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Growth, yield and quality of garden pea (*Passium Sativum* L.) as influenced by plant growth hormone at different growth stages

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Abstract
Purpose: Bangladesh is a populous country in the world. Almost 80% people suffer from malnutrition. It cannot meet its demand of vegetables in the country. It needs threefold increase of vegetable production to meet its demand. Growth regulators have serious effect on crop yield without imposing any deleterious effect on the environment and human health. Foliar application of NAA (Naphthalene acetic acid) found to increase in plant height, number of leaves per plant, fruit size, with consequent in seed yield in different crops (Lee, 1990) [30].
Research Method: The experiment consisted of two factors: Factor A: Four levels at different growth stage of garden pea viz. L_1: Two leaf stage, L_2: Four leaf stage, L_3: Six leaf stage and L_4: Full blooming stage. Factor B: Four levels of NAA viz. H_0: 0 ppm of NAA (control), H_1: 25 ppm, H_2: 50 ppm and H_3: 75 ppm. There were 16 treatment combinations. The experiment was laid out in Randomized Complete Block Design (RCBD) with three replications.
Findings: Results of the study showed that the treatment combination of L_3H_3 performs the highest yield of pod per plant (24.09 t ha^{-1}). So the combination of six leaf stage + 75 ppm NAA treatment is the suitable combination for the highest yield of garden pea cv. BARI Motorshuti-2.
Research Limitation: Limited availability of historical data was a constraint during the study.
Value: Further research works at different regions of the country are needed to be carried out for the confirmation of the present findings.

Keywords: garden pea, plant hormone, NAA, leaf stage, yield.

1. Introduction
Garden pea *(Pisum sativum L.)* is a widely spread legume crop belonging to the subfamily Papilionoideae under the family Leguminosae that are commonly sold and cooked as a fresh vegetables and dried form. It is grown throughout the world in nearly every climatic zone. It is a highly self-pollinated cold climate crop and can also be grown in tropical countries in the winter season. The crop is reported to perform better in sub-tropical areas having cold period of five month duration (Makasheva, 1983) [33]. Peas are a cool-season crop grown for their edible seed or seed pods. Different types of peas are grown for various purposes.
Garden or green peas are harvested before the seed is mature for the fresh or fresh-pack market (Elzebroek and Wind, 2008) [9].
Peas are a nutritious legume, containing 15 to 35% protein, and high concentrations of the essential amino acids lysine and tryptophan (Elzebroek and Wind, 2008) [9].
Peas are most productive at temperatures of 55 to 64^0F (Hartmann *et al*., 1988) [19]. High temperatures during flowering may reduce seed set (Elzebroek and Wind, 2008) [9], and high temperatures during seed development may cause an increase starch and fiber content, lowering pea quality (Hartmann *et al*., 1988) [19]. Pea can be grown in all types of soil. The sandy loams with clay sub-soil are generally preferred for earliness. It grows best in the soils having pH 5.5 to 6.7.
It contains a unique assessment of health protective poly nutrient coumestrol which protects stomach cancer. According to nutritional profile of garden pea it is an excellent source of 80 nutrients including vitamin C, vitamin E, omega-3 fat and a good amount of vitamin B1, B2, B3, B6 and loaded with anti-oxidant and anti-inflammatory nutrient and a strong fiber and protein content.
Like many other legume seeds, the fat content (ether extract) in pea seed is low ranging from 0.8 to 6.1%. Whole pea contains 37.5%

neutral lipid and 62.5% polar lipids while dehusked seed contains 40.9% neutral lipids and 59.1% polar lipids (Vose *et al.,* 1976). Approximately, 50 to 60% of total lipid content of pea is present in the neutral lipid fraction (Reichert and Mackenzie, 1982) [53]. Peas have relatively high concentrations of insoluble carbohydrates. Reichert (1981) [52] reported that high concentrations of insoluble carbohydrates like hemicelluloses 75.0, lignin 14.0, cellulose 688.0 and crude fiber 584 g/kg were present in pea. Pea is rich in the B group vitamins. Kubin and Fink (1961) [27] were able to extract 71 mg/kg total vitamin E from peas which consisted entirely of β- and γ-tocopherol. Germination causes increases in a number of vitamins (Vanderstoep, 1981) [69]. Robertson and Sissons, (1987) [54] showed that fresh peas contained between 150 and 310 mg vitamin C/kg. In cooked preserved pea, the vitamin C content 158 mg/kg followed by freeze dried peas 92 mg/kg. Peas satisfy adult human requirements for essential amino acid except sulphur containing amino acids (Holt and Sosulski, 1979) [20].

Bangladesh is a populous country in the world. Almost 80% people suffer from malnutrition. It cannot meet its demand of vegetables in the country. It needs threefold increase of vegetable production to meet its demand. People in Bangladesh consume 23 g vegetables per head per day but the minimum requirement is 200 g per head per day (Rashid, 1993) [49].

The crop has the capacity of fixing atmospheric nitrogen to the soil. Inclusion of peas in crop rotation helps in improvement of soil fertility and yield of the succeeding crops (Rana and Sharma, 1993) [48]. The biomass of garden pea can be used as cattle feeds or can be incorporated into the soil for supplementing nitrogen for the next crop and increasing organic matter content of the soil. Chilli, Mungbean and any other late rabi crops or boro rice can be grown after the harvest of garden pea.

Cultivation of this crop is highly profitable and attractive to the farmers for its short durability. It takes about 45 to 50 days from sowing for its green pod harvest and 55 to 60 days for matured seed harvest. The garden pea is grown mainly for green pods and seeds are used as vegetables. The matured seeds can be used for preparing ‘dal’ or ‘chatpati’ and other delicious foods. For its high nutritive value and sumptuous taste, it has gained popularity. Green pea is rich in vitamin and protein. Matured seed contains 9-15% water, 18-35% protein, 4-10% sugar, 0.6-1.5% fat, 2-10% cellulose and 2-4% minerals (Makasheva, 1983) [33]. Green peas are rich in vitamins. Pea contains all the amino acids. After the main produce is used, the waste material of pea, still rich in protein, can serve as a reserve for improving the quality of feeds.

Auxins are compounds that positively influence cell enlargement, bud formation and root initiation. They also promote the production of other hormones and in conjunction with cytokinins, they control the growth of stems, roots and fruits, and convert stems into flowers (Osborne, *et al*., 2005) [39]. Auxins were the first class of growth regulators discovered. Auxins especially Naphthalene acetic acid (NAA) and Indole-3-butyric acid (IBA), are also commonly applied to stimulate root growth when taking cuttings of plants.

Growth regulators have serious effect on crop yield without imposing any deleterious effect on the environment and human health. Foliar application of NAA (Naphthalene acetic acid) found to increase in plant height, number of leaves per plant, fruit size, with consequent in seed yield in different crops (Lee, 1990) [30]. Plant hormones used for most purposes on different plant growth levels and many of these regulators have interacted in order to observe the final effect. The plant growth regulators are compounds that in minor amounts modify the physiological processes of plants and ultimately alter the yield and quality (Sajid *et al*., 2016) [55].

Thus, this experiment has been taken to find out the effect of NAA with its optimum dose at different growth stages of garden pea for better yield and quality of the crop.

2. Materials and methods

The experiment was conducted during the period from November, 2016 to March, 2017 to studies on the growth, yield and quality of garden pea (*Pisum sativum L.*) influenced by plant growth hormone at different growth stages of plant. This includes materials and methods that were used in conducting the experiment and presented below under the following headings:

3.1 Location of the experimental field

The experiment was conducted at the research farm of Horticulture Department, Hajee Mohammad Danesh Science and Technology University, Dinajpur, during the period of November 2016 to March 2017. The experimental site was situated under the Dinajpur Sadar Upazila and located at $25^0$39' N latitude and $88^0$41' E longitude with an elevation of 37.58 meter above the sea level.

3.2 Climate of the experimental area

The experimental field was a medium high having sandy loam soil with pH 7.23. the initial soil (0-15 cm depth) test revealed that the soil contained 0.06% total nitrogen, 1.24% organic matter, 62.37µg/g available phosphorus, 1.03 meq/100g available magnesium, 0.58 meq/100g available potassium, 11.1 µg/g available sulphur, available boron 0.63µg/g and available zinc 1.45µg/g. The characteristics of the soil were previously tested in the Soil Resource Development Institute (SRDI), Dinajpur.

3.4 Collection of seed

The garden pea variety used in the experiment was "BARI Motorshuti-2" collected from Bangladesh Agricultural Research Institute, Gazipur.

3.5 Design and layout of the experiment

The experiment was laid out in Randomized Complete Block Design (RCBD) having two factors with three replications. An area of 33.5 m x 10 m was divided into three equal blocks. Each block was consists of 16 plots where 16 treatments were allotted randomly. There were 48 unit plots in the experiment. The size of each plot was 1.5 m x 2 m. the distance between two blocks and two plots were kept 1m and 0.5 m respectively.

3.6 Treatments of the experiment

The experiment consisted of two factors as follows:

Factor A: Different growth stages of garden pea
L_1 = Two leaf stage
L_2 = Four leaf stage
L_3 = Six leaf stage
L_4 = Full blooming stage

Factor B: Four level of NAA (Naphthalene acetic acid)

The land preparation was started 20 days before garden pea sowing. The land was prepared thoroughly by ploughing and cross-ploughing with a power tiller. Every ploughing was

followed by laddering in order to break the clods and to level the land. All types of weed, stubble and crop residue were removed from the experimental field.

3.7.2 Manures and fertilizer application

Fertilizer	Quantity
Cow dung	15 t/ha
Urea	153 kg/ha
TSP	181 kg/ha
MOP	98 kg/ha
Gypsum	70 kg/ha

Rashid (2012) [50].

According to Rashid (2012) [50], the entire amount of cow dung was applied during land preparation. Urea, TSP, MOP and Gypsum were applied at the rate of 153 kg/ha, 181 kg/ha, 98 kg/ha and 70 kg/ha respectively.

3.7.3 Seed sowing

All seeds were sown in the experimental plots on 15th November 2016 following line sowing methods. Line to line and plant to plant distance were 20 cm and 15 cm, respectively. Seeds were sown in each row at depth of 2-3 cm. After sowing the seeds were covered with pulverized soil and gently pressed with hands.

3.7.4 Intercultural operations

After the seeds were sowing, various kinds of intercultural operations were accomplished for better growth and development of the plants, which are as follows:

3.7.4.1 Thinning

Thinning of seedling was done at 20 days after sowing of garden pea seeds for maintaining uniform plant stands. Only healthy seedling was kept in each hill.

3.7.4.2 Weeding

The experimental plots were kept weed free by hand weeding. First weeding was done at the time of thinning and other three times necessary weeding were done to keep the field reasonable weed free through the growing period and soil surface crusts were broken. It helped to increase soil moisture conservation.

3.7.4.3 Irrigation

Irrigation was done whenever necessary. The young plants were irrigated by garden pipe and watering cane. Beside this, irrigation was given four times at an interval of 7 days depending on soil moisture content.

3.7.4.4 Plant protection

Plant protection measures were taken to protect the matured seeds against the attack of pigeon and rat. Also they were protected by spraying insecticide (Asamil) and fungicide (Dithane M 45).

3.8 Formulation of doses of NAA (Naphthalene Acetic Acid)

The stock solution of 1000 ppm of NAA was made by mixing of 1 g of NAA with small amount of ethanol to dilute and then mixed in 1 liter of distilled water. Then as per requirement of 25 ppm, 50 ppm and 75 ppm solution of NAA, 25 ml, 50 ml and 75 ml of stock solution were mixed with 1 liter of distilled water respectively for application to different growth stages of garden pea according to experimental design.

3.9 Harvesting

Harvesting was done at three times. BARI Motorshuti-2 were harvested at tender stage on 16 February, 2017, 24 February, 2017, 02 March, 2017. After harvest pods were separated from plants. Then pods were weighed.

3.10 Collection of data

Five plants were selected at random in such a way that the border effect could be avoided. For this reason, the outer two lines and the outer plants of the middle line in each unit plot were avoided. Data on the following parameters were recorded from the sample plants during the course of experiment.

- Plant height (cm)
- Pod breadth (mm)
- Number of seed pod $^{-1}$
- 1000 Seeds weight (g)
- Pod weight plant^{-1} (g)
- Yield of pod plot^{-1} (kg)
- Yield of pod (t ha^{-1})

3.11 procedure of data collection

3.11.1 Plant height (cm)

The plant height was measured in centimeters from the base of plant to the terminal growth point of main stem on tagged plants was recorded at 20 days interval starting from 20 days of planting up to 60 days to observe the plant height. The average height was computed and expressed in centimeter.

3.11.2 Pod breadth (mm)

Among the total number of pods harvested during the period from first to final harvest, the pods, except the first and last harvest, were considered for determine the pod breadth by slide calipers. The pod breadth was calculated by making the average of five pods from each of the five plants.

3.11.3 Number of seed pod $^{-1}$

The number of seed per pod was counted at harvesting time from selected five plants. Form each plant randomly five pods were selected and counted the number of seeds per pod to make an average value for one plant. The final average value of number of seed per pod was calculated from five plants.

3.11.4 1000 Seeds weight (g)

1000 seeds weight are measured by electronic balance.

3.11.5 Pod weight plant^{-1} (g)

Yield of garden pea per plant was recorded as the whole pod per plant and was expressed in gram (g). It was measured by the following formula:

$$\text{Weight of pod per plant (g)} = \frac{\text{Total weight of pods in five sample plants}}{5}$$

3.11.6 Yield of pod plot^{-1} (kg)

An electric balance was used to measure the weight of pod per plot. The total pod yield of each unit plot measured separately from each sample plant during the harvesting period and was expressed in kilogram (kg).

3.11.7 Yield of pod (t ha^{-1})

It was measured by the following formula:

$$\text{Yield of pod (t ha}^{-1}) = \frac{\text{Pod yield per unit plot (kg) x 10000}}{\text{Area of unit plot in square meter x 1000}}$$

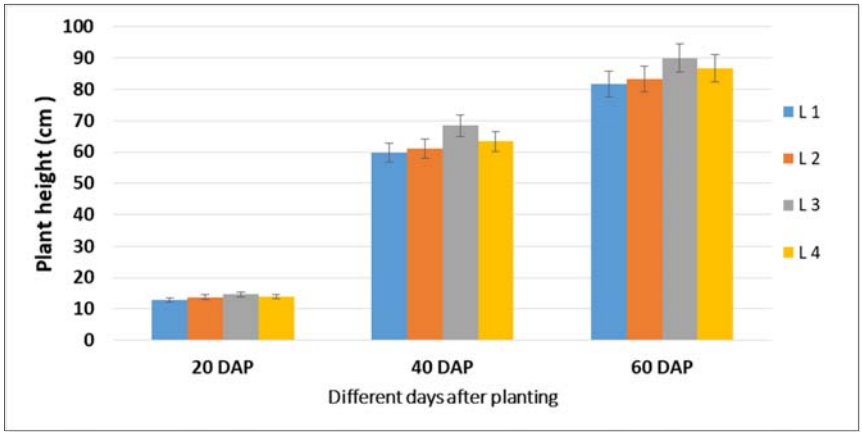
4. Result and discussion

4.1.1 Plant height (cm)

The significant difference was observed due to the leaf growth stage at 20, 40 and 60 DAP. At 20, 40 and 60 DAP the maximum plant height (14.62 cm, 68.37 cm and 90.00 cm) was recorded from L3 (Six leaf stage) treatment. On the other hand, at 20, 40 and 60 DAG minimum plant height (12.87 cm, 59.75 cm and 81.83 cm) was recorded from L_1(Two leaf stage) treatment (Fig 1).

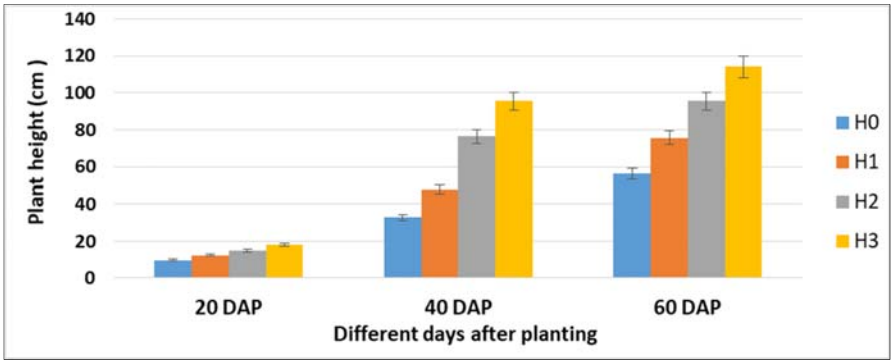
Due to the NAA application significant difference was observed at 20, 40 and 60 DAP. At 20, 40 and 60 DAP the maximum plant height (18.10 cm, 95.45 cm and 114.04 cm) was obtained from H_3 (75 ppm NAA) treatment. On the other hand, at 20, 40 and 60 DAP minimum plant height (9.74 cm, 32.70 cm and 56.45 cm) was recorded from H_0 (control) treatment (Fig 2). Similar results were observed by different researchers in different crops like groundnut (Samzzaman, 2004; Mondal, 2003) [36], Tomato (Gupta *et al.*, 2001), Singh *et al*. (2015) [64], reported that plant height was increased by the application of NAA at 45ppm on garden pea.

The significant difference was observed due to the interaction effect between the different leaf stages and the NAA application at 20, 40 and 60 DAP. At 20, 40 and 60 DAP the maximum plant height (19.00 cm, 99.00 cm and 119.16 cm) was recorded from L_3H_3 (Six leaf stage and 75 ppm NAA) treatment combination. On the other hand, at 20, 40 and 60 DAP minimum plant height (8.30 cm, 30.33 cm and 52.66 cm) was recorded from L_1H_0 (control) treatment combination (table 1).



L_1: Two Leaf Stage, L_2: Four Leaf Stage, L_3: Six Leaf Stage, L_4: Full Blooming Stage

Fig 2: Effects of various leaf stages on plant height of garden pea at different days after planting (DAP)



H_0: 0 ppm NAA (control), H_1: 25 ppm NAA, H_2: 50 ppm NAA, H3: 75 ppm NAA

Fig 3: Effects of NAA on plant height of garden pea at different days after planting (DAP)

Table 1: Interaction effect of leaf stage and concentration of NAA on plant height of garden pea at different days after planting (DAP)

Treatment	Plant Height (cm)		
	20 DAP	40 DAP	60 DAP
L_1H_0	8.30 h	30.33 g	52.66 p
L_1H_1	11.90 f	45.00 f	72.66 l
L_1H_2	14.23 e	71.33 d	92.66 h
L_1H_3	17.06 bc	92.33 b	109.33 d
L_2H_0	9.60 g	32.33 g	54.00 o
L_2H_1	12.10 f	44.00 f	74.00 k
L_2H_2	14.93 de	72.83 d	94.00 g
L_2H_3	18.56 a	94.66 ab	111.00 c
L_3H_0	10.40 g	33.33 g	56.66 n
L_3H_1	12.43 f	48.00 f	76.66 j
L_3H_2	15.10 de	76.33 d	96.66 f

L_3H_3	19.00 a	99.00 a	119.16 a
L_4H_0	10.66 g	34.83 g	62.50 m
L_4H_1	12.83 f	55.00 e	79.16 i
L_4H_2	16.00 cd	84.66 c	99.16 e
L_4H_3	17.80 ab	95.83 ab	116.66 b
LSD $_{(0.05)}$	**1.24**	**5.67**	**4.28**
Level of significance	**	*	**
CV%	5.35	5.33	2.98%

In a column, means with similar letter (s) are not significantly different by LSD at 5% level of significance.

L_1: Two Leaf Stage L_4: Full Blooming Stage H_2: 50 ppm NAA

L_2: Four Leaf Stage H_0: 0 ppm NAA (control) H3: 75 ppm NAA

L_3: Six Leaf Stage H_1: 25 ppm NAA

Note: *: 5% level of significant and **: 1% level of significant at DMRT method

4.1.8 Pod breadth (mm)

The significant difference was observed due to the leaf growth stage. The maximum pod breadth (21.46 mm) was obtained from L_3 (Six leaf stage) treatment and followed by (21.13 mm) L_4 treatment. On the other hand, the minimum pod breadth (20.61 mm) was recorded from L_1 (Two leaf stage) treatment (Table 2).

Due to the NAA application significant difference was also found (Appendix VII). The maximum pod breadth (24.29 mm) was obtained from H_3 (75 ppm NAA) treatment and followed by (22.34 mm) H_2 treatment. On the other hand, the minimum pod breadth (17.76 mm) was recorded from H_0 (control) treatment (Table 3).

The significant difference was observed due to the interaction effect of different leaf growth stage and NAA application. The maximum pod breadth (24.95 mm) was recorded from L_3H_3 (Six leaf stage and 75 ppm NAA) treatment combination. On the other hand, the minimum pod breadth (17.47 mm) was recorded L_1H_0 (control) treatment combination which is statistically identical to L_2H_0, L_3H_0 and L_4H_0 treatment combination (Table 4).

4.1.9 Number of seed pod $^{-1}$

The significant difference was observed due to the leaf growth stage. The maximum number of seed per pod (5.14) was obtained from L_3 (Six leaf stage) treatment and followed by (4.99) L_4 treatment which is statistically identical to L_2 treatment. On the other hand, the minimum number of seed per pod (4.72) was recorded from L_1 (Two leaf stage) treatment (Table 2).

Due to the NAA application significant difference was also found. The maximum number of seed per pod (6.28) was obtained from H_3 (75 ppm NAA) treatment and followed by (5.31) H_2 treatment. On the other hand, the minimum number of seed per pod (3.67) was recorded from H_0 (control) treatment (Table 3). Arora *et al.* (1998) [4] observed that application of different concentrations of NAA increased the number of seeds per pod in chickpea. Similar findings were also reported by the researcher Singh *et al.* (2015) [64].

The significant difference was observed due to the interaction effect of different leaf growth stage and NAA application. The maximum number of seed per pod (6.67) was recorded from L3H3 (Six leaf stage and 75 ppm NAA) treatment combination. On the other hand, the minimum number of seed per pod (3.61) was recorded L_1H_0 (control) treatment combination which is statistically identical to L_2H_0, L_3H_0 and L_4H_0 treatment combination (Table 4).

4.1.10 1000 Seeds weight (g)

The significant difference was observed due to the leaf growth stage. The maximum weight of 1000 seeds (324.50 g) was obtained from L_3 (Six leaf stage) treatment and followed by (322.08 g) L_4 treatment which is statistically identical to L_2 treatment. On the other hand, the minimum weight of 1000 seeds (317.33 g) was recorded from L_1 (Two leaf stage) treatment (Table 2).

Due to the NAA application significant difference was also found (Appendix VII). The maximum weight of 1000 seeds (337.87 g) was obtained from H_3 (75 ppm NAA) treatment and followed by (327.87 g) H_2 treatment. On the other hand, the minimum weight of 1000 seeds (303.54) was recorded from H_0 (control) treatment (Table 3). Singh *et al.* (2015) [64] reported that application of NAA at rate of 45 ppm increased the 1000 seeds weight in garden pea. The results of the present study revealed that different concentrations of NAA had positive effect on 1000 seeds weight (g) which also agreed with the result of Venkaten *et al*. (1984) [72], who studied on groundnut and found that various concentrations of NAA at 30 and 50 days after sowing increased 1000 seeds weight. Kelaiya *et al.* (1991) [25] also reported that groundnut cv. GG2 treated with 40 ppm NAA increased 100 seeds weight.

The significant difference was observed due to the interaction effect of different leaf growth stage and NAA application. The maximum weight of 1000 seeds (341.00 g) was recorded from L3H3 (Six leaf stage and 75 ppm NAA) treatment combination. On the other hand, the minimum weight of 1000 seeds (300.66 g) was recorded L_1H_0 (control) treatment combination (Table 4).

Table 2: Effects of various leaf stages on pod breadth, number of seeds plant^{-1}, and 1000 seeds weight of garden pea

Treatment	Pod breadth (mm)	No. Seeds /pod	1000 Seeds Weight (g)
L_1	20.61 c	4.72 c	317.33 c
L_2	21.09 b	4.96 b	321.25 b
L_3	21.46 a	5.14 a	324.50 a
L_4	21.13 ab	4.99 b	322.08 b
LSD $_{(0.05)}$	0.51	0.19	5.30
Level of significance	**	**	**
CV (%)	2.32	3.41	0.46

In a column, means with similar letter (s) are not significantly different by LSD at 5% level of significance.

L_1: Two Leaf Stage, L_2: Four Leaf Stage, L_3: Six Leaf Stage, L_4: Full Blooming Stage

Note: *: 5% level of significant and **: 1% level of significant at DMRT method

Table 7: Effects of NAA on pod breadth, number of seeds plant^{-1}, and 1000 seeds weight of garden pea

Treatment	Pod breadth (mm)	No. Seeds /pod	1000 Seeds Weight (g)
H_0	17.76 d	3.67 d	303.54 d
H_1	19.91 c	4.55 c	315.87 c
H_2	22.34 b	5.31 b	327.87 b
H_3	24.29 a	6.28 a	337.87 a
LSD $_{(0.05)}$	**0.71**	**0.24**	**2.15**
Level of significance	**	**	**
CV (%)	**2.32**	**3.41**	**0.46**

In a column, means with similar letter (s) are not significantly different by LSD at 5% level of significance.
H_0: 0 ppm NAA (control), H_1: 25 ppm NAA, H_2: 50 ppm NAA, H3: 75 ppm NAA

Table 8: Interaction effects of leaf stage and concentration of NAA on pod breadth, number of seeds plant^{-1}, and 1000 seeds weight of garden pea

Treatment	Pod breadth(mm)	No. Seeds /pod	1000 Seeds Weight (g)
L_1H_0	17.47 g	3.61 i	300.66 o
L_1H_1	19.23 f	4.25 h	310.66 k
L_1H_2	21.21 d	5.03 ef	324.00 h
L_1H_3	23.92 b	6.01 c	334.00 d
L_2H_0	17.59 g	3.70 i	304.33 m
L_2H_1	19.94 ef	4.52 gh	315.33 j
L_2H_2	22.44 c	5.29 de	327.66 g
L_2H_3	24.41 ab	6.34 b	337.66 c
L_3H_0	18.09 g	3.66 i	304.16 n
L_3H_1	20.62 de	4.78 fg	316.50 j
L_3H_2	22.80 c	5.44 d	328.83 f
L_3H_3	24.95 a	6.67 a	341.00 a
L_4H_0	17.89 g	3.70 i	305.00 l
L_4H_1	19.85 ef	4.64 g	321.00 i
L_4H_2	22.90 c	5.50 d	331.00 e
L_4H_3	23.89 b	6.11 bc	338.83 b
LSD $_{(0.05)}$	0.82	0.28	2.48
Level of significance	**	*	**
C V (%)	2.32	3.41	0.46%

In a column, means with similar letter (s) are not significantly different by LSD at 5% level of significance.
L_1: Two Leaf Stage L_4: Full Blooming Stage H_2: 50 ppm NAA
L_2: Four Leaf Stage H_0: 0 ppm NAA (control) H3: 75 ppm NAA
L_3: Six Leaf Stage H_1: 25 ppm NAA
Note: *: 5% level of significant and **: 1% level of significant at DMRT method

4.1.11 Pod weight plant^{-1} (g)

The significant difference was observed due to the leaf growth stage. The highest pod weight per plant (66.10 g) was found from L_3 (Six leaf stage) treatment and followed by (60.84 g) L_4 treatment. On the other hand, the lowest pod weight per plant (52.48 g) was recorded from L_1 (Two leaf stage) treatment (Table 5).

Due to the NAA application significant difference was also found. The highest pod weight per plant (77.00 g) was obtained from H_3 (75 ppm NAA) treatment and followed by (66.06 g) H_2 treatment. On the other hand, the lowest pod weight per plant (42.15 g) was recorded from H_0 (control) treatment (Table 6). Singh and Lal (2001) [59] conducted a field experiment and found the maximum number of fruits per plant by using NAA. Singh and Upadhaya (1967) [60] studied the effect of IAA and NAA on tomato give similar results.

The significant difference was observed due to the interaction effect of different leaf growth stage and NAA application. The highest pod weight per plant (24.95 g) was recorded from L_3H_3 (Six leaf stage and 75 ppm NAA) treatment combination. On the other hand, the lowest pod weight per plant (17.47 g) was recorded L_3H_0 (control) treatment combination (Table 7).

4.1.12 Yield of pod plot^{-1} (kg)

The significant difference was observed due to the leaf growth stage. The highest yield of pod per plot (6.63 kg) was found from L_3 (Six leaf stage) treatment and followed by (5.95 kg) L_4 treatment. On the other hand, the lowest yield of pod per plot (4.98 kg) was recorded from L_1 (Two leaf stage) treatment (Table 5).

Due to the NAA application significant difference was also found. The highest yield of pod per plot (6.88 kg) was obtained from H_3 (75 ppm NAA) treatment and followed by (6.32 kg) H_2 treatment. On the other hand, the lowest yield of pod per plot (4.87 kg) was recorded from H_0 (control) treatment (Table 6). Similar increasing result was observed by different researcher like Mondal (2003) [36], Mahla *et al.* (1999) [32]. Pandey *et al.* (2004) [41] also reported that increase by application of NAA 1500 ppm on garden pea. The finding was also in agreement with the observation of Samsuzzaman (2004) [56]. Singh and lal (2001) [59] conducted a field experiment and found the maximum number of fruits per plant by using NAA.

The significant difference was observed due to the interaction effect of different leaf growth stage and NAA application. The highest yield of pod per plot (7.03 kg) was recorded from L_3H_3 (Six leaf stage and 75 ppm NAA) treatment combination. On the other hand, the lowest yield of pod per plot (3.62 kg) was recorded L_1H_0 (control) treatment combination (Table 7).

4.1.13 Yield of pod (t ha^{-1})

The significant difference was observed due to the leaf growth stage. The highest yield of pod per hectare (22.41 ton) was found from L_3 (Six leaf stage) treatment and followed by (19.84 ton) L_4 treatment. On the other hand, the lowest yield of pod per hectare (16.61 ton) was recorded from L_1 (Two leaf stage) treatment (Table 5).

Due to the NAA application significant difference was also found. The highest yield of pod per hectare (22.10 ton) was obtained from H_3 (75 ppm NAA) treatment and followed by (20.07 ton) H_2 treatment. On the other hand, the lowest yield of pod per hectare (16.24 ton) was found from H_0 (control) treatment (Table 6). Pargi *et al.* (2014) [40] conducted a pot experiment on tomato and found maximum yield of tomato with NAA @ 50 ppm followed by NAA @ 30 ppm. Verma *et al.* (2014) [71] conducted an experiment to study the effect of varying levels of NAA and he also got the maximum yield per hectare. Singh and Lal (2001) [59] studied with Tomato plants were treated with NAA give the similar results.

The significant difference was observed due to the interaction effect of different leaf growth stage and NAA application. The highest yield of pod per hectare (24.09 ton) was recorded from L_3H_3 (Six leaf stage and 75 ppm NAA) treatment combination. On the other hand, the lowest yield of pod per hectare (12.08 ton) was recorded L_1H_0 (control) treatment combination (Table 7).

5. Conclusion and recommendation

Considering the findings of the experiment, it can be concluded that –

- The combination six leaf stage + 75 ppm NAA treatment combination is the appropriate practice for garden pea production.
- The effect of leaf stage and Naphthalene acetic acid on the growth and yield of garden pea was found positive and significant.
- The effect of leaf stage and Naphthalene acetic acid enhanced growth, yield and yield attributes of garden pea.

Further research works at different regions of the country are needed to be carried out for the confirmation of the present findings.

Table 5: Effects of various leaf stages on pod weight plant^{-1}, yield of pod plot^{-1} and yield of pod hectare^{-1} of garden pea

Treatment	Pod weight /plant (g)	Yield of pod plot^{-1} (kg)	Yield of pod (t ha^{-1})
L_1	52.48 d	4.98 c	16.61 d
L_2	56.93 c	5.52 bc	18.42 c
L_3	66.10 a	6.63 a	22.41 a
L_4	60.84 b	5.95 b	19.84 b
LSD $_{(0.05)}$	3.79	1.28	1.03
Level of significance	**	**	**
CV (%)	7.17	12.15	11.24

In a column, means with similar letter (s) are not significantly different by LSD at 5% level of significance.
H_0: 0 ppm NAA (control), H_1: 25 ppm NAA, H_2: 50 ppm NAA, H3: 75 ppm NAA
Note: *: 5% level of significant and **: 1% level of significant at DMRT method

Table 7: Interaction effects of leaf stage and concentration of NAA on pod weight plant^{-1}, number of pod plant^{-1}, and pod length plant^{-1} of garden pea

Treatment	Pod weight /plant (g)	Yield of pod plot^{-1} (kg)	Yield of pod (t ha^{-1})
L_1H_0	37.86 j	3.62 f	12.08 j
L_1H_1	45.93 hi	5.24 de	17.48 gh
L_1H_2	55.36 fg	5.66 bcde	18.86 fg
L_1H_3	70.75 bcd	5.41 cde	18.04 g
L_2H_0	40.02 ij	4.40 ef	14.68 i
L_2H_1	47.50 hi	5.09 de	16.96 hi
L_2H_2	65.77 de	5.92 abcd	19.73 e
L_2H_3	74.44 bc	6.69 abc	22.32 d
L_3H_0	46.30 hi	5.73 abcde	19.11 ef
L_3H_1	59.90 ef	6.83 ab	22.43 c
L_3H_2	73.44 bcd	6.93 b	22.78 c
L_3H_3	84.79 a	7.03 a	24.09 a
L_4H_0	44.43 hij	5.72 abcde	19.08 f
L_4H_1	51.24 gh	5.11 de	17.03 h
L_4H_2	69.66 cd	6.68 abc	22.26 de
L_4H_3	78.01 ab	6.29 abcd	23.97 b
LSD $_{(0.05)}$	7.13	1.09	2.07
Level of significance	**	*	**
C V (%)	7.17	12.15	11.24

In a column, means with similar letter (s) are not significantly different by LSD at 5% level of significance.
L_1: Two Leaf Stage L_4: Full Blooming Stage H_2: 50 ppm NAA
L_2: Four Leaf Stage H_0: 0 ppm NAA (control) H3: 75 ppm NAA
L_3: Six Leaf Stage H_1: 25 ppm NAA
Note: *: 5% level of significant and **: 1% level of significant at DMRT method

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