EFFECT OF DIFFERENT HORMONES ON PLANT ATTRIBUTE AND YIELD OF FIELD PEA (*Pisum sativum* L.)

THESIS

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BY

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June, 2015

CERTIFICATE

This is to certify that the thesis entitled **"Effect of different hormones on plant attribute and yield of Field Peas (*Pisum sativum* L.)"** submitted by **Mr. Gurjinder Singh (11309054)** son/daughter of **Shri Sohan Singh** to the Lovely Professional University, Phagwara in partial fulfilment of the requirements for the degree of **Master of Agriculture** in the discipline of Agronomy has been approved by the Advisory Committee after an oral examination of the student in collaboration with an External Examiner.

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Certification

This is to certify that the thesis entitled "**Effect of different hormones on plant attribute and yield of Field Peas (*Pisum sativum* L.)**" submitted in partial fulfilment of the requirements for the degree of Master of Science in Agronomy of the Department of Agronomy, School of Agriculture, Lovely Professional University, Phagwara, is a record of bonafide research carried out by **Mr. Gurjinder Singh**, Registration No. **11309054** under my supervision and no part of the thesis has been submitted for any other degree or diploma.

The assistance and help received during the course of this investigation have been duly acknowledged.

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Yours faithfully

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ABBREVIATIONS

N	Nitrogen
P	Phosphorus
K	Potassium
S	Sulphur
%	Percentage
DAP	Di-ammonium phosphate
MOP	Muriate of potash
IBA	Indol 3- butyric acid
GA_3	Gibberelic acid
NAA	Naphthalene acetic acid
DAS	day after sowing
cm	Centimeter
m	Meter
ha	hectare
@	At the rate of
Q	Quintal
MMT	Million metric tons
kg	Kilogram
g	gram
RBD	Randomized block design
CGR	Crop growth rate
RGR	Relative growth rate
DAS	Day after sowing
AE	Agronomic efficiency
LAI	Leaf area index
LA	Leaf area
DMA	Dry matter accumulation
TDM	Total dry matter

LAI	Leaf area index
DAE	Day after emergence
ET_c	Evapotranspiration
HI	Harvest index
PP	Plant population
V	Variety
S	Spacing
F	Fertilizer
R	Replication
ºC	Degree Celsius
hr	Hours
i.e	Id est (that is)
CD	Critical Difference
NS	Non- Significant
MSS	Mean Sum of squares

ABSTRACT

The aim of the present study was to investigate the Effect of different hormones on plant attribute and yield in field peas (*Pisum sativum* L.). The experiment is laid out in Randomized block design (RBD) with three replications, comparing nine treatments involving different hormones i.e. GA_3, IAA and IBA @ 10, 50 and 100ppm on experimental plot at Department of Agriculture, Faculty of Agriculture, Lovely Professional University, Punjab-India. Field pea is the most valuable grain legume crop in India. The successive growth of plant depends on growth hormones that may be naturally or artificially. The application of plant growth hormones has been demonstrated to enhance plant height, leaf area, leaf area index, crop growth rate, net assimilation rate, day to flowering, number of pod per plant, pod length and number of grain per pod. This study evaluated the effects of GA_3, IAA and IBA @ 10, 50 and 100ppm on the growth, development, yield and field peas grown in Punjab-India. In the field experiment, most cases the application of GA_3 @ 100ppm enhance the plant height, leaf area, leaf area index, net assimilation rate, number of grain per pod, pod length, yield and straw. The yield of field peas from the GA_3 @ 100ppm was 17.85 q/ha, which was 6.51 q/ha, higher than IBA 10ppm. Therefore the yield potential in the field pea crop depends on the plant growth, pod length and number of grain per pod.

Overall the results suggest that the application of IBA and IAA did not bring any significant changes for plant growth, development and yield thus cannot be used. Therefore, to achieve a final seed yield over 12 q/ha, to ensure economic viability in India, GA_3 @ 100ppm can be used to achieve at least 17.5 q/ha, particularly for early sown field peas.

INTRODUCTION:

The world population is increasing continuously whereas, on the other hand, food grain production is not increasing proportionally due to so many factors including soil fertility and repercussions arising from climate change phenomenon as manifested by unpredictable patterns of rainfall and temperature. The main reason for poor soil health and nutrient deficiency around the world seems to be the unbalanced nutrient application which is harmfully to soil microbes and soil structure. Amongst, various strategies to cope with above situation, soil test based integrated nutrient management holds the key to reverse above trend leading to restoration of soil fertility and in turn, boosting crop production and productivity. But the chemical fertilizers have played an important role in enhancing agricultural productivity but, their excessive applications are producing detrimental effect on environment vis-a-vis soil health, while very few farmers use growth hormones besides their expected role in sustainable agriculture. In this context, the utilized of $GA_{3,}$ IAA and IBA can go a long way in addressing the above issues because of their unique characteristics such as being of low cost, environment-friendly and easy to use sources of nutrients, enhancing to plant growth and increase crop production.

Pea (*Pisum sativum* L.) is one of the most important leguminous crops grown during winter season in India for local consumption and exportation. Field pea (*Pisum sativum,* L.) was among the first crops cultivated by man in the middle Asia, including north-west India and Afghanistan. It is an economically important crop in Asia, Africa, Japan, subtropical regions. (http://www.bestcookingpulses.com/history.php).The pods of pea contain high amount of protein and carbohydrates. So that pea is considered as one of the most important sources of human food nutrition throughout the world Hussein *et al.,* (2006). Pea has high levels of amino acids, lysine and tryptophan, which are relatively low in cereal grains. Pea contains approximately 21-25 percent protein, high levels of carbohydrates and low contents of fiber also contain 86 percent of total digestible nutrients. These characters make pea plants a good livestock feed. In India pea crop is being grown on 3.26 million ha in 2012-13 with a production of 1.75 million ton grain with the average productivity of 535 kg/ ha (http://agricoop.nic.in and http://www.indiastat.com). Field pea is an annual herbaceous plant and the stems length of 2 to 4 ft. A leaf consists of one to

three pairs of leaflets with a terminal, branched tendril. The pod is boiled and eaten whole or after splitting into dal prepared like this it has an unusual mucilaginous texture (http://corn.agronomy.wisc.edu/Crops/FieldPea.aspx). Plants play an important role in selecting and enriching the types of bacteria by the constituents of their root exudates. The productivity of pulse crops in India including field peas is not sufficient enough to meet the domestic demand of the population. Hence, there is need for enhancement of the productivity of field peas by proper following the agronomic practices. The growth and yield depend upon several factors like soil type temperature, nutrient and moisture availability etc.

Plant growth regulators (PGR's) are known to improve physiological efficiency including photosynthetic ability of plants and offer a significant role in realizing higher crop yields. The PGR's are also known to enhancing the source-sink relationship and stimulate the translocation of photo-assimilates, thereby enhancing the productivity. Though, the plant growth regulators have great potential, its application and accrual assessment.

Auxins are phytohormones which are involved in mediating a number of essential plant growth and developmental processes, such as cell elongation and division, induction of root growth and flower and fruit development. IAA (Indole-3-acetic acid) is considered to be the most important native in higher plants and is therefore the most studied one (N o r m a n l y et al., 1995). Different hormones such as GA_3 (Gibberellins), IAA (Indole-3-acetic acid), and IBA (Indole-3-butyric acid) play a vital role for promoting the quality of this crop. Apart from this the major physiological problem are fruit drop, flower drop and number of branch in a single plant are very low due to which the production of field peas remain less as compared to other pluses crop. The application of GA_3 (Gibberellins) enhance the seed germination per cent. There for the present investigation has been put forth to evaluate the effect of hormones on growth and reproductive stage with the following objectives (en.wikipedia.org/wiki/Botany).

Objectives

Hence, the purpose of this research was to investigate the "Effect of different hormones on plant attribute and yield in field peas (*Pisum sativum* L.)" based on the following objectives.

1. To determine the effect of hormones on reproductive stages.
2. To study the effect of hormones on root growth pattern.

Chapter II

REVIEW OF LITERATURE

Field Pea is rabbi pulse crop. which produce more vegetative growth than need for its maximum pod production and yield especially when climate condition favor vegetative growth, thereby directing the photo-assimilate toward the more vegetative growth, rather than reproductive growth however in recent year many plant growth regulators are being used to control excess vegetative growth and to boost the yield in other crop and very less used in field Peas

So in this chapter a survey of literature has been made on the effect of growth and yield component in field Peas (*Pisum sativum* L.) and its related crop.

2.1 PLANT GROWTH REGULATORS

Endogenous growth substances are involved in many processes which involved to growth and development. Plants have also been shown to respond to exogenous application of plant growth regulators. Considering their role in plants, plant growth regulators have been designated as magic chemicals which bring about an unprecedented growth and help in removing and circumventing many of the barriers imposed by genetics and environment.

Plant growth regulators are known to enhance the source-sink relationship and stimulate the translocation of photo-assimilates thereby helping in effective flower formation, fruit and seed development and ultimately increase productivity of the crops. Growth regulators can improve the physiological efficiency including photosynthetic ability and can increase the effective partitioning of accumulates from source and sink in the field crops (Solaimalai *et al.*, 2001).

2.1.1 Effect of NAA on plant attribute and yield

Resmi and Gopalakrishnan, (2004) observed that foliar application of cowpea plants with NAA (naphthalene acetic acid) at 15, 30 and 45 days after sowing enhancing the vegetative growth, fruit set, grain yield, seed yield, pod length, pod weight, pod number per unit area and

pod number per plant of Cowpea plants. An increase in number of pods and grains per pod in gram was found with 25ppm NAA (Bangal *et al.,* 1982), seed and pod weight was increased with foliar application of 25-50 ppm NAA to chickpea thrice at 5-days interval, beginning at flowering stage (Bangal *et al*.,1983).

NAA (Planofix) enhanced number of pods per plant, dry pod yield and 100 seed weight in groundnut (40 and 50 days after sowing) by (Singh and Sharma, 1982). Suty (1984) observed that NAA (Rhodofix) at 3.4 g per ha enhanced the number of pods per plant, seeds per pod, 100 seed weight and yield in faba bean. Bai *et al*., (1987) applied eight foliar sprays of 25 mg /litter NAA at 7 days intervals to *Vigna rediata* and reported a significant increase in seed yield and yield components. The number of pods per plant was increased by spraying 40 mg/litter NAA on groundnut once at either 45 days after sowing (DAS) and twice at 45 and 55 DAS (Devasenapathy *et al.,*1987).

Merlo *et al.* (1987) also recorded that NAA (naphthalene acetic acid) application on soybean at flowering enhance the number of branches per plant and average pod weight but latter application increased plant dry matter. 100 seeds weight was increased with the foliar application of 20 mg/litter NAA (naphthalene acetic acid) (Ravikumar and Kulkarni, 1988). Upadhyay *et al*., (1993) sprayed 0, 10, 20, or 30ppm NAA (naphthalene acetic acid) at bud initiation and pod formation stages of chickpea (*Cicer arietinum* L.). The highest seed yield of 2.35 ton/ha resulted from treatment with NAA @ 20ppm (naphthalene acetic acid). The application of NAA (naphthalene acetic acid) at 50 % flowering enhancing plant height and dry weight that reduced the flower drop percentage and led to increase seed yield.

Shukla *et al.,* (1997) concluded that a double spray of growth regulators increase the number of pods per plant, pod weight per plant and gave a 17.7% higher seed yield over the control. Maximum number of seeds per pod and grain yield was recorded when NAA (naphthalene acetic acid) was applied 15 days after emergence stage (Khanzada *et al*. 2002)**.** Productivity of some pulse crops has been found to be increased by the use of different growth regulators. Among them KNap and NAA (naphthalene acetic acid) were used in some field crops (Fattah and Wort 1970, Hossain 1976, Jahan 2001, Kalita *et al.,* 1995, Karim 2005).

NAA (Naphthalene Acetic Acid) in the synthetic auxin with the identical properties to that naturally occurring auxin. It prevents formation of abscission layer and there by flower drop. It was found that the growth regulators are involved in the direct transport of assimilates from source to sink (Sharma *et al*., 1989).The foliar application of NAA (naphthalene acetic acid) promoting the apical dominance, cell elongation and shoot development. Foliar application of micro-nutrient enhanced the synthesis of carbohydrates and protein. In addition foliar application of DAP at critical stages of the crop enhanced better photosynthetic activity as reported by Subramani *et al*., (2002).

Effect of Potassium nitrate and NAA (naphthalene acetic acid) on growth and yield of red gram was reported by the foliar application of NAA @ 20ppm + KNO3 0.5 percent significantly enhanced the dry matter production, seed yield by (Jayarani Reddy *et al*., 2004). Singh and Singh (2000) found that foliar application of NAA (naphthalene acetic acid) @ 30ppm concentration increase the number of leaves and branches. Dani (1979) observed that foliar application of NAA (naphthalene acetic acid) at 20ppm enhanced the grain yield, number of flowers and inflorescence in pigeon pea. Nawalagatti *et al*., (1988) found that NAA (planofix) at 10 to 20ppm enhance the leaf area index, dry matter production and crop growth rate in groundnut.

Shinde and Jadhav, (1995) observed that foliar application of NAA (naphthalene acetic acid) @ 50ppm enhanced the harvest index by seven per cent and dry matter production in red gram. Mahala *et al*., (1999) reported that NAA (naphthalene acetic acid) @ 30ppm increased the branches and number of leaf in black gram. Prakash *et al*., (2003) studded that in black gram NAA (naphthalene acetic acid) at 30ppm increased the branches and number of leaf. NAA (naphthalene acetic acid) @ 40ppm spray recorded in highest plant height 14.9 and 39.3 cm at vegetative and flowering stage as reported by Kumar *et al*., (2004) in green gram. Kadam *et al*. (2008) reported that NAA (naphthalene acetic acid) @ 30ppm concentrate was found to be more effective increasing the number of branches, total dry weight, number of pods per plant, 1000 grain weight and grain yield and chlorophyll content in black gram.

Application of NAA (naphthalene acetic acid) @ 50ppm significantly increased the cluster number in green gram (Kalita, 1989). Kalarani, (1991) concluded that foliar spraying of 50ppm significantly influenced the total N content in soybean. Application of one per cent urea with naphthalene acetic acid (NAA) @ 40ppm significantly increased the yield by 268 kg/ha in chillies (Katwala and Saraf, 1990).

Foliar application NAA (naphthalene acetic acid) @ 40ppm significantly enhances the 100 seed weight in green gram (Ghosh *et al*., 1991). Foliar application of NAA (naphthalene acetic acid) @ 50ppm increased the amino nitrogen concentration in black gram. Singh and Awasthi, (1998) reported that protein content was increased by foliar spray of NAA (naphthalene acetic acid) @ 40ppm in green gram. According to Sujatha, (2001) foliar application of NAA (naphthalene acetic acid) @ 40ppm significantly enhances the number of seeds per pod in green gram. Foliar spray of NAA (naphthalene acetic acid) @ 33ppm at flowering increased the average pod weight, seed pod ratio and number of flowers in green gram as reported by Sujatha, (2001).

Radhamani *et al*., (2003) founded that increase in test weight was due to NAA (naphthalene acetic acid) @ 10ppm in green gram. Kumar and Kumar, (2004) reported increased number of seeds per pod in the treatment given with NAA (naphthalene acetic acid) @ 10ppm in green gram. Foliar spray of NAA (naphthalene acetic acid) @ 30ppm concentrate was found to be more effective in increasing the number of branches, total dry weight, number of pods per plant, 1000 grain weight and grain yield, and chlorophyll content as reported by Ramanathan *et al*., (2004) in black gram.

Foliar spray of NAA (naphthalene acetic acid) @ 30 ppm was found to be more effective in enhancing the number of branches, total dry weight, number of pods per plant, 1000 grain weight and grain yield, and chlorophyll content in black as reported by Sharma *et al*., (1999) in green gram. Karim *et al.*, (2006) studded that higher protein content (23.99%) in chickpea with 100ppm of NAA (naphthalene acetic acid). NAA (Naphthalene Acetic Acid) is the organic substance which promotes the growth of plant and leads to more productivity. Varma *et al*., 2009 studded that NAA (naphthalene acetic acid) application increased seed yield in cowpea.

2.1.2 Effect of gibberellins (GA_3) on plant attribute and yield

GA_3 (Gibberellic acid) is an important growth regulator that may have many uses to modify the growth, yield and yield contributing characters of plant Rafeekher *et al*., (2002). Plant growth regulators are used widely to improve plant performance. GA_3 (Gibberellic acid) is one of those growth regulators that have positive effect on plant growth rate through the effect on cell division and elongation Batlang *et al*., (2006). Williams and De mallorca, (1984) GA_3 @ 10ppm recorded the highest germination percentage as well as the higher radical and plumule length in contrast to other treatments in horse gram. But when considered particularly on the radical and

plumule elongation, these did not show any significant effect on both the crop species. GA_3 (Gibberellins acid) could overcome the adverse in Black gram and Horse gram than the IAA (Indol-3-acetic acid) in the seed physiological activity, the findings supports the report of Chakrabarti and Mukherji, (2002).

Das Gupta *et al*., (1994) found that foliar application of plant growth regulators like Indol-3-acetic acid (IAA) and GA_3 (Gibberellins acid) helped the plant to restore retardation in water content in Mung bean plants subjected to water stress. Yadava *et al.*, (1978) conducted a field experiment on berseem seed production and found that application of 50ppm GA_3 (Gibberellins acid) increased plant height, number of branches, leaves per plant, by 3.9, 22 and 36.7 per cent respectively over higher dosages and also prevented the flower abscission.

Abdul *et al*., (1988) found that number of branches per plant in field bean was significantly increased by increasing the concentration of GA_3 (gibberellins acid) @ 50ppm to 100ppm in pepper. Foliar application of GA_3 (gibberellins acid) @ 100ppm at 45 days after planting of field bean is found more number of pods in main shoots, length of pods, number of seeds per pod and 1000 seed weight and highest seed yield (25.50 g/plant) (Yadava and Sinha, 1990).

GA_3 (Gibberellins acid) have been known as growth promoters that mediate many responses in plants, from seed germination to senescence. One frequently used, GA_3 (Gibberellins acid), increases stem length, the number of flower per plant and induces fruit setting (Azuma *et al*., 1997). El-Shraiy and Hegazi (2009) shows that the application of GA_3 (Gibberellins acid) in the concentration of 50 and 100 mg/litter, showed significant decrease for denominated chemi-cal constituents in pea seeds. Lee *et al*., (1999) reported that GA_3 increased stem length and number of flower per plant. Eraslan *et al*., (2007) also reported that exogenous application of gibberellic acid, enhanced growth, physiological process and antioxidant activity of carrot plants grown under salinity stress.

Kabar, (1990) observed that GA_3 (Gibberellins acid) accelerated bud development and stem elongation but the best results can be achieved if GA_3 (Gibberellins acid) are applied in combination with kinetin. There are also some reports which indicate that kinetin in combination with GA_3 (Gibberellins acid) enhance germination and seedling growth in chick pea (Kaur *et al.*, 1998). GA_3 (Gibberellic acid) is known to be concerned in the regulation of plant responses to the external environment Chakrabarti and Mukherji, (2003). The application of another plant

growth bioregulator has increased the saline tolerance of many crop plants (Haroun *et al*., 1991, Hoque and Haque, 2002). GA_3 (Gibberellic acid) has also been shown to alleviate the effects of salt stress on water use efficiency (Aldesuquy and Ibrahim, 2001). Chakrabarti and Mukherji (2002) noticed that GA_3 used to overcome the adverse effects in Mungbean plants. The role of plant growth regulators in overcoming the harmful effects of salinity on growth may be due to the change in the endogenous growth regulators which affects plant water balance.

Deotale *et al.,* (1998) studied the effect of GA_3 (Gibberellic acid) and NAA (naphthalene acetic acid) on growth parameter of soybean and obtained highest values for plant height, number of leaves per plant, number of branches per plant, leaf area, dry matter, days to maturity and seed yield. GA_3 (Gibberellic acid) has positive effects on increasing the endogenous plant content of growth promoters and reducing the endogenous content of growth inhibitors. Therefore, it enhances the photosynthetic pigments accumulation in plants which led to increase the photosynthesis rate and encourage the source to sink assimilates transportation pathway to materialize the increment of yield and its attributes as a result of gibberellins application (Devieln *et al.*, 1985 and Bondok *et al*., 1993).

Abou-Elleil and El-Waziri, (1978) studied the effect of spraying some growth regulators on shedding of flowers and pods of faba bean plants. They recorded that GA_3 (Gibberellic acid) @ 100ppm caused a significant increase in number of flowers and pods/plant, significantly decrease in number of shedding flowers, while GA_3 (Gibberellic acid) @ 200ppm increased shedding of flowers and pods. Herzog (1979) reported that GA3 significantly increased plant growth i.e. plant height and number of branches compared with the untreated control. Delaguardia and Benlloch (1980) reported that GA3 treatment increased plant growth i.e. plant height, LAI, number of leaves and number of branches. They mentioned that GA3 must act simultaneously on several factors related to cell growth, i.e. cell extensibility, membrane permeability, enzymatic activity, variation in osmotic potential and mobilization of potassium and sugars. Elsewhere, application of exogenous plant growth regulators such as GA_3 (Gibberellic acid) to stimulate dry accumulation and hence increase yield grain has been exploited with appreciable success (Gardner *et al.,* 1985)

Midan and Omar (1982) studied the effects of plant growth regulator GA_3 (Gibberellic acid) on plant growth and seed yield of pea plants. They emphasized that application of GA_3 (Gibberellic acid) statistically increased plant height, fresh and dry weights of plant foliage.

Also, GA_3 (Gibberellic acid) treatment increased total number of pods and seed yield compared with the control treatment. Mishriky *et al*., (1990) studied the effect of GA_3 (Gibberellic acid) on growth and yield of peas plants. They recorded that the application of growth regulators GA_3 (Gibberellic acid) markedly enhanced plant height, dry matter content in seeds and increased protein content in seeds. El-Beheidi *et al*., (1991) studied in two field experiments which were conducted to investigate the influence of GA_3 (Gibberellic acid) on faba bean growth, abscission percentage, number of flowers, number of pods and green pod yield and its components. They found that foliar spraying of GA_3 (Gibberellic acid) at 50 and 100ppm increased the total number of green pods per plant above the control plants.

Sharma *et al*., (1991) showed that spraying faba bean with GA_3 (Gibberellic acid) enhanced number of pods per plant, number of seeds per plant and pod dry matter content. In addition, GA_3 (Gibberellic acid) increased number of flowers per plant and total yield. Shaheen (1984) showed in pot experiments that V. faba cv. El-kobrosy plants grown on a loamy soil and sprayed with 0, 50 or 100ppm GA_3 (Gibberellic acid) solution when plants were (30 and 45 days) of age. Plant height of faba bean was greatest with treatment of GA_3 (Gibberellic acid) at 100ppm when sprayed after 30 and 45 days of age, while leaf area, LAI and D/M plant were greatest with GA_3 (Gibberellic acid) @ 50ppm.

2.1.3 Effect of Auxins, IAA and IBA on plant attribute and yield

Auxin application increase pod numbers, seed weight or seed yield but this based on varietals sensitivity and correct application timing in Pea crop Cho and Leal-León (2002). Natural occurring auxin in plant (IAA) could also increase the grain-filling and mobilization significantly over control, Ray and Choudhuri, 1981. Rhizospheric bacteria have been found to improve the availability of nutrients and showed detrimental effect on plant pathogens by producing hormones e.g. auxins. IAA (Indole-3-acetic acid) produced by bacteria positively affected the plant growth and nodulation in green gram (*Vigna radiate* L.) and black gram (*Vigna mungo* L.). Jangu *et al.,* (2011). IAA (Indole-3-acetic acid) showed beneficial effect on flower retention and subsequently on yield of lentil (Khalil *et al*., 2006). IAA (Indole-3-acetic acid) exerts influence on plant growth by enlarging leaves and increasing photosynthetic activities in plants. It also activates the translocation of carbohydrates during their synthesis (Awan *et al.,* 1999; Ritenour *et al.,* 1996).

Indole-3-acetic acid (IAA) is considered to be the most important native auxin in higher plants and is therefore the most studied one (N o r m a n l y *et al*., 1995). Exogenous IAA usually inhibits root growth (P i l e t and E l l i o t, 1981), but in some cases it can promote root elongation (P i l e t, 1961). Kalita (1986) found significant increase in the number of pods in green gram by foliar application of IBA @ 20ppm. El-Shraiy and Hegazi (2009) indicated that foliar application of 10 and 20 mg/litter of acetylsalicylic, as well as 50 and 100 mg/litter of IBA (Indole-3-butyric acid) to pea plants, were the most effective treatments for enhancing seed chemical constituents such total soluble proteins, sugars and carbohydrates, as phenols and proline, compared to corresponding controls.

Geetha *et al*., (1998), Das *et al*., (2002) and Roy *et al*., (2007) reported that IBA was effective for rooting of black gram. The superiority of chlorophyll concentration observed with ASA @ 20ppm and IBA @ 100ppm at the age of 3 sample 45 days after sowing, while GA_3 treatment give a significant decreased at the same age. These results were in agreement with Türkyýlmaz *et al*., (2005). IBA is a synthetic auxin. which used commercially for enhancing crop production plant growth regulation and rapid growth development such as shoot tissue, young leaves and developing seeds, elongation but do promote lateral root development in pea crop (Nagel, 2001).

Applied IAA (Indole-3-acetic acid) showed decrease in length of shoot after 30 and 60 days. It was significantly less than GA3 treatments. The decrease in length with IAA (Indole-3-acetic acid) was earlier reported by Pilot and Saugy (1985).

Chapter III

MATERIALS AND RESEARCH METHODOLOGY

The field experiment entitled **"Effect of different hormones on plant attribute and yield in field peas (*Pisum sativum* L.)"** was carried out at Lovely Professional University during *rabi* season 2014-2015. The details of materials, procedures adopted, and techniques used during the course of this study are described in this chapter

3.1 Description of experimental site

The present study was carried out at the field Experimental of the Department of Agronomy, School of Agriculture of Agriculture, Lovely Professional University, Jalandhar, Punjab (India) during 2014- 2015.

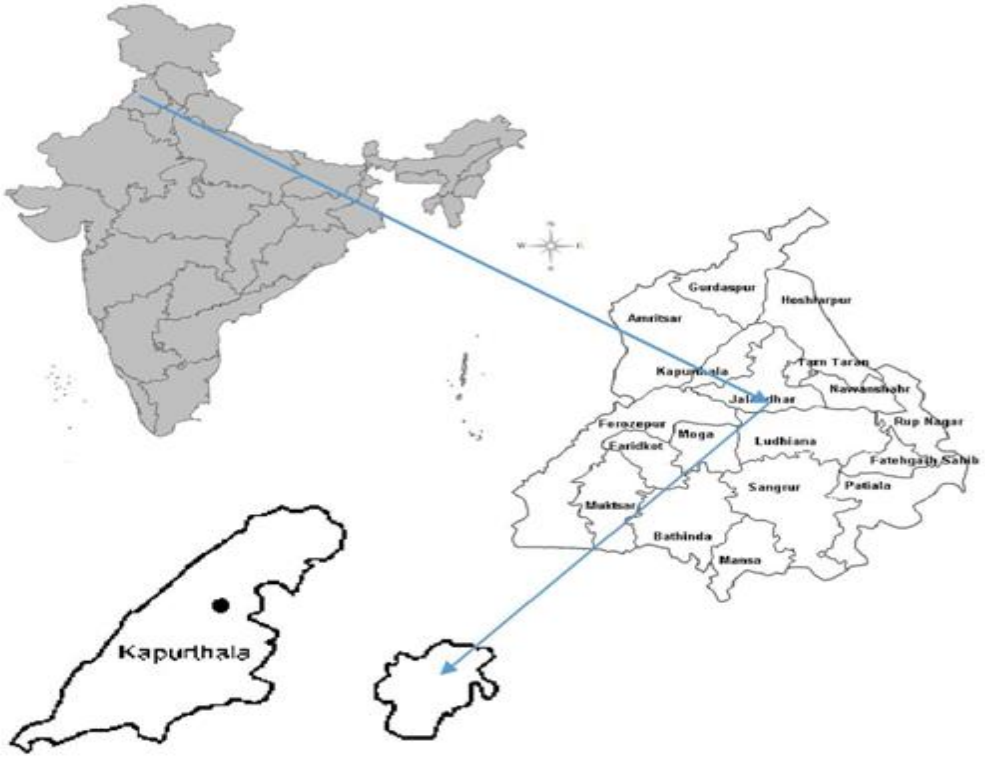

Figure 3.1 Picture showing the location of study area

The experimental site is localized in "*Central Plain Zone (PB-3)"* of Punjab. The rainfall in the region varies from 500-800 mm and about 80 per cent of which is received in a short period 3 months *(mid June to mid September)*. Major constraints of the region are declining water table and soil salinity. The soil predominantly belongs to Central Alluvial Plain or sandy loam. The major crops grown in the region are mainly wheat, rice, maize, groundnut, cotton, gram, barley, pear and guava. The experimental site is located at 31º 15' N latitude and 75^0 41' E longitudes at an elevation of 245 m above mean sea level. The climate of the experimental area is characterized as hot and dry summer and wet and humid monsoons, distinctly experiences all the four seasons. The soil of experimental field was Sandy loam. The table below contains details on experimental soil status before sowing.

3.2 Climatic and weather

The climate of the experimental site is located in Punjab State which experiences by the extreme hot and extreme cold conditions. The annual temperature in Punjab State range from 1 to 45^oC and can reach 49.5^oC during summer and 0^oC in winter. Its annually average rainfall ranges from 960 mm in the sub mountain region and 460 mm in the plains. It is also characterized by heavy rain in the northeast area near the foothills of Himalayas, whereas it receives less rainfall and high temperatures in the area lying in south and west. It experiences also three seasons as follows: Summer season (April and June) and it is characterized by the increase in temperatures up to 40^oC, Monsoon season (July to September) and it is during this period when the majority of rain occurs and in last, Winter season (December to February) with typical fall of temperatures up to 0^oC.

3.3 Meteorological data during growing season

Weather and climate are important factors that determining the success or failure of agriculture. Weather influences agricultural operations from sowing to the harvest, the reason why it is important to present the variations of climate during growing season. The mean of weekly meteorological observations were recorded during entire growing season and are represented in Table 3.3. Crops were sown on 26/11/2014. Pea was harvest on 25/3/2015. Maximum and minimum temperatures during growing season were 33.49^oC and 6.90^oC

respectively, relative humidity varied between 63 and 85 per cent. There was a total rain of 190 mm during growing period.

Month		Temperature		RH%	Rainfall (mm)
	Maximum	Minimum	Average		
November	26.9	10.9	18.9	63	0
December	17.6	6.9	12.25	80	42
January	15.6	7	11.3	85	24.5
February	22.2	10.5	16.35	79	38.6
March	25.5	13.3	19.4	76	84.6
April	33.49	19.17	26.33	62	0
Total					190

(Source: Department of Meteorology, PAU)

Table: 3.3 Monthly air temperature, relative humidity and total precipitation from November 2014 to April 2015

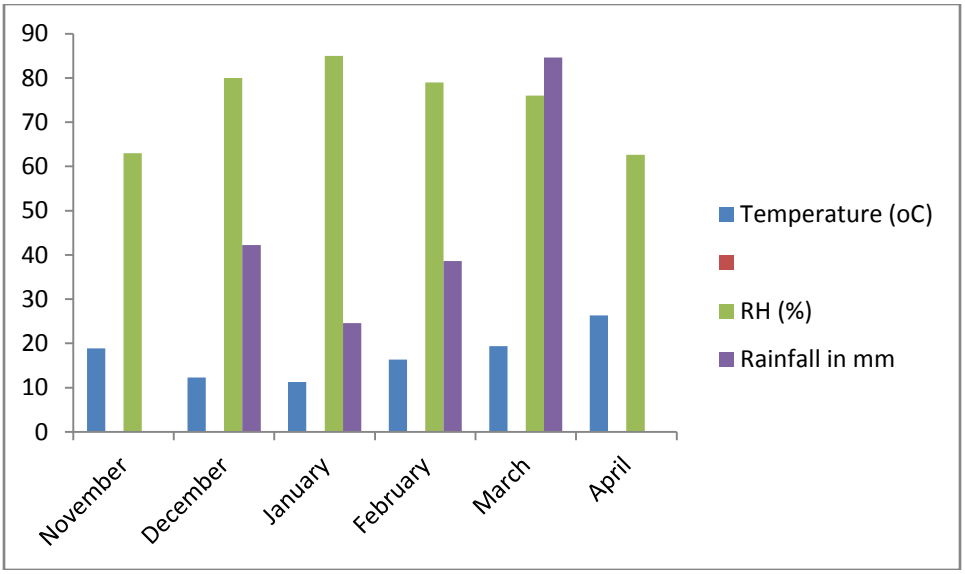

Figure: 3.3 Monthly meteorological reports

3.4 Soil Analysis

To find out physical and chemical characteristics of the experimental soil, top soil samples from 0-15 cm depth were collected from each replicates before sowing then after harvesting all crops soil samples were collected from each plot and they were air dried and sieved then a composite sample was obtained by mixing them together for further analysis of both physical and chemical properties. The results of soil analysis before sowing presented in table 3.4 showed that the soil was silt loam, slightly alkaline in reaction, non-saline, low in organic carbon, low in available nitrogen and potassium and medium in available phosphorus status.

Table: 3.4 Soil physical and chemical properties of the experimental field soil.

Sr. No	**Particulars**	**Values (0- 30 cm depth)**	**Method employed**
Physical properties			
1	Coarse sand (%)	61%	International pipette method (Piper, 1955)
2	Silt (%)	7%	
3	Clay (%)	32%	
Chemical properties			
1	pH	7.7	Buckmoric Hmeter (Piper,1955)
2	Electrical conductivity (dS/m)	0.33	Jackson (1973)
3	Organic carbon (%)	0.56	Wet oxidation method (Jackson, 1957)
4	**Available nutrient status**		
A	Available N (kg/ha)	163	Alkaline per magnate method (Subbaiah and Asija,1955)
B	Available P (Kg/ha)	24.4	Olsen’s method (Jackson,1957)
C	Available K (kg/ha)	325	Flame photometer method (Tandon, 1993)

3.5 Procedures of soil analysis

3.5.1 Triangle Method for soil textural class

Soil textural class was determined by using U.S. soil texture triangle method (Soil Survey Staff, 1998).

3.5.2 Particles distribution (%): International pipette method (Piper, 1950)

For determination of soil texture, 50 g of dried soil were sieved with the help of 2 mm sieve and placed into 500 ml bottle. After that 100 ml of dispersion solution was added into 50 g soil in 500 ml plastic bottle. Sample bottles were shacked at regular interval for half an hour on shaking machine for preparing homogeneous solution. The obtained solution was transferred in 1000 ml glass measuring cylinder then after water was added to make solution of 1000 ml. As per International approved system, the sample solution was shaken for 30 seconds. Depending on the solution temperature and sedimentation chart, first pipetting was done with 50 ml pipette at 10 cm depth. In first pipetting, 50 ml solution were sucked and transferred into 60 ml petri dish. The formed sample solution contained mixture of clay and silt particles. Depending on the solution temperature and sedimentation chart, second pipetting was done with 50 ml pipette at 10 cm depth. In second pipetting 50 ml solution were sucked and transferred in 60 ml china dish. This solution contained clay particles in soil sample. Remaining soil solution was transferred in 1 litre. Measuring cylinders and 0.02 mm sieves were washed using jet of water. Sand particles on sieve were collected in china dish. Pipetted solution was transferred in 3 dishes and kept overnight in an oven at temperature of 105^{o}C. Solutions were cooled in desiccators and weight was taken quickly. The weight of fine was determined by deducting the weight of clay, silt and coarse sand particle from 100.

3.5.3 Electrical Conductivity: Water suspension (Jackson, 1967)

To find out the electrical conductivity of soil, 25 g of dried soil were taken then transferred into 100 ml beaker then after 50 ml of distilled water was added. The suspension was mixed intermittently for half an hour and left it for 30 minutes without any disturbances. Conductivity cell was inserted in solution and EC value was recorded.

3.5.4 Organic carbon: Rapid titration method (Walkley and Black 1934)

To determine organic carbon of soil, 2 g of dried soil samples were weighed and taken into 250 ml conical flask, to which 10 ml of 1 N $K_2Cr_2O_7$ solution and 20 ml of concentrated H_2SO_4 were added. The content was shaken for a minute and was left for a half an hour to make reaction complete. Then after 200 ml of distilled water, 10 ml of orthophosphoric acid and 4 drops of drops of diphenylamine indicator were added and the violate color was appeared in the suspension. The obtained solution was titrated with ammonium ferrous sulphate and the point of the titration was marked with the change of colour from violate to bright green. The blank titration was performed in the similar way.

3.5.5 Available Nitrogen: Alkaline Permanganate Method (Subbiah and Asija, 1956)

To determine available nitrogen in the soil, 5 g of dried soil were taken and transferred into the distillation flask of micro-Kjeldhal distillation assembly. About 52 ml of 0.32% $KMnO_4$ solution was added to the distillation unit. From 150 ml conical flask, 10 ml of N/50 H_2SO_4 were pipetted out and mixed with two drops of methyl-red indicator. The conical flask and the delivery tube of the distillation unit were placed in such a way that the delivery tube was well placed into the content of the conical flask. The quantity of 25 ml of 2.5% NaOH solution was added into the distillation flask containing soil and $KMnO_4$ through the set provided in the distillation tube and the inlet was immediately closed with stop-cock. Then after, distillation was started and 30 ml of the distillate was collected. The content of the conical flask was titrated with N/50 NaOH and the end point was indicated with change of color from pink to yellow.

3.5.6 Available Phosphorus: 0.5 M $NaHCO_3$, pH=8.5 (Olsen *et al.* 1954)

A soil of 1 g of was weighed and transferred into 150 ml conical flask. A pinch of Darco-G 60 and 20 ml of 0.5 $NaHCO_3$ were added into the conical flask, then after the flask was shaken for half an hour on an electrical shaker and the suspension was filtered through Whatman No.1 filter paper. Similarly a blank solution was prepared. About 5 ml of the extract was transferred into a 25 ml volumetric flask and then after 0.5 ml 5N H_2SO_4 were added and the solution was shaken for a while till CO_2 evolution disappeared. A quantity of 4 ml of ascorbic acid (solution B) was added to it and the volume was made by addition of distilled water then after the flask

content was mixed. The intensity of the blue colour developed within a calorimeter was measured at 760 µm wavelength using red filter.

3.5.7 Available Potassium: 1 N Neutral ammonium acetate (Black, 1965)

A quantity of 5 g of dried soil was weighed and was taken into in 150 ml conical flask, then after 52 ml of neutral ammonium acetate solution were added to the flask. The content was shaken for five minutes on mechanical shaker and filtered through Whatman No.1 filter paper. The extract was collected into beaker then after 5 ml of the extract was diluted with distilled water. The diluted extract was atomized flame photometer to note K reading.

3.6 Experimental details

3.6.1. Treatments

The experimental design was comprised of 9 treatments combination with three hormones such as GA_3, IAA and IBA.

Table: 3.6.1 Details of treatments used in the experiment

Treatment	Doses
T1	GA_3 10ppm
T2	GA_3 50ppm
T3	GA_3 100ppm
T4	IAA 10ppm
T5	IAA 50ppm
T6	IAA 100ppm
T7	IBA 10ppm
T8	IBA 50ppm
T9	IBA 100ppm

3.6.2 Design and layout

The experiment laid out in RBD (randomized block design) and consisted of nine treatments with three replications and each replication received nine treatments randomly. Thereby it was 27 total experimental plots and plot size was 2.5 m x 1.5 m. The field preparation was done by applying the primary and secondary tillage, using mould board plough, harrow and rotavator respectively which were mounted on a tractor. It was followed by planking of the field using. Once the field was leveled uniformly, the layout was carried out manually.

(i) Total number treatments : 3 x 9 = 27
(ii) Replications : 3
(iii) Design : RBD
(iv) Total number of plots : 27
(vi) Net plot size : 2.5 m x 1.5 m = 3.75 m^2
(vii) Spacing : 30 cm x 10 cm for pea

3.6.3 Field layout

	Water channel			
	T1	**T7**		**T4**
	T2	**T8**		**T5**
	T3	**T9**		**T6**
	T4	**T1**		**T8**
	T5	**T2**		**T9**
	T6	**T3**		**T1**
	T7	**T4**		**T2**
	T8	**T5**		**T7**
	T9	**T6**		**T3**

Table: 3.6.3 Field Layout with treatments randomly in each replication

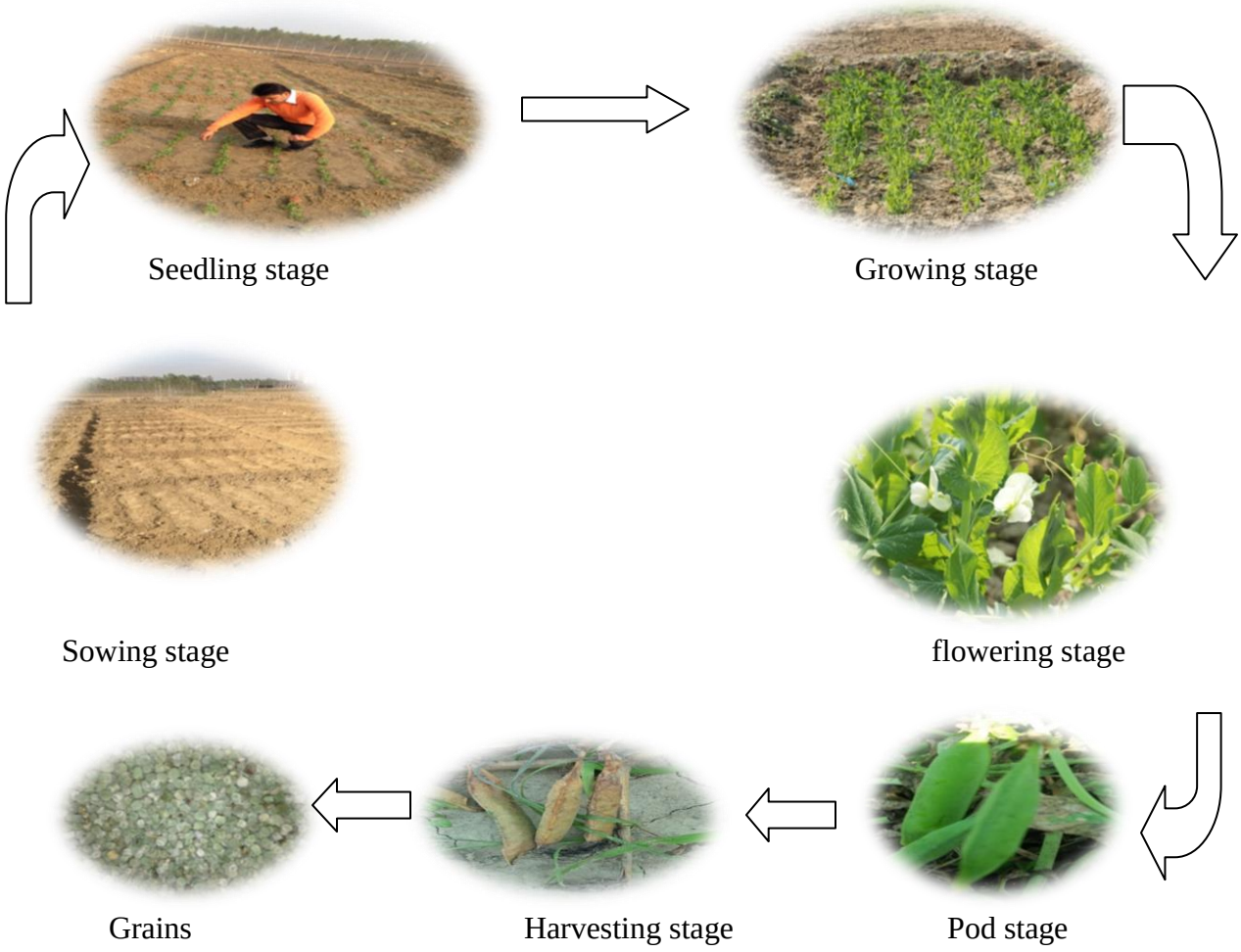

Figure: 3.6.4 Different developmental stages of field pea.

Figure: 3.6.5 Field after 104 DAS

3.7 Variety and hormones description

3.7.1 Source of Seed

Seed used in this research was obtained from Punjab Agriculture University,

3.7.2 Variety detail

Punjab green 3 varieties was a dwarf plant type with white flowers. It is early in flowering and maturity. The grains are creamy white, slightly wrinkled and possess high swelling capacity. It has very good cooking quality. It escapes heavy damage from pod borer and powdery mildew due to early maturity. It matures in about 125-135 days. It yields about 7 quintals per acre. This variety developed by Punjab Agriculture University

3.7.3 Hormones

The hormones used in this research were Gibberellins, Indol-3-acidic acid Indol-3-butyric acid as a spray on field peas and obtained from agriculture department of Lovely professional university Jalandhar.

3.8 Field preparation and subsequent operations

November 15th 2014 the first ploughing was done and this was followed by harrowing and leveling the soil to provide a good seedbed before sowing. All crop residues and weeds were removed as necessary to control weeds during the growing period. The urea, DAP and potash were basally applied in plots according to the treatment assigned in each plot before sowing, one part of seeds of field pea were treated with *Rhizobium* culture based on treatments definition and then left to dry under shade for about 30 minutes. In each plot 30 cm was maintained as planting distance between two successive rows. The other normal agricultural practices required including irrigation water canal cleaning were done. Details in table 4.8 below

Table: 3.8 Schedule of various agronomic operations done in this experiment

Sr.No.	Operation	Date
1.	Ploughing and planking of the field	15thnovember, 2014
2.	Pre sowing irrigation	20thnovember, 2014
3.	Lay out of field experiment	25thnovember, 2014
4.	Sowing	25thnovember, 2014
5.	Fertilizer application (urea and DAP)	25thnovember, 2014
6	1st foliar application of hormones	25thDecember, 2014
7.	1st weeding	9th January 2015
8.	Thinning	9th January 2015
9.	2nd foliar application of hormones	24 th January 2015
10.	Irrigation	10thfebruary, 2015
11.	2^{and}Weeding	3rd February,2015
12.	3rdfoliar application of hormones	23rd February,2015
13.	Harvesting	28th March,2015

3.9 Data Collection

Before collecting data directly from the field, in each plot four field pea plants were randomly selected, tagged and used to record vegetative parameters including plant height, number of leaves and number of pods etc.

3.10 Measurements

In this thesis various plant parameters such as plant height, leaf area, leaf area index, net assimilation rate, crop growth rate, accumulation growth rate, number of pods plant per pant, number of seeds per pods, pod length, chlorophyll content in leaf, straw and final seed yield were measured.

3.10.1 Plant height, number of flower and number of pods etc. determination

Plant height of 4 tagged plants in each plot was recorded three times during crop growth at interval of 15 days using a meter scale from ground level to the upper youngest leaf of the plant. Number of green leave were counted without considering the yellowish old ones three times the same period interval as well as the number of pods on each tagged three within.

3.10.2 Pod characteristics

At maturity (when the leaf canopy started to change to yellow), 10 random plants were cut and used to determine pod length, the number of pods per plant and seeds per pod.

3.10.3 Determination of Dry matter

The dry matter of single plant was estimated at flowering stage field pea. The randomly selected plants were removed from each plot. Above plant samples were dried in an oven at $75^{o}C$ for 24 hour until weight become constant. After 24 hour was weighting the dry matter the help of electrical weighing machine than reading was noted down.

3.10.4 Number of pods per plant / Number of seed per pod

The number of pods on single plant was counted when pods were filled with grains. The pods were counted from our tagged plants in each plot.

3.10.5 Pod and root length

The pod and root lengths were measure with the help of scale.

3.10.6 Determination of leaf area index

Leaf area index is the ratio between leaf areas to ground area.

LAI = leaf area /ground area

3.10.7 Determination of net assimilation rate

Using given formula to calculating

$$NAR= (W_2-W_1) (\log_e L_2 -\log_e L_1) / (t_2 - t_1) (L_2 - L_1)$$

Where L_1 and W_1 are leaf area and dry weight of plants at the time t_1, and L_2 and W_2 are leaf area and dry weight of plants at time t_2.

3.10.8 Determination of crop growth rate

It is the rate of crop per unit area and expressed as g/m^2 /day

$CGR = 1/P \times (W_2 - W_1)/ t_2 - t_1$

Where P is land area

3.10.9 Chlorophyll estimation in leaf

Total chlorophyll (Chl) concentrations were determined in the fourth leaf (fully expanded leaves) from shoot tip. Samples of 0.1 g leaves was ground and extracted with 5 ml of 80% (v/v) acetone in the dark according to the methods described by Holder, (1965). After that extract was continuously shacked and for 5 minutes centrifugation done at 10000 rpm/sec in centrifuged machine. The mixture was filtered then the absorbance values at 645 and 663 nm were measured. Using Jenway 6105 UV/VIS Spectrophotometer

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3.11 Statistical analysis

All the field and laboratory data were analyzed statistically by the methods described by FRBD software

Chapter IV

RESULTS AND DISCUSSION

Plant Growth and Growth Parameters

The experiment was conducted at the Agriculture Farm, Lovely Professional University, Punjab during the rabi season 2014-15 to investigate the effects of different hormones on plant attribute and yield in field peas (*Pisum sativum* L.). The experiment was laid out in RBD Design with three replications having a plot size of 3.75 m^2. The crop was sown as per recommended package of practice published annually by Punjab Agricultural University (Package of practices for the crop of Punjab) at three different hormones i.e. GA_3, IAA and IBA as in three different doses 10ppm, 50ppm and 100ppm. The data was recorded for important morphological and agronomic characters namely as

1. Plant height.
2. Leaf area.
3. Leaf area index.
4. Root depth.
5. Net assimilation rate.
6. Crop growth rate.
7. Chlorophyll content in leaf.
8. Days to Flowering 50% & 100%
9. Number of Pods per plant.
10. Pod length.
11. Number of grain in per pod.
12. Yield and straw ratio.

4.1 Plant height (cm).

In this present research work data showed the performance of three hormones GA_3, IAA, and IBA were significantly different from each other for plant height (Table 4.1). The results indicate that plant height was influenced by the application of different hormones and their

dosages also. The application of GA_3 @ 100ppm resulted in maximum height at 75 and 90 day after sowing was 52.83 cm and 72.83 cm, respectively. While IAA (10, 50 and 100ppm) and IBA (10, 50 and 100ppm) were growth retardants decreased the plant height. The plant height was significantly lower in IAA and IBA as compared to GA_3 treatment at different dosages. Eraslan *et al*., (2007) reported that exogenous application of GA_3, enhanced growth, physiological process and antioxidant activity of carrot plants grown under salinity stress. Similar results has been reported by James and Abraham 1989, who found that the exogenous application of GA_3 (50ppm and 100ppm) increased cowpea plant height. While in IBA with the increase in hormone doses the plant height was not significantly increased such as 39.91cm to 44.91cm with in respective days. However the application of IAA @ 10, 50 and 100ppm were not significantly increased the plant height (35.08 to 44.75 in IAA 10ppm and 33.66cm to 48.25 in IAA @ 100ppm after 75 and 90 DAS.

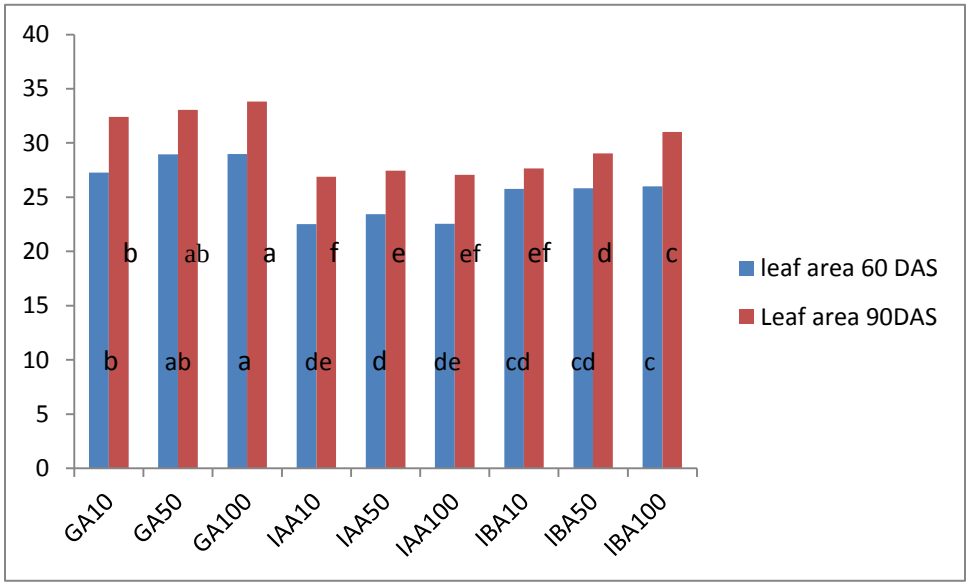
Basically, plant height was a genetically controlled character. But several studies indicated that the plant height can either be increased or decreased by the artificially application of plant growth regulators. However, in the present investigation significant differences in plant height was noticed from among the plant growth regulators. This clearly indicates that the mode of action of growth regulator is quite different. Similarly, in soybean, the application of GA_3 was more effective and increased the plant height and such increase was due to increased photosynthetic activity (Shukla *et al.*, 1997).

Treatment	plant height at 60 DAS (cm)	Plant height at 90 DAS (cm)
GA10	41.50^{b}	61.41^{bc}
GA50	47.75^{ab}	63.50^{b}
GA100	52.83^{a}	72.83^{a}
IAA10	35.08^{a}	44.75^{c}
IAA50	36.00^{c}	45.25^{de}
IAA100	33.66^{cd}	48.25^{c}
IBA10	39.91^{bc}	44.91^{de}
IBA50	32.83^{cd}	45.66^{d}
IBA100	32.66^{cd}	46.08^{cd}
CD	5.04	2.37

Table: 4.1 Effect of different hormones on plant height of field peas**.**

4.2 Leaf area (cm^2).

In the present studies there was significant different between GA_3, IAA and IBA hormones as well as in different doses @ 10, 50 and 100ppm for leaf area. The highest leaf area was obtained from the application of GA_3 @ 100ppm at 60 and 90 day after sowing i.e. 28.98 cm^2 & 33.82 cm^2 and lowest leaf area obtained in IAA @ 100ppm i.e. 22.53 cm^2 and 26.89 cm^2 at respective days (Fig. 4.2). On the other hand with the application of IBA @ 10ppm and 50ppm registered leaf area at par with IAA except IBA (100ppm) where leaf area was recorded 26 cm^2 and 31.01 cm^2 after sowing 60 and 90 days, respectively. These results were line with the finding of Deotale *et al.* (1998), who studied the effect of GA_3 (Gibberellins) and NAA (Naphthalene acetic acid) on growth parameter of soybean and obtained highest values for plant height, number of leaves per plant, number of branches per plant, leaf area, dry matter, days to maturity and seed yield. Leaf area gives a good idea of the photosynthetic capacity of the plant. In the present experiment, the leaf area increased up to 90 DAS and decreased thereafter due to senescence and ageing of leaves. In general, the application of growth regulators, showed a profound effect over these parameters and significant differences were noticed among the growth regulator treatments at both the growth stages. However, growth regulators GA_3 recorded significantly higher leaf area as compared to other hormones at both the growth stages.



Figur: 4.2 Effect of different hormones on Leaf area of field peas.

4.3 Leaf area index

The data pertaining to influence of plant growth regulators such as GA_3, IAA and IBA on leaf area index (LAI). Presented in Figure 4.3 indicated that the leaf area periodically at 60 and 90 DAS highest with the application of GA_3 @ 10, 50 and 100ppm. It was significant different from IAA and IBA. Among the growth regulators the maximum leaf area was noticed in the treatment GA_3 @ 100ppm at both stages (LAI 0.10 at 60 DAS and 0.11 at 90 DAS) and it was also found at par with the application of GA_3 @ 10ppm and 50ppm the leaf area index (LAI) were 0.09, 0.10 at 60 DAS and 0.10, 0.11 at 90 DAS with respective doses. Plant attained LAI of 0.09, 0.10 and 0.10 at 60 DAS which increased to 0.10, 0.10 and 11 at 90 DAS with the application of GA_3 @ 10ppm, 50ppm and 100ppm respectively. Successive increments of gibberellins up to highest dose i.e. 100ppm significantly increased the leaf area index over its lower dose at both growth stages. Proportional increase leaf area index (LAI) up to 90 DAS with the application of GA_3 @ 100ppm. Similarly result was recorded by Shaheen (1984) showed in pot experiments that V. feba cv. El-kobrosy plants grown on a loamy soil and sprayed with GA_3 @ 10, 50 or 100ppm solution when plants were 30 and 45 days of age. Plant height of feba bean was greatest with treatment of GA_3 @ 100ppm when sprayed after 30 and 45 days of age, while leaf area, LAI and D/M plant were greatest with GA_3 at 50ppm.

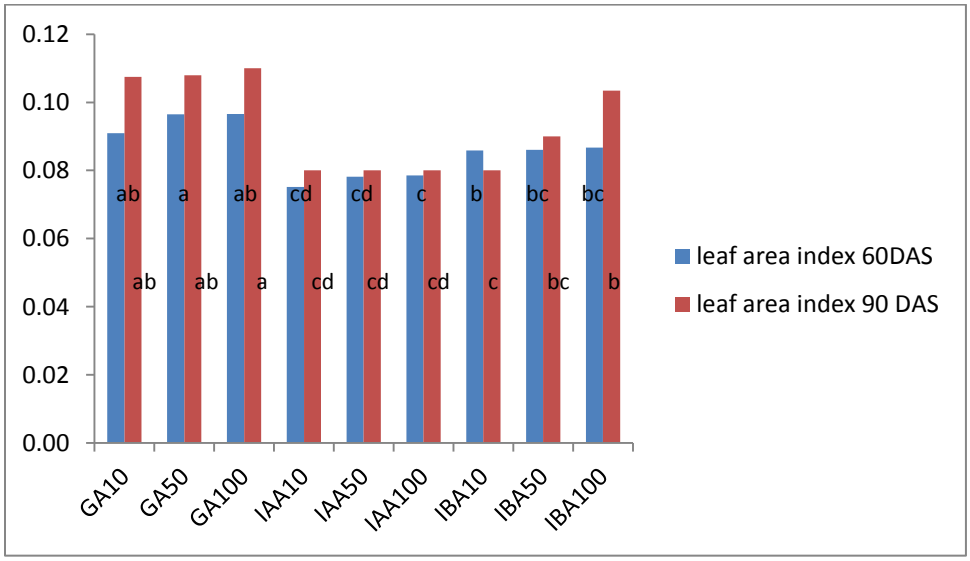


Figure: 4.3 Effect of different hormones on LAI in field peas**.**

However, the application of IAA and IBA @ 10, 50 and 100ppm treatments recorded both were significantly at par for leaf area index. It can be easily concluded from present studied that GA_3 @ 50ppm and 100ppm can be recommended for better leaf area index in field pea crop.

4.4 Crop growth rate (g/m^2)

The data presented in figure 4.4 revealed that there was non-significant different in crop growth rate with the application of GA_3, IAA and IBA @ 10, 50 and 100ppm. Crop growth rate was observed maximum at 30-60 day after sowing, where the maximum crop growth rate was recorded in the treated plot with GA_3 @ 50ppm with 0.214 at 30-60 days, followed by GA_3 @ 10ppm and 100ppm (0.211 and 0.196 g/m^2). At this stage, the treatment IAA @ 10, 50 and 100ppm (0.159, 0.159 and 0.148 g/m^2) were found at par with the treatments IBA @ 10, 50 and 100ppm (0.152, 0.155 and 0.162 g/m^2). The least crop growth rate was recorded in IAA @ 100ppm. Among the hormones, GA_3 @ 50ppm maintained significantly higher crop growth rate but GA_3 @ 10ppm and 100ppm also showed significantly higher crop growth rate. The present finding on crop growth rate are in accordance with the result of Batlang et al., 2006, Williams and De Mallorca, (1984) had found the positive effect of GA_3 on plant growth rate through the effect on cell division and elongation.

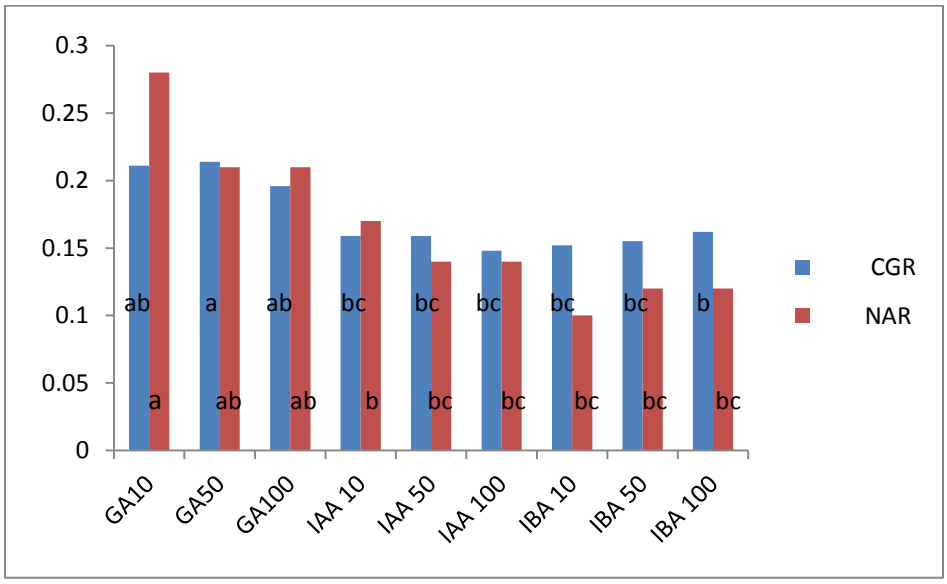


Figure 4.4 Effect of different hormones on crop growth rate in field pea crop**.**

The crop growth rate is important growth parameter influencing yield which is dependent not only on the hormones but also on the management practices and environment. In the present investigation, it was observed that the growth parameters studied i.e. crop growth rate less with the application of IAA and IBA as compare to GA_3 in all the treatment. So it can be easily concluded from present studied that GA_3 @ 50ppm can be used for crop growth rate in field pea crop.

4.5 Net assimilation rate ($g/cm^{-2}/day^{-1}$)

Result pertaining to net assimilation rate presented in figure 4.5 indicated that net assimilation rate was significantly different in three hormones such as GA3, IAA and IBA @ 10, 50 and 100ppm. Net assimilation rate (NAR), synonymously called as 'unit leaf rate', and expresses the rate of dry weight increase at any instant on a leaf area basis with leaf representing an estimate of the size of the assimilatory surface area. In the present studding on GA_3 @ 10, 50 and 100ppm have show better significant results (0.28, 0.21 and 0.21 $g/cm^{-2}/day^{-1}$), whereas IBA 10, 50 and 100ppm shows negative result (0.17, 0.14 and0.14 $g/cm^{-2}/day^{-1}$). The significant effect of GA_3 @ 10ppmon net assimilation rate was recorded, when compare with GA_3 @ 50ppm and 100ppm. As far as performance of three hormones i.e. GA_3, IAA and IBA at different doses is concerned, GA_3 10ppm performs significantly better for net assimilation rate. However, IBA performed significantly poor at 10ppm. It can be easily concluded from present investigations that higher net assimilation rate can be obtained by using GA_3 @ 10ppm in field peas.

The finding of Devieln *et al.*, (1985) and Bondok *et al*., (1993) with respect to GA_3 are supportive to the present investigation. Who found revealed that the positive effect on increasing the exogenous plant content of growth promoters and reducing the endogenous content of growth inhibitors. Therefore, study are accordance to enhances the photosynthetic pigments accumulation in plants which led to increase the photosynthesis rate and encourage the source to sink assimilates transportation pathway to materialize the increment of yield and its attributes as a result of GA_3 application.

4.6 Chlorophyll content in leaf (µg/cm^{-2})

4.6.1 Chlorophyll 'a'

Result pertaining to chlorophyll 'a' as presenting in figure 4.6.1 the maximum chlorophyll 'a' was observed in IBA @ 10, 50 and 100ppm which was statistically at par with 1.118, 1.180 and 1.219 µg/cm^{-2}, respectively. The minimum chlorophyll 'a' was found in GA_3 @ 100ppm with 0.820 and the average chlorophyll 'a' was recorded in IAA @ 10, 50 and 100ppm with 0.985, 0.963 and 0.938 µg/cm^{-2}, respectively.. Awan *et al.,* (1999), Ritenour *et al.,* (1996) showed the effectiveness of IAA on the plant growth by enhancing the leaves and increasing photosynthetic activities in plants is line to the presenting investigation.

4.6.2 Chlorophyll 'b' content

A perusal of data from figure 4.6 indicated that the application of hormones gave significant effect on chlorophyll 'b' content in the leaf of field peas. The highest chlorophyll 'b' was found in IAA @ 100ppm with 1.490 µg/cm^{-2}, while the lowest chlorophyll 'b' was recorded in GA_3 @ 100ppm and in IBA @ 10, 50 and 100ppm with 1.41, 1.42 and 1.39 µg/cm^{-2} respectively. The effect on chlorophyll 'b' content in leaf by application of IAA @ 100ppm was significant. Though, treated plants gave highest values. Literature pertaining to this study is very scanty. But in the present investigation IBA @ 100ppm was superior among the other hormones.

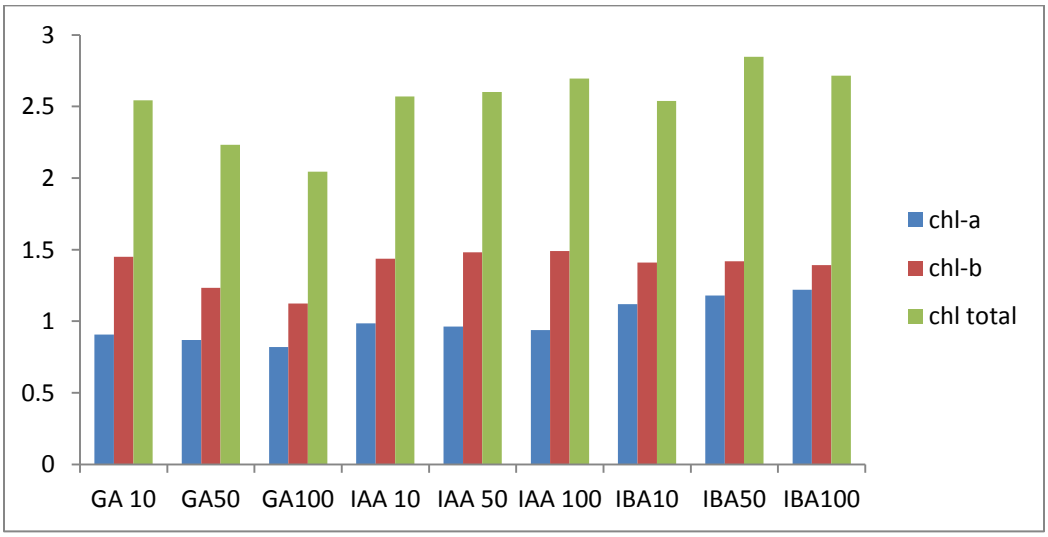


Figure: 4.6 Effect of different hormones on chlorophyll content in leaf of field pea**.**

4.6.3 Total Chlorophyll

There were significant differences of these hormones for chlorophyll content in leaf at different plant growth stages (figure: 4.6.1). Similar statistical maximum total chlorophyll content was recorded in IBA @ 50ppm and 100ppm with 2.846 μg/cm^{-2} and 2.716 μg/cm^{-2} respectively, while the minimum total chlorophyll content was 2.04 μg cm^{-2} noticed in GA_3 @ 100ppm. These results were in agreement with Türkyýlmaz *et al*., (2005) who has recorded the superiority of chlorophyll concentration of ASA @ 20ppm and IBA @ 100ppm at the age 45 days after sowing, while GA_3 treatment give a significant decreased at the same age.

4.7 Root depth

In agriculture, the study on root is a very important. It is apparent from data (Table 4.7) that there was a significantly difference in root depth with the application of GA_3, IAA and IBA @ 10, 50 and 100ppm in field pea. IBA @ 100ppm was reported to encourage vertical growth of roots (Table 4.7) as to increase rooting depth. Data showed that the maximum root depth was recorded in IBA @ 100ppm with 11.34, 13.93 and 15.74 cm at 30, 60 and 90 DAS respectively. While the minimum root depth was observed in IAA @ 100ppm with 8.50, 12.65 and 13.25 cm in respective days. Similar result was reported by Nagel, (2001) who observed that the IBA hormones was commercially used for enhancing the crop production and promote lateral root development in pea crop.

Treatment	At 30 DAS (cm)	At 60 DAS (cm)	At 90 DAS (cm)
GA 10	9.00 ±0.58	12.67 ±0.67	13.33 ± 0.88
GA50	9.07 ±0.52	12.00 ± 0.58	13.33 ± 0.33
GA100	9.67 ±1.76	12.67 ±1.76	14.33 ± 0.88
IAA 10	9.13 ±0.31	12.65 ± 0.84	13.25 ± 0.27
IAA50	8.87 ±0.55	11.09 ± 0.52	12.33 ± 0.73
IAA 100	8.50 ±0.76	12.00 ± 0.58	13.00 ±1.16
IBA 10	9.77± 0.91	11.83 ± 0.73	12.33 ± 0.88
IBA 50	10.50 ±1.04	13.00 ±1.16	15.00 ±1.16
IBA 100	11.34 ±1.02	13.94 ±1.12	15.74 ±1.08

Table: 4.7 Effect of hormones on Root depth**.**

4.8 Day to flowering

4.8.1 Day to 50% flowering

The comparison of treatment mean with different hormones and their dosages indicated that there was significant difference in field peas for days to 50% flowering (figure 4.8). The maximum day to 50% flowering was 107.33 days which was recorded in IAA @ 10, 50 and 100ppm. While the minimum days were taken for 50% flowering in GA_3 @ 10, 50 and 100ppm with 102.6, 103.33 and 103.33 days respectively. Results from the present investigation showed that GA_3 causes early flowering in field peas. Literature pertaining to this study work is very scanty but in the present investigation IAA @ 100ppm superior among the other hormones.

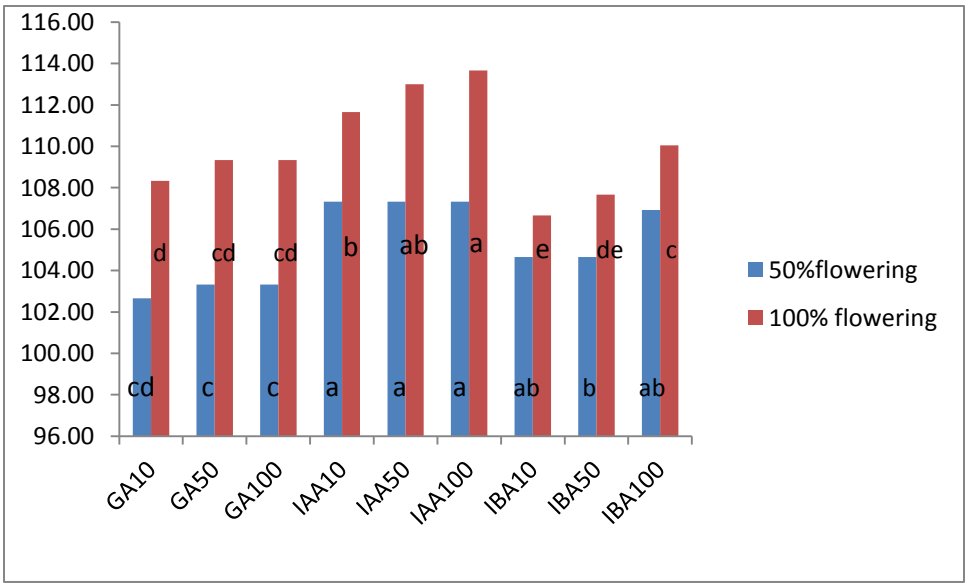


Figure: 4.8 Effect of different hormones on day to flowering in field peas.

4.8.2 Day to 100% flowering

In the present study figure 4.8 showed that the effect of different hormones and their dosage was significantly different. Application of GA3, IAA, and IBA influence the commencement of complete flowering days. However data indicates delay of flowering with application IAA. The variation among hormones for number of days taken for 100% of flowering and maturity were significant for each other (figire 4.8). IAA in different doses took significantly higher number of days for 100% flowering (111.66, 113 and 113.66 DAS) than

other hormones. GA_3 flowered early and gave 108.33, 109.33 and 109.33 DAS with the application of 10, 50 and 100ppm, respectively. The IBA gave significantly lower number of days for complete flowering than GA3 and IAA. Similar result was found with the application of GA_3, increases stem length, the number of flower per plant and induces days of maturity, (Azuma *et al*., 1997).

4.9 Number of pods per plant

In this present studding, figur 4.9 showed that the number of pods per plant was affected by the application of GA_3, IAA and IBA at different dosases. The different hormones had significant difference on the number of pods per plant in field peas. The highest number of pods per plant was found in IBA @ 10ppm with 22.66 pods. The minimum number of pods per plant of 19.53 pods was found in IAA @ 10ppm. While, the lowest number of pods (19.53) was recorded in IAA @ 10ppm. Among the three hormones IBA @ 10ppm produce more number of pods per plant than other hormones. The numbers of pods per plant in GA_3 @ 50ppm and 100ppm were almost similar in IAA 50ppm, 100ppm. This is on agreements with Yadava and sinha, 1990 who found the more number of pods in main shoots and length of pod in field peas with the foliar application of GA_3 @ 100ppm after 45 days of planting. Similarly, Cho and Leal-León, (2002) also reported the application of auxin increased pod number in field peas crop.

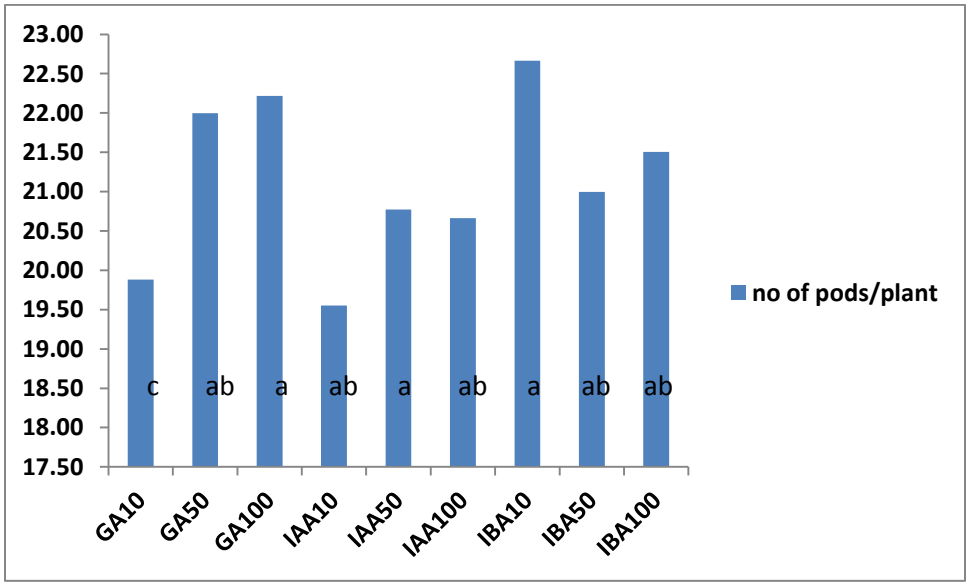


Figure: 4.9 Effect of different hormones on number of pod per plant in field pea.

4.10: Number of Grain per Pod

In this present investigation, there was non-significant difference was found between three hormones (GA_3, IAA and IBA) for number of grains per pod in plant, but significant difference was found between different doses of these hormones i.e. 10, 50 and 100ppm. The maximum number of grains per pod was noticed in GA_3 @ 100ppm with 8.33 seeds while the minimum number of seeds per pod was found in case of IAA @ 10ppm with 6.66 seeds per pod. The present finding is in accordance with Yadava and Sinha, 1990. Who found the foliar application of GA_3 @ 100ppm at 45 days after planting of field bean produce more number of seeds per pod and 1000 seed weight and highest seed yield. Thereby, it can be concluded from the result the GA_3 has performed well for increases the number of grain as compared to IAA or IBA (figure 4.10). So it can be easily concluded from present studied that GA_3 @ 100ppm can be used for getting more number of grain per pod in field pea crop.

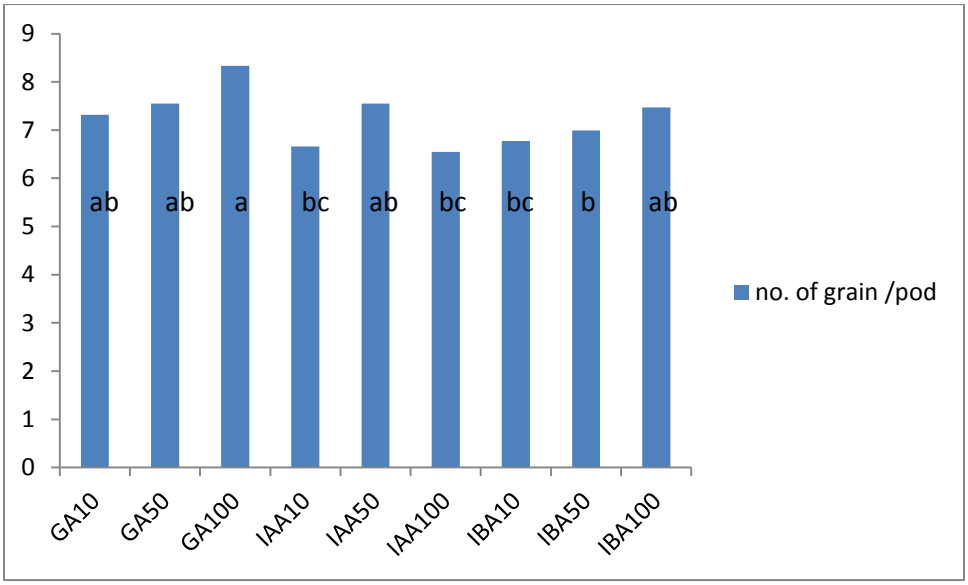


Figure: 4.10 Effect of different hormones on number of grain per pod in field peas**.**

4.11 Pod length

It is apparent from data (figure 4.11) that there was a non significantly difference in pod length with the application of GA_3, IAA and IBA @ 10, 50 and 100ppm in field pea. Pod length was directly related to number of seeds per pod. The longest pod was observed in GA_3 @ 100ppm and GA_3 @ 10ppm which was statistically similar with 7.33 cm and 6.88 cm

respectively. The shortest pod was found in IAA @ 100ppm with 5.44 which is not significant difference. Thereby in this present investigation it can be concluded that GA_3 100ppm performing better result as compare to IAA and IBA. These results were in agreement with Yadava and Sinha, 1990 who observed the foliar application of GA_3 (gibberellins acid) @ 100ppm at 45 days after planting of field bean is found more number of pods in main shoots, length of pods, number of seeds per pod and 1000 seed weight and highest seed yield.

Treatment	No of pods/plant	Pod length
GA10	19.88^{ab}	6.88
GA50	21.99^{ab}	6.55
GA100	22.21^{a}	7.33
IAA10	19.55^{ab}	5.66
IAA50	20.77^{ab}	6.22
IAA100	20.66^{ab}	5.44
IBA10	22.66^{ab}	6.22
IBA50	20.99^{ab}	6.1
IBA100	21.50^{ab}	5.99
CD	3.52	NS

Table: 4.11 Effect of different hormones on pod length in field peas.

4.12 Yield and straw ratio

In this present studied, the performance of GA_3, IAA and IBA hormones is significantly different from each other at 10, 50 and 100ppm dosages. There was significant difference in grain yield and straw yield with in all treatment. Table 4.12 showed that the highest seed yield and straw (kg/acre) in field peas was recorded in GA_3 @ 100ppm with 1077.33 and 1056.00 kg/acre respectively. While the lowest seed yield and straw (kg/acre) in field peas was found in IBA @ 100ppm with 773.33 and 714.67 kg/acre respectively. Significant effect of GA_3 showed higher seed yield compared to other treatments. GA_3 performs significantly better than IAA and IBA. The present observation is accordance with Khalil *et al.,* 2006 who found that IAA showed beneficial effect on flower retention and subsequently on yield of lentil. It can be easily concluded from present investigation that GA3 @ 100ppm can be used for attaining better grain yield and straw yield of the field pea crop.

Table: 4.12 Effect of different hormones on yield and straw ratio of field peas.

Treatment	Grain yield for 15 plant	q/ha.	Straw yield	q/ha.
GA10	67.33c	14.78	77.33c	16.97
GA50	71.00b	15.58	82.66b	18.14
GA100	81.33a	17.85	99.00a	21.73
IAA10	61.33b	13.46	70.00ab	15.36
IAA50	60.33c	13.24	70.33ab	15.44
IAA100	62.33a	13.68	71.00a	15.58
IBA10	51.66b	11.34	68.00a	14.92
IBA50	57.66ab	12.65	68.00a	14.92
IBA100	58.00a	12.73	67.00ab	14.71
CD	0.88		5.82	

Chapter V

SUMMARY AND CONCLUSION

The present study was conducted to investigate the "Fffects of different hormones on plant attribute and yield in field peas (*Pisum sativum* L.)". Perusal of the data from this study yielded in the following salient findings

1. The application of GA_3 @ 10ppm showed significant effect on plant height and also it showed significant influence on leaf area, and net assimilation rate in field pea.
2. In GA_3 @ 50ppm showed significant result on crop growth rate and the maximum crop growth was obtained with application of GA_3 @ (0.214 g/m^2)
3. The application of GA_3 @ 100ppm was found to be increases in the leaf area, leaf area index, plant height, net assimilation rate, pod length, number of grain per pod and yield in field peas crop.
4. The application of IAA @ 10ppm showed less number of pods per plant and also took more number of days for 100% flowering (111.66 days).
5. With the application of IAA @ 100ppm less number of grains per pod and pod length was obtained.
6. IBA @ 10ppm showed a significant effect on flowering. It reduces the number of days for complete flowering and also increases the number of pod per plant (22.66 pods/plant)
7. The application of IBA @ 50ppm showed significant effect on chlorophyll content in leafs and maximum chlorophyll content was obtained in this treatment.
8. IBA100ppm observed significant effect on photosynthetic process. It enhance the chlorophyll content in leafs and also enhance the root depth.

On the basis of this experiment results it can be concluded that hormones are components of plant growth and yield. The seed yield of pea wad more affected by GA_3 and highest yield was recorded when GA_3 was applied @100ppm. In case of GA_3 @ 50ppm, the yield was reduced up to 12.20 %, when compared with GA_3 @ 100ppm. Therefore, it can be concluded that the application GA_3 @ 100ppm was the most effective in terms of yield in field peas.

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Appendix

Field preparation

Field crop at15 DAS

Hand weeding at 45 DAS

Flowering stage in field pea crop at 108 DAS

Pod bearing stage in field pea

Grain after threshing