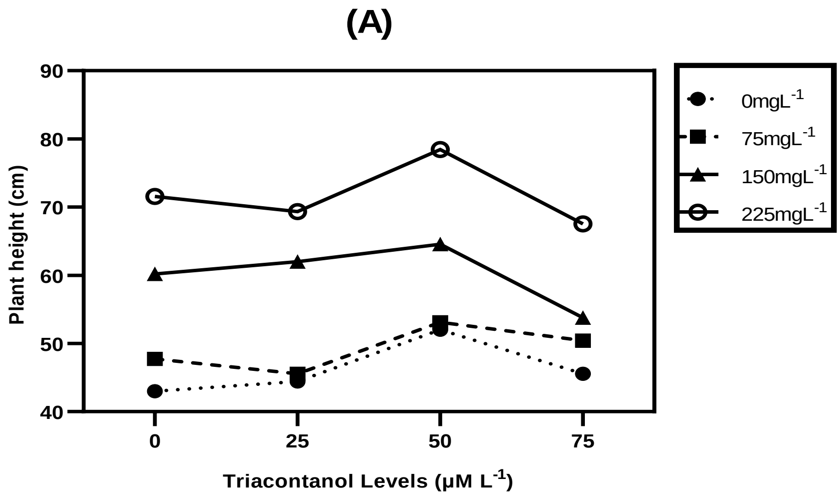
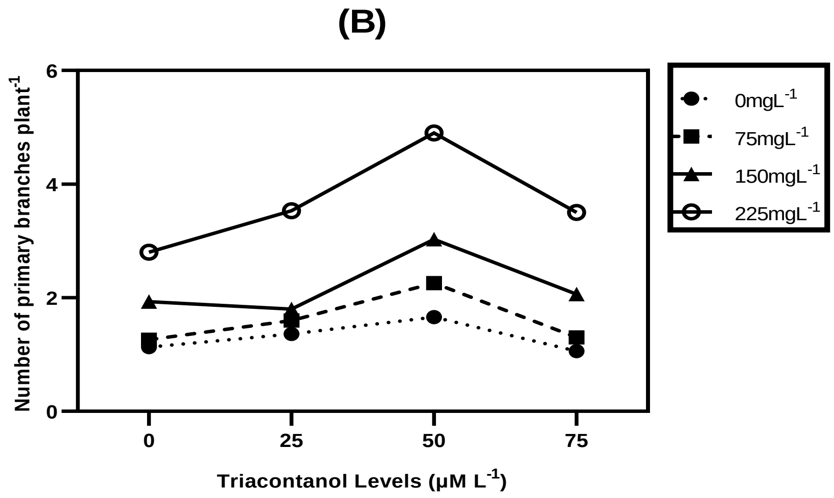
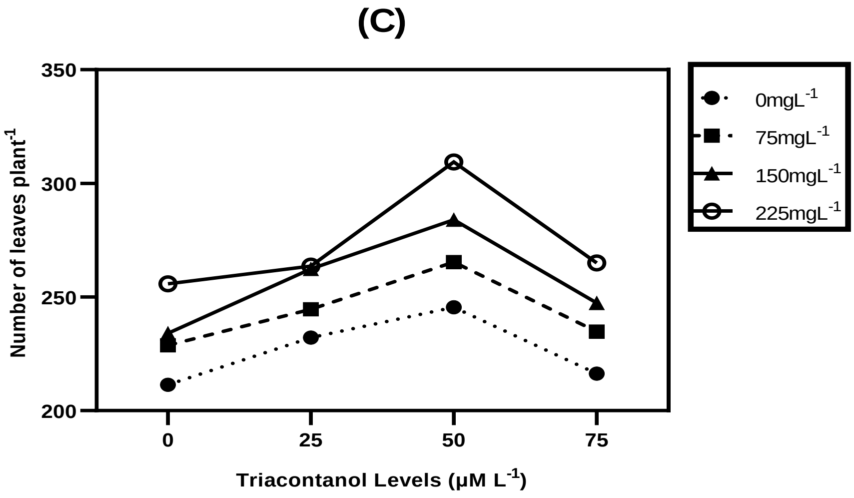


Figure 2. Growth and yield-related attributes of *Pisum sativum* as influenced by foliar application of Salicylic acid.


(A)
Plant height (cm)
90
80
70
60
50
40
0
25
50
75
Triacontanol Levels (μM L-1)
0mgL-1
75mgL-1
150mgL-1
225mgL-1


(B)
Number of primary branches plant-1
6
4
2
0
0
25
50
75
Triacontanol Levels (μM L-1)
0mgL-1
75mgL-1
150mgL-1
225mgL-1


(C)
Number of leaves plant-1
350
300
250
200
0
25
50
75
Triacontanol Levels (μM L-1)
0mgL-1
75mgL-1
150mgL-1
225mgL-1

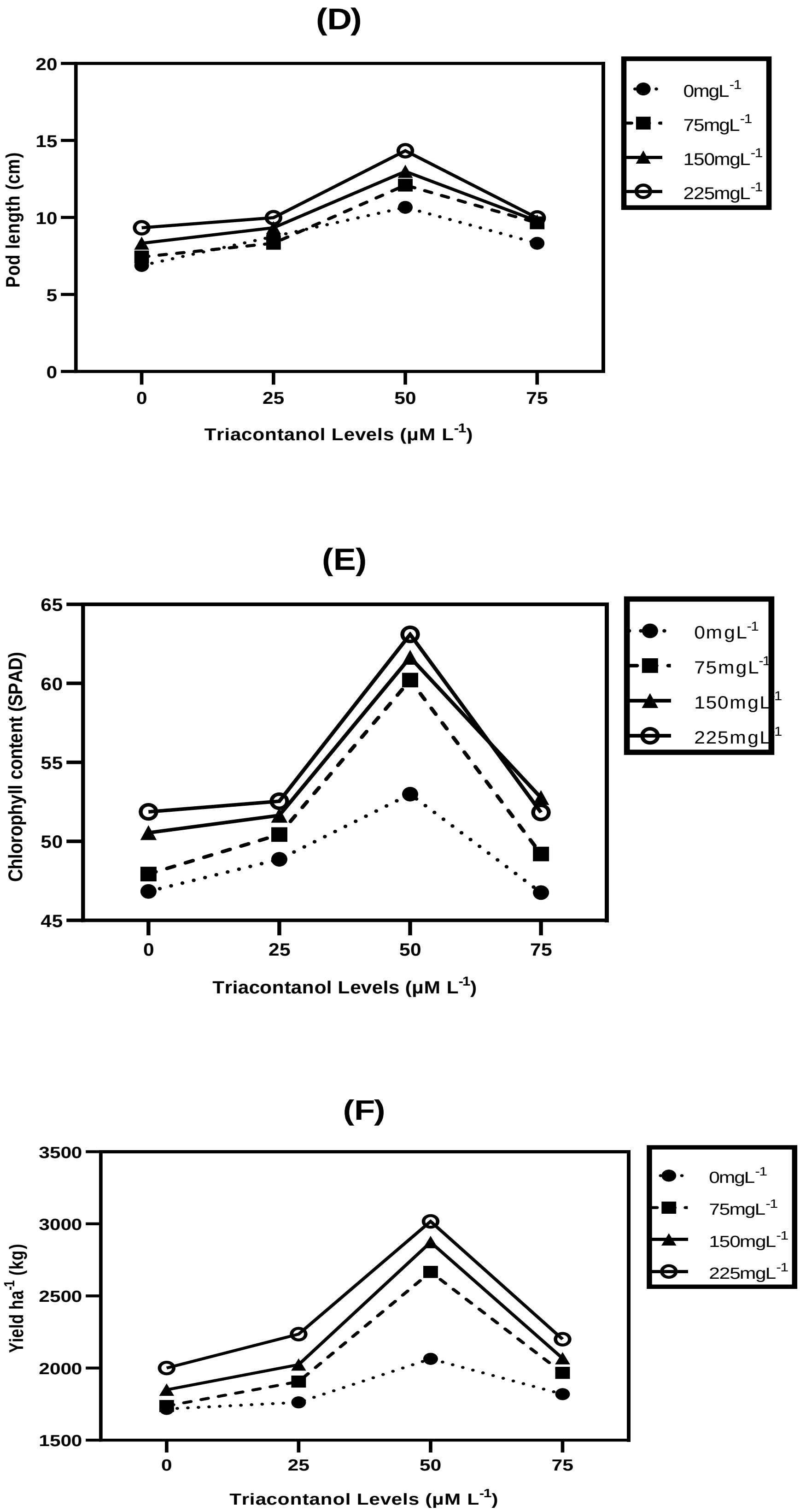


Figure 3. Growth and yield-related attributes of *Pisum sativum* as influenced by an interactive effect of Triacontanol and Salicylic acid.

4. Discussion

Triacontanol increased pea's plant height which could be attributed to the increase in the number of cells and cell division (Hangarter and Ries, 1978). Salicylic acid increased pea's plant height which might be due to increased nutrients available to the plants and thus pea's plants attained the height (Yildirim *et al.*, 2008). The results of the study are in agreement with Sitinjak and Pandiangan (2015) when conveyed that plant height of chocolate was increased when treated with triacontanol foliar application.Growth promoter triacontanol and salicylic acid significantly increased the number of primary branches in peas. Triacontanol-treated plants produced more branches which could be due to the increased rate of photosynthesis (Sahu *et al.*, 2017). Salicylic acid positively increased the pea's branches which might be due to increased transportation of nutrients to the plants (Davies, 2004). The findings are analogs with the findings by Singh *et al.* (2012) who also noted an increased number of branches in capsicum treated with triacontanol. The outcome of the present study is also in line with the discoveries of Abbasi *et al.* (2019) who explained that the number of branches of cucumber was increased with the application of salicylic acid.Leaves of pea were significantly increased by different levels of triacontanol and salicylic acid foliar application. It might be due to increased uptake of nutrients and water by the plants and increased rate of photosynthesis (Sharma, 1995; Hassoon and Abduljabbar, 2019). The outcome is supported by Miniraj and Shanmugavelu (1987), who used different triacontanol concentrations on chili plants and noted that triacontanol treated plants had more leaves when compared with untreated plants. The outcome is also similar to Mohamed *et al.* (2018) who applied salicylic acid on strawberries plants and reported that salicylic acid-treated plants had more leaves than control plants. Pod plant^{-1}of pea was significantly increased with different applications of triacontanol and salicylic acid. It might be due to the increase in the rate of photosynthesis and nutrient uptake and transportation of photosynthates to reproductive tissue (Naeem *et al.*, 2009; Kumar *et al.*, 1999). The outcome of the present study is supported by Kumaravelu *et al.* (2000), who reported that triacontanol treated green gram plants produced more pods. The findings are also similar to Kumar *et al.* (1997) who reported that numbers of pods of peas were increased with salicylic acid treatment.Pod length (cm) was significantly increased with triacontanol and salicylic acid levels. It might be due to the increased cell division and elongation (Sahu *et al.*, 2017). The findings are similar to Choudhary *et al.* (2006) who explained that the fruit volume of chilies was increased when treated with triacontanol. The outcomes are also in line with the findings of Khan *et al.* (2010) who explained that the pod length of mung bean increased with the application of salicylic acid.Seeds pod^{-1} of pea was significantly increased by different triacontanol and salicylic acid levels which may be attributed to enhanced phosphorus and potash levels which results in more number of seeds (Gnyandev *et al.,* 2019). The outcome of the experiment is supported by Radha Krishnan (2004) who used triacontanol on French bean and explained that seeds per pod in bean increased with the application of triacontanol. The values are also in a line with Rasheed (2018) who identified that salicylic acid-treated plants produced more seeds per pod when compared with untreated plants. Triacontanol and salicylic acid significantly increased the yield of peas. It could be attributed to the key enzyme activities regarding nitrogen metabolisms and transportation to the leaves (Kumaravelu *et al.,* 2000). The result of the present study is in line with Ries (1985) who found that triacontanol concentration increased yield in cowpea. The outcomes are also similar with Munne´-Bosch (2009), who used different salicylic acid applications to Arabidopsis and reported that salicylic acid increased yield in Arabidopsis. Triacontanol and salicylic acid showed positive effects on pea chlorophyll contents. Triacontanol enhanced the pea chlorophyll content which might be due to the biosynthesis of the several compounds present in the chloroplasts (Munne-Bosch and Alegre, 2001). It could also be attributed to salicylic acid which promotes the leaf area and hence increased the SPAD value (Souri and Tohidloo, 2019). The outcome of the experiment is supported by Miniraj and Shanmugavelu (1987) they reported that the chlorophyll content of chilies was increased by triacontanol. The findings are also in acceptance with that of Souri and Tohidloo (2019) according to them salicylic acid promoted the chlorophyll content of tomatoes by increasing its leaf area. Peroxidase is an important enzyme that works along with other enzymes to scavenge reactive oxygen species. It plays a key role during the formation of lignin, Triacontanol enhances the oxidation-reduction activity in the chloroplasts which is linked to the increased activity of the polyphenol oxidase enzyme (Egbart and Dana, 2008). Similar outcomes were also reported by Naeem *et al.,* (2009) who concluded that triacontanol stimulated polyphenol oxidase activity along with other enzymes in hyacinth bean (*Lablab purpureus* L.), hence causing improved plant defense system, nitrogen fixation, photosynthesis and better crop productivity. Several reports had stated that SA increased the activity of defence-related enzymes such as phenylalanine lyase and polyphenol oxidase (Qin et al., 2003; Cao et al., 2013; Ojaghian et al., 2013). Recent reports have also stated that the increase in disease resistance was directly associated with an increase in POD activity (Yu et al., 2008; Xu et al., 2008; Tareen et al., 2012). These studies are in line with those of Lee *et al.,* (1990) who stated the salicylic acid increase the polyphenol oxidase activity in Kinnow mandarin.

5. Conclusions

The use of plant growth regulators especially salicylic acid is essential for the efficient growth of pea in the summer season since it enables the pea plant to withstand the hot temperature. It was concluded from the results that the application of 50 µM L^{-1} triacontanol gave the best result in all the studied parameters as compared to other concentrations of triacontanol. Regarding salicylic acid foliar application, 225 mg L^{-1} gave the best outcome in all the studied parameters. Treatment of pea cultivar Climax with 50 µM L^{-1} triacontanol and 225 mg L^{-1} salicylic acid could be ideal to achieve better growth and yield in the summer season. Therefore, combined application of 50 µM L^{-1} triacontanol and 225 mg L^{-1} salicylic acid is highly recommended for pea cultivar Climax grown in the summer season in the agro-climatic conditions of Peshawar valley.

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