INNSPUB

International Journal of Agronomy and Agricultural Research (IJAAR)
ISSN: 2223-7054 (Print) 2225-3610 (Online)
http://www.innspub.net
Vol. 15, No. 3, p. 10-20, 2019

RESEARCH PAPER OPEN ACCESS

Effect of Chitosan (Growth Enhancer) on the growth and yield of different Pea (*Pisum sativum* L.) varieties under arid condition of Bannu Pakistan

Zakiullah*[1], Muhammad Fareed Khan[1], Irfanullah[2], Najeebullah[3], Abdul Khaliq[4], Muhammad Riaz[3], Tahsin Razzaq[1], Madiha Urooj[1], Habibullah Kakar[5], Faheemullah[2], Saima Shafique[1]

[1]*Faculty of Agriculture, University of Poonch Rawalakot, Azad Jammu and Kahmir (AJ&K), Pakistan*

[2]*Nanjing Agriculture University, Jaingsu, China*

[3]*Faculty of Agriculture, Gomal University Dera Ismail Khan (K.P), Pakistan*

[4]*Directorate of Potato Pishin, Quetta, Pakistan*

[5]*Directorate of Agriculture Research, Loralai, Pakistan*

Article published on September 30, 2019

Key words: Detoxification, $NADH^{+}$, Potassium dichromate (Cr^{+6}), Chromium, Resistant bacteria

Abstract

The effect of Chitosan on the growth and yield of different Pea (*Pisum sativum* L.) varieties were investigated. Three varieties of pea namely Meteor, Alina, Meteor indian were tested with four levels of Chitosan i.e. 0, 200, 250, and 300ppm. This research was conducted in Agriculture Research Area of Bannu during 2011. The study was designed with randomized complete blocks design (RCBD) with 3 replications. Data were recorded for various metric and biochemical trails. Germination percentages, survival percentage, plant height (cm), no. of leaves plant^{-1}, chlorophyll contents, total sugar (%), no of flowers plant^{-1}, no of pods plant^{-1}, vitamin C (mg/10). It is concluded that the application of Chitosan 250ppm Alina variety gives good results in most of parameters growth and yield at arid condition of Bannu.

* **Corresponding Author:** Zakiullah ✉ zakiullah_k@yahoo.com

Introduction

Pea (*Pisum sativum* L.) is one of the most important leguminous crops in many countries including Pakistan. High quality of green pods and mature seeds are used for fresh meals and food industries. Peas (*Pisum sativum* L.) a grain legume and a member of the leguminoseae family is a native of central or Southeast Asia. It grows well in cool weather in the presence of ample moisture. It is widely cultivated in temperate regions for its fresh green seed. Peas are an excellent human food, either eaten as a vegetable or used in preparation of soup. The peas are full of nutrition because its grain is rich in protein (27.8%), complex carbohydrates (42.65%), vitamins, minerals, dietary fibers and antioxidant compounds (Urbano *et al*., 2003). Peas ranks 4th in the world on a production basis (441.53 thousand tons) among grain legumes after soybean, groundnut and French beans and is grown on an area of 528.71 thousand hectares in the world (FAO, 2009).

In Pakistan, Peas is an important crop of the Punjab Province, Which plays a major role in farmer's economy. It is the most common crop and enjoys a great commercial demand due to its nutritive value. Total production of peas per unit areas both in terms of green pods and for seeds can hardly be over-emphasized. The dried peas contain 24.6 percent protein as compared to wheat which contains only 9.4% In Pakistan, it is cultivated on an area of 10 thousand hectares with a total production of 82 thousand metric tons (Xiao *et al.,* 2010).

Chitosan, an eco-friendly substance, is used as plant growth enhancer for crops grown commercially including orchids. Chitosan application enhances plant growth, increases photosynthesis, stimulates nutrient uptake, and boosts plant vigor. Chitosan is of the best materials used to improve the growth of crop plants, including beans. Chitosan excels most of substances as some of these substances can develop negative effects when used in similar environment.

Material and methods

The present study was designed to evaluate the influence of Chitosan on growth and yield of three varieties of Peas. The experiment was conducted in the Agriculture Research Area Bannu.

Three varities were sown Alina (V1), Meteor (V2) and Meteor Indian (V3). Chitson were sprayed at the rate of 0, 200, 250 and 300ppm before the flowering stage at 3 to 4 leaves. The experiment was laid out as Randomized Complete Block Design with three replications. The area for experiment used was 405 m^2. There were 27 sub plots. The size of sub was plot 15m^2. A fertilizer dose of 45-90-90kg ha^{-1} of N, P_2O_5 and K_2O were given for getting better yield.

Cultural Practices

First irrigation was done at the time of sowing. While irrigation were done weekly intervals depending upon the environmental condition. During the entire growth period, proper hoeing and weeding was practiced.

Main Experiments

The data were recorded for the following parameters.

Germination percentage

The germination percentage was calculated by following formula

Germination percentage = No of seedlings emerged/No of seed sown x 100

Survival percentage

The numbers of plants were counted for all treatments in each replication and percentage was calculated by following formula

Survival % age= No of plants survived/ Total No of plants sprouted x100

Chlorophyll Contents

Chlorophyll content in leaves from five randomly plants were taken. Onecm^2 leaf discs were cut and put in 5ml acetone in a test tube. Then the leaves were allowed to stay for 24 hours for complete extraction of chlorophyll from the leaf then the reading was taken by using the spectrophotometer at 663- 645nm wavelength. Total chlorophyll contents were calculated by following formula

Total Chlorophyll= 8.02x Absorbance at 663nm +29.2 absorbance at 645nm.

Total sugar

The sugar contents were determined by the method given in AOAC (1994). Twenty five ml of filtered juice was neutralized to Ph 7.5-8.0 with IN NaOH and 2ml of lead acetate was added along few drops of potassium oxalate and diluted 5gm of citric acid was added to the filtrate and neutralized using phenolphthalein as an indicator with 20% NaOH until pink color was obtained. The end point of titration was colorless.

Vitamin C (mg/100ml of fruit juice)

Vitamin C contents were also determined by the method given in AOAC (1994). Juice was taken in to volumetric flask by pipette, volume was made up with 0.4% oxalic acid and filtered through Watman filter number 4, 10ml of aliquot was taken for titration by the pipette and 15 mloxalic acid was added and titrated in 50 ml Erlenmeyer flask with 0.04% dye to a faint pink end point last for few seconds. Vitamin C of fruit juice was calculated by using following formula.

Vit C per 100 ml juice = Dye equivalent x Titer x Dilution

Protein Content

The protein content were estimated by Kjelhal method as described by AOAC (1994). The sample was weighed and transferred in to the digestion flask, 2-3g digestion mixture was added and 25ml sulphuric acid and was digested. The flask was removed, cooled and transferred the material to the 250ml volumetric flask and rainsed with small portion of water and then make up the volume. Fifty ml material was taken and 10ml strong alkali (NaOH) was added till alkaline. The material was distilled into 25ml 4% boric acid solution using methyle red as an indicator. At last material was titrated with N/10 H_2SO_4 solution.

No of flowers plant^{-1}

The number of flower was counted from flowering to the end of experiment.

No. of pods plant^{-1}

The No. of pods was counted of five randomly selected plants and average was calculated.

Weight of seed pod^{-1} (g)

The weight of seed per pod was taken of randomly selected five plants with the help of electronic balance.

Seed index (100-seed weight in grams)

The seed index was taken with the help of electronic balance.

Seed yield plot^{-1} (Kg ha^{-1})

Seed yield per plot was taken by the help of electronic balance.

Statistical analysis

The means of the selected plants per unit for each trait was analyzed using standard method of Steel *et al*., (1997) using MSTATC software. In the end mean was compared using Duncan's Multiple Range Test (DMRT).

Results and discussion

Germination percentage

There were significant ($p<0.05$) main and interactive effect of treatments and cultivars on germination % age as presented in Table (1a) Results demonstrated that maximum germination % age was 55.4% while minimum 30.5% was observed in V_1 at T_2 and T_4 respectively. However, mean value of treatments showed that better response was recorded in T_2 where Chitosan was applied @250ppm. While poor germination % age was recorded with T_1 where Chitosan was applied @.200ppm among cultivars, there was no significant difference was found among all varieties. However, V1 showed more pronounced response to the Chitosan application for germination % age as shown in figure (1a).

Maximum germination % age with the application of Chitosan might be due to the fact that Chitosan enhance the germination rate and germination index (Dong *et al*., 2004). Furthermore, many scientists have been reported that Chitosan increase the energy of germination, germination percentage, lipase activity, and gibberellic acid (GA_3) and indole acetic acid (IAA) level (Xiao *et al*., 2009; Yin and Yang, 2009).

Table 1. Differential response of pea's cultivars to chitosan application for Germination % age.

Treatment	Variety			Mean
	Alina	Metore	Indian Metore	
T1 (200ppm)	44.4 de	38.9 ef	44.5 cde	42.6 B
T2 (250ppm)	52.8 bc	61.1 a	55.5 ab	56.5 A
T3 (300ppm)	44.5 cde	47.2 bcd	47.2 bcd	46.3 B
T4 (Control)	36.1 fg	30.5 g	36.1 fg	34.2 C
Mean	44.4 A	44.4 A	45.8 A	
LSD	8.300**	4.15		4.792*

Values in a column sharing same letter(s) are statistically similar at P = 0.05; *Treatments differed significantly at P = 0.05.

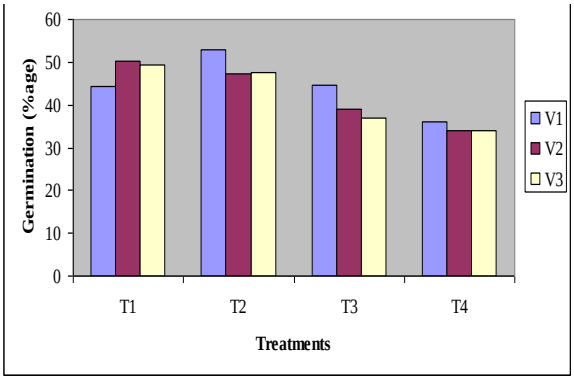

Fig. 1. Different response of pea cultivars to application of Germination % age.

Survival percentage

There were significant ($p<0.05$) main and interactive effect of treatments and cultivars on survival % age as presented in Table 2. Results demonstrated that maximum survival % age was 80.5% while minimum 27.4% was observed in V_2 and V_3 respectively. However, mean value of treatments showed that better response was found with T_2 where Chitosan was applied @250ppm. While poor survival % age was recorded with T_1 where Chitosan was applied @200ppm. Among cultivars, V_1 showed more pronounced response to the Chitosan application for survival % age as shown table 2.

It might be the reason for maximum survival % age that Chitosan improved the physio-chemical processes which enhanced the survival % age. Moreover, it has been used in agriculture as fertilizer to controlled agrochemical release to improve the immunity system of plants to protect the plants against microorganisms (Bautista-Banos *et al.*, 2003) and to stimulate plant growth and survival. That might be the reason for better survival % age. Furthermore, Chitosan act as a chelator (*Becker et al., 2000 and Bassi et al., 2000*) which make the availability of benefial nutrients like N, P and K (Farouk *et al.*, 2011) and micronutrients (Fe, Zn, Ca etc.) which help in the healthy and better plants growth. Chitosan contains nitrogen (carbon atom num2) in the basic unit of its formula (c11 h1707 n2), which is considered one of the most important nourishing elements for plants and soil alike. When the nitrogen contained in the Chitosan is dissolved, it penetrates gradually and remains in the soil for a long period of time and so does its effect. This was the scientist (*becker et al., 2000)* describtion.

Table 2. Differential response of peas's cultivars to Chitosan application for Survival % age.

Treatment	Variety			Mean
	Alina	Metore	Indian Metore	
T1 (200ppm)	55.5 bc	27.4	52.8 c	53.7 B
T2 (250ppm)	80.5 a	77.8 a	63.9 a	74.1 A
T3 (300ppm)	63.9 bc	61.1b	52.8 c	59.3 B
T4 (Control)	38.9 d	38.9 d	30.5 d	36.1 C
Mean	59.7 A	57.6 A	50.0 B	
LSD	10.11**	5.055*		5.838*

Values in a column sharing same letter(s) are statistically similar at P = 0.05; *Treatments differed significantly at P = 0.05.

Number of Leaves Per Plant

Table (3a) shows that maximum number of leaves per plant (61.33) were produced by T2, followed by T3 (50.89) and T1 (41.33). The minimum numbers of leaves per plant (27.67) were observed in case of T4. The interaction of treatments with crop varieties were non-significant and the maximum number of leaves per plant were produced by T1 x Metore (63.00) and T1xAlina (61.58) followed by T1xIndian Metore with 59.67. The minimum number of leaves per plant (22.67) was produced by T4 x Metore.

As far as varieties are concerned, the maximum number of leaves per plant (46.42) was obtained by Metore, followed by Indian Metore (44.92); whereas, the minimum number of leaves per plant (44.58) was observed by variety Alina.

Table 3. Effect of treatments on number of leaves per plant of different varieties of pea.

Treatments	Variety			
	Alina	Metore	Indian Metor	Mean
T1 (200ppm)	39.33 de	45.33 cd	39.33 de	41.33 C
T2 (250ppm)	61.58 a	63.00 a	59.67 a	61.33 A
T3 (300ppm)	49.33 bc	54.67 ab	48.67 bc	50.89 B
T4 (Control)	28.33 fg	22.67 g	32.00 ef	27.67 D
Mean	44.58	46.42	44.92	

LSD (0.05) for treatment = 5.293
LSD (0.05) for variety = NS
LSD (0.05) for interaction= 9.168

Plant Height

The data in Table (4a) shows that tallest plants (52.11cm) were produced by T2, followed by T3 (45.33cm) and T1 (36.89cm). The smallest (24.33cm) plants were observed in case of T4. The interaction of treatments with crop varieties were significant and the tallest plants were produced by T1xAlina (56.33cm) and T2 x Alina (56.00cm). The shorter plants (23.67cm) were produced by T4xMetore followed by T4xAlina with 24.33cm. Plant height is a genetic as well temperature and moisture related trait which indicates that adequate moisture and optimum temperature for vegetative growth were available to crop. As far as varieties are concerned, the tallest plants (43.92cm) were obtained by Alina, followed by Metore (40.08cm); whereas, the shortest plants (35.00cm) were observed by variety Indian Metore.

The above results are in accordance with the findings of Abdel-Mawgoud *et al.* (2010) who stated that in the Egypt to investigate the effect of chitosan foliar application on the growth, yield and fruit quality of strawberry plants. Chitosan application improved plant height, number of leaves, fresh and dry weights of the leaves and yield components (number and weight). The responses were positively related to the applied concentrations with the highest peak recorded with 2cm^3 /l then started to decline with higher applied concentrations but still significantly.

Table 4. Effect of treatments on plant height (cm) of different of pea varieties.

Treatments	Variety			
	Alina	Metore	Indian Metore	Mean
T1 (200ppm)	39.00	38.67	33.00	36.89 B
T2 (250ppm)	56.33	49.67	50.33	52.11 A
T3 (300ppm)	56.00	48.33	31.67	45.33 A
T4 (Control)	24.33	23.67	25.00	24.33 C
Mean	43.92 A	40.08 AB	35.00 B	

LSD (0.05) for treatment = 8.228
LSD (0.05) for variety = 7.125
LSD (0.05) for interaction = NS

Chlorophyll contents (mg/L)

Chlorophyll contents (CC) is greatly affected by both treatments and cultivars. There were significant ($p<0.05$) main and interactive effect of treatments and cultivars as shown in Table 5. Data demonstrated that maximum CC was 12.8mg L^{-1} found in V1 at T1 while minimum 7mg L^{-1} was recorded in V2 and V3 at T4. However, mean value of treatments showed that better response was found with T_2 where Chitosan was applied @250ppm while minimum 7.1 was recorded with T_4 where Chitosan was applied @0ppm.

Table 5. Differential response of peas's cultivars to chitosan application for Chlorophyll Contents.

Treatment	Variety			Mean
	Alina	Metore	Indian Metore	
T1 (200ppm)	9.4 c	8.0 d	9.9 c	9.1 B
T2 (250ppm)	12.8 a	11.2 b	10.8 b	11.6 A
T3 (300ppm)	8.0 d	7.5 de	7.6 de	7.7 C
T4 (Control)	7.4 de	7.0 e	7.0 e	7.1 D
Mean	9.4 A	8.4 B	8.8 B	
LSD	0.845**	0.422*		0.4877**

Values in a column sharing same letter(s) are statistically similar at P = 0.05; *Treatments differed significantly at P = 0.05.

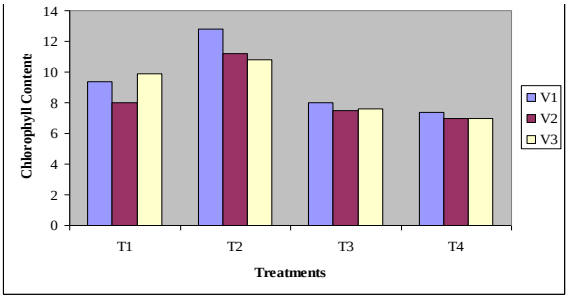

Fig. 5a. Different response of pea cultivars to application for Chlorophyll Contents.

Total sugar (mg/g)

There were significant ($p<0.05$) main and interactive effect of treatments and cultivars on total sugar as presented in Table (6a). Results showed that maximum total sugar was 2.15mg/g observed in V1 at T2 while minimum 0.86mg/g was observed in V_3 at T_1. However, mean value of treatments showed that better response was found with T_2 where Chitosan was applied @250ppm. While minimum total sugar was recorded with T_1 where Chitosan was applied @200ppm. Among cultivars, V_1 showed better response to the Chitosan application for total sugar followed by V2 and V3 as shown in figure 6a.

Maximum total sugar was obtained with Chitosan application might be related to the fact that Chitosan has ability for increasing nutrients uptake specially nitrogen and potassium which increased number of chloroplast per cell as well as photosynthetic efficiency and increased sugar content in plants (Farouk *et al.*, 2011). Similar results have been reported by Abdel-Mawgoud *et al.* (2010) that Chitosan application significantly enhanced the total sugar contents in strawberry.

Table 6. Differential response of pea's cultivars to chitosan application for Total sugar.

Treatment	Variety			Mean
	Alina	Metore	Indian Metore	
T1 (200ppm)	1.11 g	1.01 h	0.86 i	1.0 D
T2 (250ppm)	2.15 a	1.96 b	1.72 d	1.9 A
T3 (300ppm)	2.01 b	1.82 c	1.61 e	1.8 B
T4 (Control)	1.32 f	1.27 f	1.09 g	1.2 C
Mean	1.6 A	1.5 B	1.3 C	
LSD	0.0756**	0.378**		0.0436*

Values in a column sharing same letter(s) are statistically similar at P = 0.05; *Treatments differed significantly at P = 0.05.

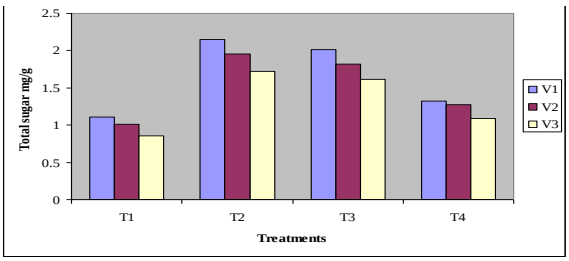

Fig. 6a. Differential response of peas cultivars to Chitos an application for total Sugar.

Vitamin C (gm)

Vitamin C is greatly affected by both treatments and cultivars. There were significant ($p<0.05$) main and interactive effect of treatments and cultivars as shown in Table 7. Data demonstrated that maximum vitamin C was 9.7gm found in V1 at T2 while minimum 4.7gm was recorded in V2 at T4. However, mean value of treatments showed that better response was found with T_2 where Chitosan was applied @250ppm while minimum 5.1 was recorded with T_4. Among cultivars, V1 showed more pronounced response to the Chitosan application for vitamin C followed by V2 and V3 as shown in figure 7a.

Vitamin C is an important nutritional component of food and it is present in pea's seed. Peas have good potential nutritional value (Baloch *et al.*, 1994) and good source of vitamins A, B and C, and also contain a high proportion of minerals. There is no exact mechanism is available that how vitamin is affected by Chitosan application in plants. Furthermore, there is no any vital evidence about the differential behavior of cultivars of peas to the Chitosan application and this part of the study much be carried. However, Lee *et al.* (2005) have been reported showed significant deference in vitamin C contents when soybean treated with Chitosan.

Table 7. Differential response of pea's cultivars to Chitosan application for Vitamin C.

Treatment	Variety			Mean
	Alina	Metore	Indian Metore	
T1 (200ppm)	6.3 bcde	7.7 abcd	6.7 bcde	6.9 B
T2 (250ppm)	9.7 a	8.3 abc	9.0 ab	9.0 A
T3 (300ppm)	5.0 de	6.7 bcde	6.3 bcde	6.0 BC
T4 (Control)	4.1 de	4.7 e	4.8cde	5.1 C
Mean	1.6 A	1.5 B	1.3 C	
LSD	2.816**	1.407*		1.626*

Values in a column sharing same letter(s) are statistically similar at P = 0.05; *Treatments differed significantly at P =0.05.

Among cultivars, V1 showed more pronounced response to the Chitosan application for CC followed by V3 and V2 as shown in figure 7a. Maximum CC with Chitosan application might be related to

increased availability of benefial nutrients like N, P and K (Farouk *et al.*, 2011) and micronutrients (Fe, Zn, Ca etc.) which help in better plants growth parameter (shoot length, leaf area etc.) and yield. Murillo *et al.* (2005) have been reported that Chitosan stimulate growth and leaf N and chlorophyll content in wild olive.

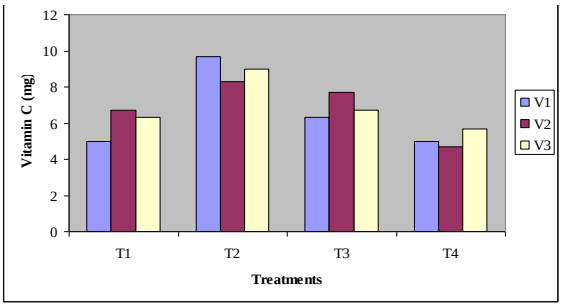

Fig. 7a. Different response of pea cultivars to application for vitamin C.

Similar results have been observed by Chibu and Shibayama (2001); Abdel-Mawgoud *et al.* (2010); Sheikha (2011) that higher CC was related to the Chitosan application.

However, there is no any vital evidence about the differential behavior of cultivars of peas to the Chitosan application**.** It might be related to the genetic potential of cultivars.

Protein (%)

Results showed (Table 8) that maximum protein% age was 15.7% observed in V1 at T2 while minimum 7% was observed in V3 at T4. However, mean value of treatments showed that better response was found with T_2 where Chitosan was applied @250ppm. While minimum protein% age was recorded with T_1 where Chitosan was applied @200ppm. Among cultivars, V1 and V2 showed almost similar response to the Chitosan application for protein% age followed by V3 as shown in table 8.

Protein is an important nutritional component of food and it is present in good quantity in pea's seed. Peas have good potential nutritional value (Baloch *et al.*, 1994) and good source of protein vitamins A, B and C, and also contain a high proportion of minerals.

Table 8. Differential response of pea's cultivars to Chitosan application for Protein % age.

Treatment	Variety			Mean
	Alina	Metore	Indian Metore	
T1 (200ppm)	12.0 bc	10.3 cde	8.0 ef	10.1 B
T2 (250ppm)	12.0 bc	15.7 a	11.7 cde	13.1 A
T3 (300ppm)	14.3 b	11.3 bc	10.0 cde	11.9 A
T4 (Control)	8.7 def	9.3 cdef	7.0 f	8.3 C
Mean	11.8 A	11.7 A	9.2 B	
LSD	2.841*	1.420*		1.640*

Values in a column sharing same letter(s) are statistically similar at P = 0.05; *Treatments differed significantly at P=0.05

There is no exact mechanism is available that how protein contents is affected by Chitosan application in plants. Furthermore, there is no any vital evidence about the differential behavior of cultivars of peas to the Chitosan application and this part of the study much be carried. However, the maximum response of cultivars to Chitosan application might be related to the fact that N is main constituent of protein and Chitosan which become available to the plant uptake upon degradation of Chitosan. Thus it resulted in higher protein contents.

Number of Flowers Per Plant

Table (9a) shows that maximum flowers (11.11) were produced by T2, followed by T1 (7.78) and T3 (7.00). The minimum numbers of flowers (4.44) were observed in case of T4. The interactions of treatments with crop varieties were non-significant and the maximum numbers of flowers were produced by T2 x Alina (12.33) and T2 x Indian Metore (12.00). The minimum numbers of flowers (4.33) were produced by T4 x Alina and T4 x Metore.

As far as varieties are concerned, the maximum numbers of flowers (8.75) were obtained by Alina, followed by Indian Metore (7.92); whereas, the minimum number of flowers (6.08) was observed by variety Metore.

Number of Pods Per Plant

Table (10a) shows that maximum pods (12.11) were produced by T2, followed by T3 (8.78) and T1 (8.67). The minimum numbers of pods (4.56) were observed

in case of T4. The interaction of treatments with crop varieties were non-significant and the maximum number of pods were produced by T2 x Alina (12.67) and T2 x Metore (12.00) followed by T2 x V3 with (11.67). The minimum numbers of pods (4.00) were produced by T4 x Indian Metore.

Table 9. Effect of treatments on number of flowers per plant of different Varieties of pea.

Treatments	Variety			
	Alina	Metore	Indian Metore	Mean
T1 (200ppm)	9.67 abc	6.00 def	7.67 cde	7.78 B
T2 (250ppm)	12.33 a	9.00 bcd	12.00 ab	11.11 A
T3 (300ppm)	8.67 cd	5.00 ef	7.33 cdef	7.00 B
T4 (Control)	4.33 f	4.33 f	4.66 ef	4.44 C
Mean	8.75 A	6.08 B	7.92 A	

LSD (0.05) for treatment = 1.758

LSD (0.05) for variety = 1.523

LSD (0.05) for interaction= 3.046

Table 10. Effect of treatments on number of pods per plant of different varieties of pea.

Treatments	Variety			
	Alina	Metore	Indian Metore	Mean
T1 (200ppm)	9.00 bcd	8.67 cd	8.33 d	8.67 B
T2 (250ppm)	12.67 a	12.00 ab	11.67 abc	12.11 A
T3 (300ppm)	8.00 de	10.67 abcd	7.67 def	8.78 B
T4 (Control)	4.67 ef	5.00 efg	4.00 g	4.56 C
Mean	8.58	9.08	7.92	

LSD (0.05) for treatment = 1.856

LSD (0.05) for variety = NS

LSD (0.05) for interaction = 3.215

Number of Seeds Per Pod

Table (11a) shows that maximum number of seeds per pod (12.22) were produced by T2, followed by T3 (8.67) and T1 (8.11). The minimum number of seeds per pod (3.78) was observed in case of T4. The interaction of treatments with crop varieties were non-significant and the maximum number of seeds per pod were produced by T2 x Alina (13.00) and T2xMetore (12.00) followed by T2 x Indian Metore with (11.67). The minimum number of seeds per pod (3.33) was produced by T4 x Metore. Analysis of variance of number of seeds per pod shows significant results of treatments but varieties and their interaction showed statistically non-significant results (Table 11b).

As far as varieties are concerned, the maximum numbers of seeds per pod (8.42) were obtained by Alina, followed by Metore (8.17); whereas, the minimum numbers of seeds per pod (8.00) were observed by variety Indian Metore.

Table 11. Effect of treatments on number of seeds per pod of different varieties of pea.

Treatments	Variety			
	Alina	Metore	Indian Metor	Mean
T1 (200ppm)	8.00	8.33	8.00	8.11 B
T2 (250ppm)	13.00	12.00	11.67	12.22 A
T3 (300ppm)	8.67	9.00	8.33	8.67 B
T4 (Control)	4.00	3.33	4.00	3.78 C
Mean	8.42	8.17	8.00	

LSD (0.05) for treatment = 1.358

LSD (0.05) for variety = NS

LSD (0.05) for interaction = NS

Seed Index (1000 seed weight in gm)

There were significant ($p<0.05$) main and interactive effect of treatments and cultivars on seed index as presented in Table 12. Results showed that maximum seed index was 173gm observed in V1 at T2 while minimum 95gm was observed in V3 at T4. However, mean value of treatments showed that better response was found with T_2 where Chitosan was applied @250ppm while poor seed index was recorded with T_1 where Chitosan was applied @200ppm. Among cultivars, V1 showed more pronounced response to the Chitosan application for seed index followed by V2 and V3 as shown in table 12a.

For optimum production of good quality and quantity of seed better plant growth and survival rate is important. Here it is important to mention that Chitosan resulted in better germination and survival % age as shown in Table (1a) and (2a). Furthermore, Chitosan has been reported as stimulating the growth and yield of various crops such as soybeen, potato, tomato and cabbage (Lee *et al.*, 2005) which might be possible reason for maximum production of seed index with the application of Chitosan. Another reason might be that Chitosan act as a chelator (El Hadrami *et al.*, 2010) which make the availability of benefial nutrients like N, P and K (Farouk *et al.*, 2011) and micronutrients (Fe, Zn, Ca etc.) which help in the

healthy and better plants growth and yield. However, the exact mechanism is not known which need further research on the part.

Table 12. Differential response of pea's cultivars to Chitosan application for Seed Index (gm).

Treatment	Variety			Mean
	Alina	Metore	Indian Metore	
T1 (200ppm)	133.0 c	119.0 de	122.3 de	124.8 C
T2 (250ppm)	173.0 a	161.7 b	162.7 b	165.8 A
T3 (300ppm)	124.7 cd	134.0 c	132.0 c	130.2 B
T4 (Control)	114.3 e	104.7 f	95.0 g	104.7 D
Mean	136.3 A	129.8 B	128.0 B	
LSD	9.398	4.699*		5.426**

Values in a column sharing same letter(s) are statistically similar at P = 0.05; *Treatments differed significantly at P = 0.05.

Seed Yield Per Plot

Table (13a) shows that maximum seed yield per plot (58.47g) was produced by T2, followed by T3 (50.91g) and T1 (40.34g). The minimum seed yield per plot (36.88g) was observed in case of T4. The interaction of treatments with crop varieties were non-significant and the maximum seed yield per plot were produced by T2 x Metore (60.60g) and T2 x Indian Metore (60.27g) followed by T2 x Alina with 54.54g. The minimum seed yield per plot (34.90g) was produced by T4 x V2.

As far as varieties are concerned, the maximum seed yield per plot (49.34g) was obtained by Indian Metore, followed by Metore (46.15g); whereas, the minimum seed yield per plot (44.45g) was observed by variety Alina.

Table 13. Effect of treatments on seed yield per plot (gm) of different varieties of pea.

Treatments	Variety			Mean
	Alina	Metore	Indian Metore	
T1 (200ppm)	36.07 e	39.20 de	45.77 cd	40.34 C
T2 (250ppm)	54.54 ab	60.60 a	60.27 a	58.47 A
T3 (300ppm)	47.83 bc	49.90 bc	55.00 ab	50.91 B
T4 (Control)	39.37 de	34.90 e	36.37 e	36.88 C
Mean	44.45 B	46.15 AB	49.35 A	

LSD (0.05) for treatment = 4.160

LSD (0.05) for variety = 3.603

LSD (0.05) for interaction = 7.205

This study intended to focus on the growth parameters and the chlorophyll content responses of pea plants. Throughout the study, recorded growth parameters and chlorophyll content responded positively to the application of Chitosan. (Chibu and Shibayama, 2001) reported positive effects of Chitosan incorporated into the soil on early growth stages of soyabean, mini-tomato, upland rice and lettuce. These improvements include plant height, leaf area, and dry weight of plants. Observations conducted during the whole study, (Chibu and Shibayama, 2001) indicate the existence of the higher chlorophyll content in the plants treated with Chitosan. Both factors (higher area of leaves and chlorophyll content) has contributed into the increase of the photosynthesize production which reflects a significant amount of dry weight and plants productivity.

It is also reported that Chitosan increased the growth rates of roots and shoots of daikon radish (*Raphanus sativus* L.) (Tsugita *et al.*, 1993) (Utsunomiya and Kinai, 1994). The application of (Chitosan-Oligosaccharides) to the soil gave better results for cultivating passion fruit (Passiflora edulis Sims). It showed that (Chitosan – Oligosaccharides) can increase the flowering time and flower numbers (Utsunomiya and kinai1994). Another study been conducted to see the effect of Chitosan on the growth of gerbera plants, the results showed that Chitosan significantly enhanced the growing factors and improved the average values of flower-stem length, number of growing leaves (including leaf width and length as well as the number of flowers per bush) (Wanichpongpan *et al.,* 2000). Chitosan also promoted the growth of various crops such as cabbage (Brassica oleracea L. var. Capitata) (Hirano1988), soya bean sprouts (Lee *et al.,* 2005) and sweet basil (Kim, 2005).

Conclusion

From the above discussion it is clearly established that the maximum growth and yield was obtained with the application of 250ppm of Chitosan. Chitosan play provital role in terms of plant growth and yield. Chitosan is natural, nontoxic, and biodegradable plant growth regulator that can be obtained from

various sources, particularly from the exoskeletons of crustaceans. It has been concluded that Alina (V_1) Chitosan @250ppm (T_2) have showed best performance for the number of pods plant^{-1}, seed yield plot^{-1}, plant height.

References

Abdel-Mawgoud AMR, Tantawy AS, El-Nemr MA, Sassine YN. 2010. Euro. J. of Scientific Research **39(1),** 161-168.

AOAC. 1994. Official methods of analysis, Association of Analytical Chemists. Ed. 16th Arlington Virginia, USA.

Bassi R, Prasher SO, Simpson K. 2000. Extraction of Metals from A Contaminated Sandy Soil Using Citric Acid. Environ. Prog **19(4),** 275-282.

Bautista-Bonus S, Hernandez-Lauzardo AN, Velaquez-Delvalemg, Lopez M, Barka E, Bosque-Molina, Wilson L. 2006. Chitosan as A. Potential natural compound to control pre and post harvest diseases of Horticulture commodities. Crop Pord **25,** 108-118.

Becker T, Schlaak M, Strasdeit H. 2000. Adsorption of Nickel, Zinc and Cadmium Cation by New Chitosan Derivatives. React. Funct. Polym **44(3),** 289-298.

Chibu H, Shibayama H. 2001. Effects of Chitosan applications on the growth of several crops, in: T. Uragami, K. Kurita, T. Fukamizo (Eds.), Chitin and Chitosan in life science, Yamaguchi, pp. 235-239.

Delphine Vincent, Catherine Lapierre, Brigitte Pollet, Gabriel Cornic, Luc Negroni, Michel Z. 2005. Water Deficits Affect Caffeate O-Methyltransferase, Lignification, and Related Enzymes in Maize Leaves. A Proteomic Investigation. Plant Physiology **137,** 949-960.

Dong H, Cheng L, Tan J, Zheng K, Jiang Y. 2004. Effects of Chitosan coating on quality and shelf life of peeled litchi fruit. J. of Food Engineering **64,** 355-358.

Farouk SAA, Mosa AA, Heba M, Ibrahim AM, Gahmery H. 2011. Protective effect of humic acid and chitosan on radish *Raphanus sativus* (L. var. sativus) plants subjected to cadmium stress physiol. Biochem **7,** 99-116.

Food and Agriculture Organization of the United Nations (FAO). 1994. Production Year Book. Rome, Italy.

Gornik K, Grzesik M, Romanowska-Duda B. 2008. The Effect of Chitosan on Rooting of Grapevine Cuttings and on Subsequent Plant Growth under Drought and Temperature Stress. J. of Fruit and Ornamental Plant Research **16,** 333-343.

Hirano S. 1997. Applications of chitin and Chitosan in the ecological and environment fields, in: M.F.A. Goosen (Ed), Application of chitin and Chitosan, Technomic Publishing Company, pp. 31-54.

Kim HJ, Chen F, Wang X, Rajapakse N. 2005. Effect of Chitosan on the biological properties of sweet basil (*Ocimum basilicum* L.). Journal of Agricultural and Food Chemistry **53,** 3696-3701.

Lee YS, Kim YH, Kim B. 2005. Changes in the respiration, growth, and vitamin C content of soybean sprouts in response to Chitosan of different molecular weight. Hort Science **40,** 1333-1335.

Muzzarelli C, Riccardo A, Muzzarelli A. 2005. Natural and artificial Chitosan-inorganic composites. Journal of inorganic Biochemistry **92,** 89-94.

Sheikha S. 2011. Physiological studies for different concentration from biochikol 020 PC (Chitosan) on Bean Plant. J. Asian Sci. Res **1,** 73-86.

Tsugita T, Takahashi K, Muraoka T, Fukui H. 1993. The application of chitin/Chitosan for agriculture. 7th Symposium on chitin and Chitosan, Fukui, Japan, pp 21- 22(in Japanese).

Urbano G, Aranda P, Gomez EV. 2003. Nutritional evaluation of pea (*Pisum sativum* L.) protein diets after mild hydrothermal treatment and with and without added phytase. Journal of Agricultural and Food Chemistry **51,** 2415-2420.

Utsunomiya N, Kinai H. 1994. Effect of Chitosan – oligosaccharides soil conditioner on the growth of passion fruit. Journal of the Japanese Society for Horticultural Society **64,** 176-177(in Japanese).

Wanichpongpan P, Suriyachan K, Chandrkrachang S. 2001. Effect of Chitosan on the growth of Gerbera flower plant (*Gerbera jamesonii*).Chitin and Chitosan: chitine and Chitosan in life science, Yamaguchi, japan, pp 198-201.

Xiao J, Liwei Z, Wen L, Xiaoyong S, Yun D. 2010. Combined action of pure oxygen pretreatment and chitosan coating incorporated with rosemary extracts on the quality of fresh-cut pears. Food Chemistry **121,** 1003-1009.

Yin H, Xiaoming Z, Yuguag D. 2009. Low molecular weight and oligomeric Chitosans and their bioactivities. Current Topics in Medicinal Chemistry **9(16),** 1546-1559.

Zohuriaan-Mehr MJ, Kabiri K. 2008. Superabsorbent Polymer Materials: A Review. Iranian polymer Journal **17(6),** 451-477.