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Original Research

Effect of Salicylic Acid and Amino Acid on Pea Plant (*Pisum sativum*) Late Season, Growth and Production

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Abstract

Salicylic acid and amino acid are plant growth promoters. Therefore, the study entitled "Effect of salicylic acid and amino acid on late season peas growth and production" was conducted. The study has two factors: amino acid (Glycine) and salicylic acid each having four levels that were sprayed on peas. Analysis of data showed that maximum germination percentage (92.50 %), plant height (63.16 cm), primary branches plant^{-1} (2.80), leaves plant^{-1} (264.27), leaf chlorophyll content (57.25 SPAD), pods plant^{-1} (49.25), seeds pod^{-1} (10.41), pod length (11.74 cm) and yield ha^{-1} (1922.5 kg) having least days to flowering and pod formation (50.13 and 5.12 days) were noted in 225 mg L^{-1} amino acid. Salicylic acid levels showed that maximum germination percentage (95.83 %) height of plants (71.85 cm), leaves plant^{-1} (257.13), primary branches plant^{-1} (3.25), leaf chlorophyll content (55.81 SPAD),

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pods plant^{-1} (52.16), seeds pod^{-1} (10.91), pod length(11.05 cm) and yield ha^{-1} (1895.0 kg) having least days to pod formation and flowering (5.26 and 48.30 days) were noted in salicylic acid level of 300 mg L^{-1}. The combined effect of 225 mg L^{-1} amino acid and 300 mg L^{-1} salicylic acid levels positively improved primary branches plant^{-1} (3.93), pod plant^{-1} (66.33), pod length (13.77 cm), seeds pod^{-1} (12.44), leaf chlorophyll content (64.49 SPAD) and maximum yield ha^{-1} (1942.66 kg). It is concluded that for higher growth and yield pea cultivar Climax when cultivated late could be applied with 225 mg L^{-1} amino acid and 300 mg L^{-1} salicylic under Peshawar climatic conditions.

Keywords: salicylic acid, amino acid, season, peas, yield

Introduction

Pea belongs to the Fabaceae family it is a rich source of secondary metabolites and nutrients is required for the health of humans including vitamins C and E, minerals, β-carotene, flavonoids, phenol and organic acids [1]. Pea pods are very nutritive. It plays role in the control of heart diseases. It contains various antioxidants which help in the reduction of many diseases. It controls blood sugar levels because pea has a low glycemic index [2]. In the winter season, different vegetables are cultivated including pea. In Pakistan, peas are sown in mid-October. It produces flowers and pods in December. Pea is also grown in the summer season but only in hilly areas of Pakistan [3]. In a normal season which is sowing from mid-October to mid-November peas in Pakistan are sold cheaply with less profit. But when in the later month peas are not available in the markets. In the later months out of their normal season, it can be sold with more profit three or four times than the normal season. The other importance of the late sowing of peas is that it extends its market duration and is available for a longer period. Late sowing helps in the fresh availability of peas in the market. Peas are day-neutral crops and there is no impact of light and length of the day on their production [4].

Pea production in Pakistan is very low due several reasons. The use of conventional farming methods results in the low production of peas in Pakistan. Chemical fertilizer not only pollutes the environment but also leaches down and contaminates the groundwater table. The use of chemical fertilizer other than the optimum level also causes the burning effect. Organic fertilizers are used to increase the production of crops. It has no negative effects on the surrounding environment. Some organic fertilizers or substances are foliar sprayed on the crops and then absorbed by the plants through stomata. These organic substances activate several enzymes inside the plant's body which functions in the plant's growth and development [5].

Plant growth promotors are the substances that promote growth and are naturally present inside the plant's body. Some plants growth promoters are synthetically prepared. These substances are applied in different forms as some are applied as a foliar spray while others are in the soil. They also boost cellular activities. These organic substances play a role in the uptake of water and nutrients by plants. The rate of Photosynthesis increases with the application of organic substances to plants. Several enzymes are activated by the plant growth promoters responsible for the growth and development [6]. Pea is a very nutritive vegetable crop. In Pakistan, it contributes about 40 % in trading among pulses as it is an export and cash crop of the world. It is a leguminous crop and ranks 4th in production among other legumes. Peas are mostly grown in a cooler climate because it is a winter crop. It has a taproot system. It bears seeds in pods which are consumed as a vegetable. Their seeds are cooked and have high medicinal value [7].

Salicylic acid is an organic substance used to promote plant growth. It can be applied to plants as a seed treatment or can be foliar sprayed on the plants. When seeds are soaked in the salicylic acid solution then it is absorbed by the seeds and goes inside the seeds. Inside the seeds, it activates several enzymes in the seeds to germinate. When salicylic acid is foliar sprayed on the plants then it goes inside the plant body through stomata in leaves. Inside the plant body, it activates many enzymes such as phenylalanine ammonia-lyase, nitrite reductase, glucanase, etc which enhances plant growth. Whenever there is stress on the plant such as drought, salinity, or heat stress then provide signals to the plants by activating enzymes. It is a plant growth promoter and can be applied to plants in normal as well as in stress [8]. Amino acid is another plant growth promoter that helps plants to maintain their growth. It promotes the growth of the plant in stress conditions like heat stress, salinity, cold stress, etc. It plays a role in the translocation of nutrients from the source to the targeted tissues. These nutrients are prepared in the leaves through the photosynthesis process and then are translocated to the sinks. It activates several enzymes inside plant body due to which plants continue their growth in stressful conditions. It promotes plant growth [9].

Nutrient availability when low in the soil results in poor growth of the plants. Normal functions of plants are negatively affected by the limited nutrients in the soil. Amino acid are organic substances that enhance the nutrient uptake by plants [10]. High-temperature effects are also minimized by amino acid by regulating the opening and closing of stomata. When the temperature is too high than the optimum temperature

then it provides signals for stomata closing. It is the survival strategy so that no more water evaporated from the plants because during heat stress plants are suffering from both heat and limited water. When water is limited to plants the process of photosynthesis is affected because water has also a role in the process of photosynthesis and then plants cannot prepare their food therefore its growth and development slow down and it stops. When water availability completely stops to the plants then it causes the wilting of plants. So plant growth promotors play an important role so that plants can uptake more deeply water from the soil and continues their normal growth activities. The process is achieved by the activation of several enzymes inside the plant body by the plant growth promotor. Every enzyme has its specific functions inside the plant body. When enzymes get activated then plants keep their normal growth and developmental activities [11].

Materials and Methods

The study on the "Effect of salicylic acid and amino acid on late season peas growth and production" was accomplished at Horticulture Department Research Farm, Malakandair Peshawar.

Design of Experiment

A Randomized Complete Block Design (RCBD) with two factorial arrangement having sixteen treatment combination replicated thrice were used. Row-to-row and plant-to-plant distances were kept at 50 cm and 30 cm, respectively. The Climax variety was used in this experiment. Amino acid and salicylic acid levels were sprayed on plants after 30 days of germination and were applied once to the plants. Normally peas are sown in mid-October. In this experiment, peas were sown in the last week of January and were subjected to heat stress.

Results and Discussion

Germination Percentage

The effects of various concentrations of salicylic acid and amino acid were analyzed on germination percentage. The data table showed that that maximum germination percentage (95.83%) was found in 300 mg L^{-1} salicylic acid. Minimum germination percentage (73.33%) was noted in control plants. Regarding amino acid concentrations, maximum germination percentage (92.50%) was found in 225 mg L^{-1} amino acid treated plants. Minimum germination (76.25%) was noted in control treatment Table 1, 2.

Germination percentage of peas was considerably enhanced with the amino acid and salicylic acid concentration which might be due to its signaling role in promoting key enzymatic activities [12]. The consequences are alike with the experiment of [13] who described that germination percentage of *Arabidopsis* was increased with salicylic acid treatment. The findings are also in line with experiment of [14] who revealed that germination percentage of soybean was enhanced with amino acid application when compared with untreated plants.

Plant Height

The effects of various concentrations of salicylic acid and amino acid were analyzed on plant height. The data table showed that showed that tallest plants (71.85 cm) were found with spray of salicylic acid of 300 mg L^{-1} and smallest plants (45.34 cm) were noted in control plants. Regarding amino acid levels, highest plants (63.16 cm) were judged in 225 mg L^{-1} amino acid, and lowest plant (53.88 cm) was noted in control plants Table 1, 2.

Pea height was considerably improved with foliar treatment of amino acid and salicylic acid. Increased rate of photosynthesis increased the plant height of pea.

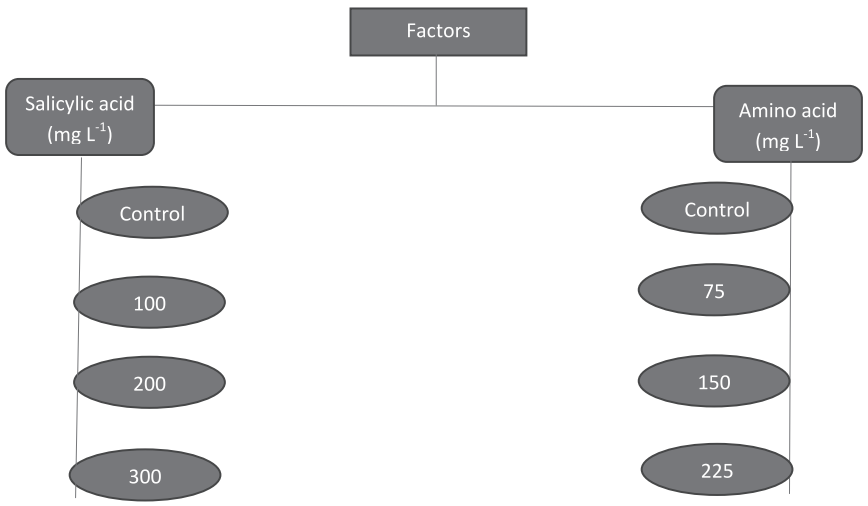

Fig. 1.The experiment design for the amino acid and salicylic acid response on Pea plant.

Plant height was also increased with salicylic acid which might be attributed to increased nutrients accessibility to the plants [15]. The conclusions of the experiment are alike with [16], who exposed that faba bean plant height was improved with foliar application of amino acid. The outcomes are also in line with [17] who described that when peas were grown in salt stress and was sprayed with reported with salicylic acid then its plant height was increased.

Number of Primary Branches Plant^{-1}

The effects of various concentrations of salicylic acid and amino acid were analyzed on number of primary branches plant^{-1}. The data table showed that highest primary number of branches (3.25) were in salicylic acid spray of 300 mg L^{-1}. And control plants showed least primary number of branches (1.39). Amino acid levels described that highest primary branches (2.80) were observed in 225 mg L^{-1} and lowest number (1.70) was shown by untreated plants. In case of salicylic acid and amino acid interaction, more primary branches (3.93) were shown by 300 mg L^{-1} salicylic acid and 225 mg L^{-1} amino acid level. And lower number of primary branches (1.03) was noted in control treatments Table 1, 2.

Amino acid and salicylic acid foliar spray had considerably enhanced number of primary branches in peas. Peas plants applied with amino acid increased the rate of photosynthesis and cell division and hence produced more branches [18]. Pea plants branches were also positively increased with salicylic acid which might be due to availability of nutrients to the plants [19]. The findings are supported by Kocira ([20] who also observed increased number of branches in soybean plants treated foliar application of amino acid. The consequences are also in analogue with [21] who determined that when cucumber plants were treated with salicylic acid then its branches were increased.

Days to Flowering

The effects of various concentrations of salicylic acid and amino acid were analyzed on days to flowering. The data table showed that more days to flowering (60.30 days) was found in control plants. And lowest days (48.30 days) were shown by salicylic acid with 300 mg L^{-1} spray. Regarding amino acid concentrations, highest days to flowering (58.94 days) was noted in control treatment. While lowest days to flowering (50.13 days) was noted 225 mg L^{-1} amino acid treated plants Table 1, 2.

Amino acid and salicylic acid levels considerably affected days to flowering of peas hence produced earlier flower which might be due to the increased rate of photosynthesis and florigen in the leaves. The results are sustained by [16] who explained that faba beans plants produced earlier flower when treated amino acid. The results are also in confirmation with the work performed by Singh and Usha [22], in their experiment they applied wheat plants with salicylic acid and observed that it produced early flower.

Days to Pod Formation

The effects of various concentrations of salicylic acid and amino acid were analyzed on days to pod formation. The data table showed that maximum days were taken in pod development (9.74 days) by control plants, while minimum days were taken (5.26 days) by foliar spray of salicylic acid with 300 mg L^{-1}. Concerning amino acid levels, highest days were taken in pod formation (9.86 days) by control treatment (those plants which were only sprayed with distil water), while lowest days (5.12 days) were taken by 225 mg L^{-1} amino acid treated plants Table 1, 2.

Amino acid and salicylic acid concentrations pointedly affected peas pod formation. Amino acid and Salicylic Acid treated plants enhanced early pod formation which might be due to the proper transportation of photosynthetic from sinks to the sources. Both amino acid and salicylic acid promoted the nutrients to plants hence earlier pod formation was achieved. The results are alike with [10] who observed that the snap beans lead to in earlier pods when applied with amino acid. The discoveries are stated that soybean plants caused in earlier pods when applied with salicylic acid.

Pods Plant^{-1}

The effects of various concentrations of salicylic acid and amino acid were analyzed on pods plant^{-1}. The data table showed that highest pods number per plant (52.16) were found in salicylic acid spray of 300 mg L^{-1} and lowest pods number per plant (27.58) were judged in untreated plants. Regarding amino acid concentrations, maximum pods plant^{-1} (49.25) were noted in 225 mg L^{-1} amino acid and lowest pods number per plant (30.83) were judged in control treatment. In case of salicylic acid and amino acid interaction, maximum pods plant^{-1} (66.33) were shown by 300 mg L^{-1} and 225 mg L^{-1} concentration of salicylic and amino acid and lowest pods plant^{-1} (21.33) were judged in un treated plants Table 1, 2.

Different concentration of amino acid and salicylic acid considerably enhanced pea pods which might be due to the increased nutrient uptake and its utilization that results in more flower and pod formation [23]. The consequences are identical with [24], who conveyed that when bean plants were sprayed with amino then its enhanced its pods and also showed similar findings because who sprayed peas with salicylic acid and observed increased in pods.

Pod Length

The effects of various concentrations of salicylic acid and amino acid were analyzed on pods length.

The data table showed that maximum pod length (11.05 cm) was observed in 300 mg L^{-1} salicylic acid and least pod length (8.08 cm) was noted in control plants. Regarding amino acid levels, maximum pod length (11.74 cm) was observed in 225 mg L^{-1} amino acid and least pod length (7.08 cm) was noted in control plants. In case of salicylic acid and amino acid interaction, enhanced length of pods (13.77 cm) were shown by 300 and 225 mg L^{-1} salicylic acid and amino acid level, while least length of pods (5.88 cm) were observed in no treatments Table 1, 2.

It was meaningfully enlarged by the foliar application of amino acid and salicylic acid levels which could be due to rapid division of cells inside the plant body along with cell elongation and increased number of seeds that enhanced the pod length [25]. The consequences of the experiment are alike with [26] who stated that pod length of green bean was improved with amino acid. The discoveries of present study are also similar with [26] who clarified that common bean pod length was enlarged with the foliar spray of salicylic acid.

Seeds Pod^{-1}

The effects of various concentrations of salicylic acid and amino acid were analyzed on pods length. The data table showed that highest seeds pod^{-1} (10.91) were found in salicylic acid spray of 300 mg L^{-1} and lowest seeds number per pod (7.13) were calculated in control treatment. Regarding amino acid concentrations, maximum seeds pod^{-1} (11.74 cm) were noted in 225 mg L^{-1} and lowest seeds number per pod (7.08 cm) were observed in no treatment. In case of interaction of both treatments, maximum seeds pod^{-1} (12.44) was observed in 300 mg L^{-1} salicylic acid and 225 mg L^{-1} amino acid, while lowest seeds number per pod (5.66) were found in no treatments.

Seeds pod^{-1} of pea was considerably enhanced by foliar spray of amino acid and salicylic acid. It may be due to enhanced phosphorus and potash levels and other nutrients [27]. The outcomes of the experiments are in agreement with [28] who used amino acid foliar spray on soybean and reported that seeds in soybean pods were increased with amino acid. The results are also alike with [29] who applied peas plants with salicylic acid and noted increased of seeds inside the pods.

Number of Leaves Plant^{-1}

The effects of various concentrations of salicylic acid and amino acid were analyzed on number of leaves plant^{-1}. The data table showed that highest number of leaves plant^{-1} (257.13) were found in 300 mg L^{-1} salicylic acid and least leaves plant^{-1} (213.72) was noted in control plants. Regarding amino acid concentrations, maximum leaves plant^{-1} (264.27) was noted in 225 mg L^{-1} amino acid and lowest (208.19) leaves were observed in no treatment Table 1, 2.

Pea leaves were considerably improved by various levels of amino acid and salicylic acid. It might be due to increase in root volume, length and surface which promotes the nutrients and water uptake [30]. The outcomes are in line with [31] who used different amino acid concentration on rice and explained that amino acid concentration increased rice leaves. The results are also alike to [32] who determined that salicylic acid concentration increased leaves in okra.

Table 1. Effect of different salicylic acid and amino acid levels on various parameters of peas production.

Treatments	Salicylic acid				Amino acid			
Parameters	Control	100 mg L^{-1}	200 mg L^{-1}	300 mg L^{-1}	Control	75 mg L^{-1}	150 mg L^{-1}	225 mg L^{-1}
Germination percentage	73.33^{C}	80.00^{BC}	87.91^{AB}	95.83^{A}	76.25^{c}	81.25^{bc}	87.08^{ab}	92.50^{a}
Plant height (cm)	45.34^{D}	53.05^{C}	58.96^{B}	71.85^{A}	53.38^{C}	54.63^{C}	58.03^{B}	63.16^{A}
Primary number of branches plant^{-1}	1.39^{D}	1.82^{C}	2.49^{B}	3.25^{A}	1.70^{C}	1.91^{C}	2.52^{B}	2.80^{A}
Number of leaves plant^{-1}	60.30^{A}	56.22^{B}	51.88^{C}	48.30^{D}	58.94^{A}	55.19^{B}	52.44^{C}	50.13^{C}
Days to flowering	9.74^{A}	8.42^{B}	6.45^{C}	5.26^{D}	9.86^{A}	7.87^{B}	6.72^{C}	5.12^{D}
Days to pod formation	27.58^{D}	34.00^{C}	43.6^{B}	52.16^{A}	30.83^{D}	35.16^{C}	42.16^{B}	49.25^{A}
Number of pod plant^{-1}	8.08^{D}	9.10^{C}	10.10^{B}	11.05^{A}	7.08^{D}	8.69^{C}	10.83^{B}	11.74^{A}
Pod length (cm)	7.13^{D}	8.52^{C}	9.52^{B}	10.91^{A}	7.27^{D}	8.69^{C}	9.71^{B}	10.41^{A}
Total seeds pod^{-1}	213.72^{D}	227.33^{C}	242.86^{B}	257.1^{A}	208.19^{D}	225.86^{C}	242.72^{B}	264.27^{A}
Leafchlorophyll content (SPAD)	49.14^{D}	51.34^{C}	53.02^{B}	55.81^{A}	49.46^{C}	50.46^{C}	52.13^{B}	57.25^{A}
Yield ha^{-1} (kg)	1858.9^{D}	1876.3^{C}	1889.2^{B}	1895.0^{a}	1846.5^{D}	1851.6^{C}	1898.8^{B}	1922.5^{A}

LSD for both treatments at 1 and 5 % significance level.

Table 2. Represents the various plant parameters percentages on peas growth and production.

Parameters	Values	%
Germination percentage	8.81	1-5
Plant height (cm)	3.23	1
Primary number of branches plant^{-1}	0.32	5
Number of leaves plant^{-1}	2.59	1
Days to flowering	0.81	1
Days to pod formation	5.13	5
Number of pod plant^{-1}	5.13	5
Pod length (cm)	0.66	5
Total seeds pod^{-1}	5.41	1
Leaf chlorophyll content (SPAD)	2.39	1
Yield ha^{-1} (kg)	9.80	1

Leaf Chlorophyll Content

The effects of various concentrations of salicylic acid and amino acid were analyzed on chlorophyll content. The data table showed that highest chlorophyll contentment (55.81 SPAD) was found in plants sprayed with 300 mg L^{-1} salicylic acid and lowest chlorophyll contentment (49.14 SPAD) was noted in control plants. Regarding amino acid concentrations, maximum chlorophyll contentment (57.25 SPAD) was noted in 225 mg L^{-1} amino acid and least chlorophyll contentment (49.46 SPAD) was noted in control plants. In case of salicylic acid and amino acid interaction, maximum chlorophyll contentment (64.49 SPAD) was judged in 300 mg L^{-1} salicylic acid and 225 mg L^{-1} amino acid level and least chlorophyll contentment (46.16 SPAD) was noted in control treatments Table 1, 2.

Amino acid and salicylic acid significantly affected chlorophyll contents which might be due to biosynthesis chloroplasts and increased in leaf area [33]. The result of experiment is alike with whom reported that chlorophyll content of celeriac was increased with amino acid foliar application of The discoveries are also alike with [34] who explained that salicylic acid promoted the chlorophyll content of cucumber.

Yield ha^{-1} (kg)

The effects of various concentrations of salicylic acid and amino acid were analyzed on yield ha^{-1}. The data table showed that highest yield ha^{-1} (1895.0 kg) was found in 300 mg L^{-1}. And lowest yield ha^{-1} (1858.9 kg) was noted in no treatment. Regarding amino acid concentrations, maximum yield ha^{-1} (1922.5 kg) was noted in 225 mg L^{-1} amino acid and lowest yield ha^{-1} (1846.5 kg) was noted in control plants. In case of salicylic acid and amino acid interaction, maximum yield ha^{-1} (1942.66 kg) was shown by 300 225 mg L^{-1} salicylic and amino acid and lowest yield ha^{-1} (1831.66 kg) was noted in no treatments (Table 1, 2).

Both the treatments meaningfully improved yield. It might be because of the enzymatic actions that regulates uptakes of nitrogen [35]. The result is in agreement with [36] who found that amino acid increased yield in squash. The results are also alike with [37] they applied basil plants with salicylic acid and noted an increased its yield.

Conclusion

Results confirmed that, regarding of amino acid levels 225 mg L^{-1} showed best results. In case of salicylic acid levels 300 mg L^{-1} gave the best outcomes. Regarding interaction 225 mg L^{-1} amino acid and 300 mg L^{-1} salicylic acid significantly improved, primary number of branches per plant, pod per plant, pod length, seeds number per pod, chlorophyll content of leaf and yield per hectare.

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Conflict of Interest

All the authors declare having no conflict of interest.

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