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EFFICACY OF FOLIAR APPLICATION OF CHITOSAN ON GROWTH AND PRODUCTIVITY OF CHICKPEA

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ABSTRACT

The objective of this study was to determine the appropriate concentration of chitosan applied to chickpea. The experiment was conducted at Farm of Agricultural Botany Section, College of Agriculture, Nagpur during *rabi* 2020. The experimental design was RBD replicated three times. Eleven concentrations of chitosan *viz.,* 0 ppm, 10 ppm, 20 ppm, 30 ppm, 40 ppm, 50 ppm, 60 ppm, 70 ppm, 80 ppm, 90 ppm and 100 ppm were tested. Data revealed that foliar application of 60 ppm concentration of chitosan at 25 and 45 DAS significantly enhanced plant height, number of branches, leaf area, dry matter, NAR, RGR and yield of chickpea.

(Key words:Chickpea, chitosan, foliar application, growth, yield)

INTRODUCTION

Chickpea [*Cicer arietinum* (L.)] belongs to genus *Cicer,* tribe Cicereae, family Fabaceae and sub family Papilionaceae. Among the pulses, chickpea ranks third in the world. The important chickpea growing countries in the world are India, Turkey, Pakistan, Iran, Canada, Russia and Morocco. The largest chickpea producing countries are India and Pakistan. India ranks first in the world in terms of production as well as acreage followed by Pakistan.

In Maharashtra, chickpea ranks second next to pigeonpea in production and productivity.Foliar application of chitosan has been reported in many systems and for several purposes. For instance, foliar application of a chitosan pentamer affected the net photosynthetic rate of soybean and maize one day after application.This correlated with increases in stomatal conductance and transpiration rate. Chitosan foliar application did not have any effect on the intercellular CO_2 concentration.

The significant impact of chitosan on plant growth may be credited to an increase in the key enzyme activities of nitrogen metabolism and increases photosynthesis which enhances plant growth [Gornik *et al*.,2008 ; Mondal *et al*.,2012] . De-acetylation chitosan provides 5-8% nitrogen which is mostly in the form of primary aliphatic amino group which ultimately increases the leaf nitrogen content in plant tissue and chlorophyll content also.

Foliar application of chitosan especially CH_2 significantly increases nutrient elements and carbohydrates in plant tissue. The high cation exchange capacity of chitosan prevents nutrients from leaching. Chitosan absorbs the nutrients from chemical fertilizer and these exchange nutrients slowly releases to the plant.

Chitosan increases availability and uptake of nutrients through adjusting osmotic pressure and reducing accumulation of harmful free radicals by catalysing antioxidants and enzyme activities.Considering the above facts, present investigation was undertaken to study the effect of foliar application of different concentrations of chitosan on growth and productivity of chickpea.

MATERIALS AND METHODS

A field experiment was conducted during *rabi* 2020 to study the effect of different concentrations *viz*., 0, 10 ppm, 20 ppm, 30 ppm, 40 ppm, 50 ppm, 60 ppm, 70 ppm, 80 ppm, 90 ppm and 100 ppm on morpho-physiological parameters and yield of chickpea. The experiment was conducted in RBD with three replications. Two foliar applications at 25 and 40 DAS were given. Cultivar JAKI-9218 was used in the investigation. Observations on plant height were recorded at 85 DAS and at harvest. Number of branches was recorded at the time of harvest. Observations on leaf area and dry matter production were recorded at 45, 65 and 85 DAS. RGR was calculated as per formula given by Fischer (1971) and NAR was calculated as per formula given by Williams (1946). Both were calculated at 25-45, 45-65 and 65-85 DAS. Seed yield $plot^{-1}$ was recorded at the time of harvest. The observed data were analysed statistically

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during analysis of variance at 5% level of significance (Panse and Sukhatme, 1954).

RESULTS AND DISCUSSION

Plant height (cm)

Plant height is an important character of the vegetative phase and indirectly influences the yield components. It is the shortest vertical distance between the upper boundary of the main photosynthetic tissue on a plant and the stem or shoot base from the ground level.

The data on plant height as influenced by plant growth promoter chitosan at two stages of observations *viz*., 85 DAS and at maturity are presented in Table 1.

At 85 DAS, significantly maximum plant height was recorded in treatment T_7 (60 ppm chitosan). Also treatments T_8 (70 ppm), T_5 (40 ppm), T_6 (50 ppm), T_9 (80 ppm) and T_{10} (90 ppm) were found significantly superior over treatment T_1 (control), whereas treatments T_{11} (100 ppm), T_4 (30 ppm), T_3 (20 ppm) and T_2 (10 ppm) were found at par with treatment T_1 (control) in plant height at this stage of observation.

At maturity, trend was different. At this stage of observation it was noticed that significantly highest plant height was recorded with the foliar application of 60 ppm chitosan followed by 70 ppm, 80 ppm, 90 ppm, 50 ppm, 40 ppm and 100 ppm in a descending manner when compared with control. But treatments i.e.100 ppm, 30 ppm, 20 ppm and 10 ppm were found at par with treatment control in plant height.

Chitosan improved plant height might be due to increased number of internodes or length of internodes due to increased cell number (Hong Yan and Shu Yu, 2001). Increasing plant growth due to chitosan application is mainly triggered by chitosan's ability in improving plant metabolism. Chitosan is a form of polysaccharide that functions as a biological signal in cells and is able to regulate symbiotic defenses, as well as plant development processes (Dzung, 2010). Chitosan contains plant growth promoters in the form gibberellin, IAA, and Zeatin which enhances plant growth (Rekso, 2005). Chitosan is having 5-8 % nitrogen which enhances the synthesis of protein, nucleic acid and protoplasm formation. These might be the reasons in increase in plant height in the present investigation.

Farouk *et al.* (2012) reported that foliar application of chitosan @ 250 ppm, increased plant height in cowpea. Mondal *et al.* (2012) tested various concentrations of chitosan (0, 50, 25, 75 and 100 ppm), applied at 3 different stages *viz*., 35, 50, and 65 DAS. They reported that foliar application of chitosan at 100 ppm significantly increased plant height in okra.Deotale *et al.* (2018) studied the effect of different concentrations of growth regulators (chitosan and IBA) on morpho-physiological parameters on soybean. They found that foliar application of chitosan @ 25 ppm significantly enhanced plant height in soybean when applied at 30 DAS.Thakare *et al.* (2019) tried different concentrations of foliar sprays of chitosan and IBA @ 25, 50, 75, 100 and 125 ppm on morpho-physiological parameters of pigeonpea. Two foliar sprays were given at 45 and 65 DAS. They reported that foliar application of 50 ppm chitosan and 25 ppm IBA significantly enhanced plant height in pigeonpea when compared with control and rest of the treatments. Chande *et al.* (2020) reported that foliar application of 100 ppm chitosan at 25 and 45 DAS significantly increased plant height over control in groundnut.

Number of branches plant^{-1}

Branches are the site of the leaves, flower and peg formation. Hence, they are closely associated with the photosynthetic activity and yield of plant. So, number of branches is desirable attribute for higher biomass production and yield. The data were recorded at harvest and are presented in Table 1.

The observations of number of branches plant^{-1} were recorded at the time of harvest. Significantly more number of branches were seen in treatment T_7 (60 ppm) which was followed by treatments T_8 (70 ppm), T_6 (50 ppm) and T_5 (40 ppm) when compared with treatment T_1 (control). Remaining treatments *viz.,* T_{10} (90 ppm), T_{11} (100 ppm), T_3 (20 ppm), T_4 (30 ppm), T_2 (10 ppm) and T_9 (80 ppm) were found at par with the treatment T_1 (control) accordingly.

Chitosan increased growth character *viz*., number of branches might be due to increased number of internodes or length of internodes because of increased cell number (Hong Yan and Shu Yu, 2001). Increasing plant growth due to chitosan application is mainly triggered by chitosan's ability in improving plant metabolism. The proper chitosan application also enriches the availability of nutrients from the soils needed by plant to support their growth. This might be the reasons for increased number of branches in present investigation.

Mondal *et al.* (2011) studied the effect of foliar application of chitosan on Indian spinach and reported that application of chitosan @ 250 ppm expressively enhanced number of branches.Farouk *et al.* (2012) reported that foliar application of chitosan @ 250 ppm enhanced number of branches significantly in cowpea. Meshram *et al.* (2018) tested various concentrations of chitosan and IBA (25, 50, 75, 100 and 125 ppm) sprayed at 30 DAS and stated that application of 25 ppm of chitosan increased number of branches in soybean. Monirul *et al.* (2018) reported that foliar application of oligo-chitosan enhanced number of branches plant^{-1}with the application of 100 ppm chitosan in chilli and 50 ppm in tomato. Chande *et al.* (2020) observed that foliar application of 100 ppm chitosan at 25 and 45 DAS significantly enhanced number of branches plant^{-1} over control in groundnut.

Leaf area plant^{-1}

Leaf area depends upon the number and size of leaves. Leaves play an important role in the absorption of light radiations and using it in photosynthetic process. Leaf size is influenced by light, moisture and nutrients. Hence,

yield depends on leaf area of crop. Leaf area gives a fairly good idea of the photosynthetic capacity of the plant. Leaf area depends upon the number and size of leaves. Leaf area plays an important role in absorption of light radiation and using it in photosynthesis process. Leaf size is influenced by light, moisture and nutrients. Leaf area ultimately is conclusive factor of yield of particular crop.

Data regarding leaf area were recorded at three growth stages *viz*., 45, 65 and 85 DAS and are furnished in Table 1. The data exhibited significant variation regarding leaf area at all the stages of observations.

At 45 DAS, significant increase in the leaf area was depicted in the treatment T_7 (60 ppm) followed by T_8 (70 ppm) when compared with treatment T_1 (control). Along with these, treatments T_9 (80 ppm), T_6 (50 ppm), T_5 (40 ppm) and T_{10} (90 ppm) were remarkably and significantly superior over the treatment T_1 (control). While, treatments T_{11} (100 ppm), T_4 (30 ppm), T_3 (20 ppm) and T_2 (10 ppm) were found at par with the control.

At 65 DAS, remarkable and significant variation in leaf area was shown by the treatment T_7 (60 ppm) succeeded by treatments T_8 (70 ppm), T_6 (50 ppm) and T_9 (80 ppm) in a descending manner. Treatments T_{10} (90 ppm) and T_5 (40 ppm) significantly increased leaf area over the treatment T_1 (control). Rest of the treatments namely T_{11} (100 ppm), T_4 (30 ppm), T_3 (20 ppm) and T_2 (10 ppm) were found at par with the treatment T_1 (control) respectively.

At 85 DAS stage, treatment T_7 (60 ppm) was at the peak of all the treatments in the enhancement of leaf area significantly when compared with treatment T_1 (control), whereas treatments T_8 (70 ppm), T_9 (80 ppm), T_6 (50 ppm), T_5 (40 ppm) and T_{10} (90 ppm) were significantly superior over the treatment T_1 (control). Other treatments T_{11} (100 ppm), T_4 (30 ppm), T_3 (20 ppm) and T_2 (10 ppm) were in the same range of treatment T_1 (control).

Chibu and Shibayama (2001) noticed greatest chlorophyll content in the plant applied with chitosan. This contributed into the increase of the photosynthesize production and leaf area. The application of chitosan increased key enzymes activities of nitrogen metabolism and improved transportation of nitrogen in functional leaves which might be the reason for enhanced leaf area in the present study.

Rabbi *et al.* (2016) performed an experiment by applying different concentrations of chitosan *viz*., 0 (control), 25, 50, and 75 ppm at different growth stages i.e., 30 and 40 DAS on mungbean plant. It was found that application of 50 ppm chitosan prominently increased leaf area over control.Baraskar *et al.* (2018) worked out with four different plant growth regulators. Study was done to evaluate the effect of foliar sprays of plant growth regulators GA_3 (100,150,200 ppm), NAA (100,150,200 ppm), salicylic acid (500, 1000, 1500 ppm) and chitosan (100,125,150 ppm) at three different concentrations and one control (without spray) in Okra. They noted that application of 60 ppm chitosan enhanced leaf area when compared with control. Meshram *et al.* (2018) performed an experiment to study the efficacy of various concentrations of chitosan and IBA (25, 50, 75, 100 and 125 ppm) on soybean. Foliar spray was given at 30 DAS. Results showed that application of 25 ppm of chitosan increased leaf area plant^{-1}. Thakare *et al.* (2019) applied two foliar sprays of chitosan and IBA @ 25, 50, 75, 100 and 125 ppm on pigeonpea at 45 and 65 DAS. They reported that foliar application of 50 ppm chitosan and 25 ppm IBA significantly enhanced leaf area in pigeonpea when compared with control and rest of the treatments.Chande *et al.* (2020) carried out field experiment with the application of foliar spray of different concentrations of chitosan on groundnut. Application of 100 ppm chitosan at 25 and 45 DAS significantly increased leaf area when compared with control.

Dry weight plant^{-1}

Total dry matter is an important criterion. It determines source sink relationship and depends upon the net gain in processes on anabolism and catabolism of plant.

The data pertaining to mean dry matter accumulation plant^{-1} as influenced by different stages of crop growth are presented in Table 1.

At 45 DAS, the significant enhancement in the dry matter production was recorded in the treatment T_7 (60 ppm) followed by treatment T_8 (70 ppm) when compared with treatment T_1 (control). Moreover, treatments T_9 (80 ppm), T_6 (50 ppm), T_5 (40 ppm) and T_{10} (90 ppm) were also found significantly superior over treatment T_1 (control). The leftover treatments *viz.,* T_{11} (100 ppm), T_4 (30 ppm) and T_3 (20 ppm) were found at par with the treatment T_1 (control).

At 65 DAS observation, significantly maximum dry matter production was noted in the treatment T_7 (60 ppm) when resembled with treatment T_1 (control). Treatments T_8 (70 ppm), T_9 (80 ppm), T_6 (50 ppm), T_5 (40 ppm) and T_{10} (90 ppm) were also found significantly superior over the treatment T_1 (control) in dry matter production. While, other treatments T_{11} (100 ppm), T_4 (30 ppm), T_3 (20 ppm) and T_2 (10 ppm) were found at par with treatment T_1 (control) in dry matter production.

At 85 DAS, treatment with the foliar application of 60 ppm chitosan was significantly at the crest over all other treatments and control except treatment T_8 (70 ppm). Treatments with the foliar application of 80 ppm and 50 ppm chitosan were also significantly supercilious over the control, whereas the rest of the treatments i.e. application of 40 ppm, 90 ppm, 100 ppm, 30 ppm, 20 ppm and 10 ppm chitosan were at parity with the treatment control in the dry matter accumulation production.

It is reported that chitosan has molecular signals that serve as plant growth promoters. Stimulating effect of chitosan on plant growth *viz*., dry matter maybe attributed to an increase in the availability and uptake of water and essential nutrients through adjusting osmotic pressure and reducing the accumulation of harmful free radicals by increasing antioxidants and enzyme activities (Guan *et al.,* 2009) or may occur due to increment in the main enzymatic

activities of nitrogen metabolism (nitrate reductase, glutamine synthetase and protease) and also improved the transportation of nitrogen (N) in the functional leaves which enhance photosynthesis process and improved plant growth and development (Mondal *et al*., 2012). Higher area of leaves and chlorophyll content has contributed into the increase of the photosynthesize production which reflects significant amount of dry weight (Chibu and Shibayama, 2001). These might be the reasons for increase in dry matter in the present investigation.

To optimize vegetative growth, the application of chitosan should be done at the proper concentration and frequency. The proper chitosan application enriches the availability of nutrients in the soil needed by plants to support their growth.

Meshram *et al.* (2018) studied the efficacy of foliar application of chitosan and Indole-3-buteric acid on growth and productivity of soybean and found that the application of chitosan @ 25 ppm improved dry weight significantly when applied at 30 DAS.Baraskar *et al.* (2018) tested four different plant growth regulators *viz.,* GA_3 (100,150,200 ppm), NAA (100,150,200 ppm), salicylic acid (500, 1000, 1500 ppm) and chitosan (100, 125,150 ppm) at three different concentrations and one control (without spray) on okra. They concluded that foliar application of 100 ppm chitosan significantly increased dry weight when compared with control. Thakare *et al.* (2019) tested different concentrations of foliar sprays of chitosan and IBA @ 25, 50, 75, 100 and 125 ppm on pigeonpea. Two foliar sprays were given at 45 and 65 DAS.They reported that foliar application of 50 ppm chitosan and 25 ppm IBA significantly enhanced dry matter in pigeonpea when compared with control and rest of the treatments. Chande *et al*. (2020) carried out an experiment on groundnut and examined that total dry weight drastically increased with the foliar application of 100 ppm chitosan at 25 and 45 DAS.

Growth analysis

Plant growth analysis refers to a set of concepts and equations by which changes in size of plants over time can be summarised and dissected in component variables. It is often applied in the analysis of growth of individual plants, but can also be used in a situation where crop growth is followed over time.Growth analysis is one of the measures for accessing the seed yield of plant. The physiological basis of yield difference can measured through an evaluation of difference in growth parameters and their impact on yield. The productivity of crop may be related with the parameter such as RGR, NAR and partitioning of total photosynthates into economic and non- economic sink.

Chitosan affected the physiological characters of chickpea which ultimately determined the yield and yield attributing characters. The data regarding RGR was recorded at 25-45, 45-65 and 65-85 DAS and are mentioned in Table 1.

Relative growth rate

At 25-45 DAS, significantly highest RGR was noted in the treatment T_7 (60 ppm) followed by treatments T_8 (70 ppm), T_9 (80 ppm) and T_6 (50 ppm) when compared with treatment T_1 (control) ,whereas treatments T_5 (40 ppm), T_{10} (90 ppm), T_{11} (100 ppm), T_4 (30 ppm), T_3 (20 ppm) and T_2 (10 ppm) were found at par with the treatment T_1 (control) when calculated.

At 45-65 DAS, significant rise in RGR was observed in the treatment T_7 (60 ppm) followed by treatments T_8 (70 ppm), T_9 (80 ppm), T_6 (50 ppm), T_5 (40 ppm), T_{10} (90 ppm), T_{11} (100 ppm) and T_4 (30 ppm) when compared with treatment T_1 (control). Moreover, treatments T_3 (20 ppm) and T_2 (10 ppm) were found at par with treatment T_1(control).

At 65-85 DAS, significant increase in RGR was depicted in the treatment T_7 (60 ppm) succeeded by treatments T_8 (70 ppm), T_9 (80 ppm), T_6 (50 ppm), T_5 (40 ppm), T_{10} (90 ppm), T_{11} (100 ppm), T_4 (30 ppm) and T_3 (20 ppm) when compared with treatment T_1 (control). Whereas, treatment T_2 (10 ppm) alone was noted at par with treatment T_1 (control).

Mondal (2012) carried out a field experiment to study the effect of different concentrations of chitosan (0, 50, 75, 125 and 150 ppm) on okra. He found that application of chitosan remarkably increased relative growth rate by the application of 100 ppm chitosan.Zhang *et al.* (2018) investigated the effect of 1 g l^{-1} chitosan, 0.5 mM spermine or 1 g l^{-1} chitosan + 0.5 mM spermine on white clover. Results revealed that application of chitosan significantly gave highest relative growth rate when compared with rest of the treatments.Meshram *et al.* (2018) conducted an experiment and applied chitosan and IBA with different concentrations (25, 50, 75, 100 and 125 ppm) on soybean crop. They noted that foliar application of 25 ppm chitosan enhanced RGR significantly. Chande *et al*. (2020) examined the effect of chitosan with different concentrations (0, 25, 50, 75, 100 and 125 ppm) on groundnut. They observed that application of chitosan at 100 ppm at 25 and 45 DAS increased RGR significantly over control.

Net assimilation rate

Net assimilation rate (NAR), synonymously called as unit leaf rate 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 (Gregory, 1926). NAR is closely connected with photosynthetic efficiency of leaves, but it is not a pure measure of photosynthesis. NAR depends upon the excess of dry matter gained over the loss in respiration. It is increase in plant dry weight $unit^{-1}$ area of assimilatory tissue $unit^{-1}$ time.

The data regarding NAR were recorded at 25-45, 45-65 and 65-85 DAS and are presented in Table 1.

At 25-45 DAS, treatment T_7 (60 ppm) was observed significantly highest in enhancement in NAR followed by treatments T_8 (70 ppm), T_9 (80 ppm), T_6 (50 ppm), T_5 (40 ppm), T_{10} (90 ppm), T_{11} (100 ppm) and T_4 (30 ppm) when compared with treatment T_1 (control). Whereas treatments T_3 (20 ppm) and T_2 (10 ppm) were noted at par with treatment T_1 (control) during the study.

At 45-65 DAS, significant increase in NAR was noted in the treatment T_7 (60 ppm) followed by treatments T_8 (70 ppm), T_9 (80 ppm), T_6 (50 ppm), T_5 (40 ppm) and T_{10} (90 ppm) when compared with treatment T_1 (control). While, treatments T_{11} (100 ppm), T_4 (30 ppm), T_3 (20 ppm) and T_2 (10 ppm) were found at par with the treatment T_1(control).

At 65-85 DAS, a remarkable and significant increase in NAR was seen in the treatment T_7 (60 ppm) followed by treatments T_8 (70 ppm), T_9 (80 ppm), T_6 (50 ppm), T_5 (40 ppm), T_{10} (90 ppm), T_{11} (100 ppm) and T_4 (30 ppm) when compared with the treatment T_1 (control). Remaining treatments T_3 (20 ppm) and T_2 (10 ppm) were found at par with treatment T_1(control).

Meshram *et al*. (2018) conducted an experiment to study the impact of chitosan and IBA with different concentrations (0, 25, 50, 75, 100 and 125 ppm) on soybean. They concluded that highest net assimilation rate obtained by the application of 25 ppm chitosan at 30 DAS.Shaheen *et al.* (2019) investigated the effect of bio stimulants on plant growth and yield of potato. Foliar application of some plant growth stimulants was done (amino acid, 2.5 cm^3 l^{-1}, chitosan 5 cm^3 l^{-1}, potassium silicate 2 cm^3 l^{-1} and control treatment) for 3 times in 10 days interval starting at 40 days after planting date. They found that application of chitosan @ 5 cm^3 l^{-1} significantly increased net assimilation rate. Chande *et al*. (2020) specified that foliar application of chitosan @ 100 ppm at 25 and 45 DAS significantly enhanced net assimilation rate in groundnut over control.

Seed yield plot^{-1}

Treatment with 60 ppm chitosan as a foliar spray at 25 and 40 DAS gave the significantly highest yield followed by treatments with the application of 70 ppm, 80 ppm, 50 ppm, 60 ppm, 90 ppm, 100 ppm and 30 ppm chitosan in decreasing manner when compared with control treatment. On the other hand, treatments with the application of 20 ppm and 10 ppm chitosan were found at par with the treatment control.

The increase in chickpea yield due to chitosan application may be due to its effect in stimulating physiological processes, improving vegetative growth, followed by the active translocation of photo assimilates from source to sink tissue (Sharifa, 2013). Chitosan when applied externally was observed to increase crop growth and ultimately the yield. It improves the nutritional status of plant system. Chitosan increases the absorption and translocation of nutrients and ultimately influences the yield.

All the physiological activities of plant significantly contribute to the quantitative trait i.e. seed yield .It is influenced by morpho-physiological parameters such as plant height, number of branches, total dry matter production, leaf area. The application of different concentrations of chitosan (10, 20, 30, 40, 50, 60, 70, 80, 90 and 100 ppm) remarkably enhanced all the above parameters. Chitosan functions as a carbon source for microbes in the soil, accelerates the process of transforming organic compounds into inorganic compounds and helps root systems in plants to absorb more nutrients from the soil.

This is so because chitosan is easily absorbed by the roots after being decomposed by bacteria in the soil. Thus, the administration of chitosan act as an organic fertilizer which plays an important role in supporting plant growth and productivity.

Rabbi *et al.* (2016) formulated an experiment to study the effect of chitosan (0, 25, 50, 75 and 100 ppm) sprayed at 30 and 40 DAS on mungbean. Results showed that application of chitosan @ 50 ppm significantly enhanced seed yield. Deotale *et al.* (2019) studied the effect of foliar sprays of chitosan @ 25, 50, 75, 100 and 125 ppm on yield of pigeonpea. They reported that foliar application of 50 ppm chitosan significantly enhanced seed yield in pigeonpea over control and rest of the treatments. Chande *et al*. (2020) conducted an experiment on various concentrations of chitosan and found that 100 ppm chitosan at 25 and 40 DAS gave significantly more seed yield over control in groundnut.

Table 1. Effect of chitosan on growth and productivity in chickpea

Treatments	Plant height (cm)		No. of branches plant^{-1}	Leaf area (dm^2) plant^{-1}			Dry weight (g) plant^{-1}			RGR (g g^{-1} day^{-1})			NAR (g dm^{-2} day^{-1})			Yield plot^{-1} (kg)
	85 DAS	At Maturity	At Harvest	45 DAS	65 DAS	85 DAS	45 DAS	65 DAS	85 DAS	25-45 DAS	45-65 DAS	65-85 DAS	25-45 DAS	45-65 DAS	65-85 DAS	After Harvest
T1(control)	19.08	19.84	2.66	1.81	2.01	2.05	3.47	5.83	8.13	0.063	0.045	0.044	0.063	0.043	0.039	0.821
T2(10 ppm)	19.66	20.51	2.76	2.08	2.13	2.61	3.62	6.15	8.19	0.066	0.048	0.046	0.060	0.044	0.040	0.889
T3(20ppm)	19.92	21.34	2.83	2.08	2.27	2.68	4.30	6.34	8.80	0.081	0.051	0.049	0.071	0.045	0.043	0.933
T4(30ppm)	20.02	21.43	2.80	2.26	2.45	2.69	4.41	6.56	9.25	0.084	0.052	0.051	0.079	0.047	0.046	0.980
T5(40ppm)	21.80	22.33	3.10	2.71	2.79	3.12	4.76	7.51	9.98	0.085	0.056	0.053	0.091	0.052	0.050	1.050
T6(50ppm)	21.30	22.90	3.16	2.85	3.23	3.36	4.92	7.53	10.33	0.094	0.058	0.056	0.094	0.057	0.055	1.069
T7(60ppm)	23.91	24.11	3.46	3.64	3.67	4.69	7.41	9.83	12.73	0.149	0.065	0.060	0.144	0.062	0.059	1.169
T8(70ppm)	22.08	23.83	3.40	3.16	3.35	3.50	6.28	8.32	11.06	0.124	0.060	0.058	0.140	0.060	0.058	1.124
T9(80ppm)	21.76	23.75	2.73	2.91	3.19	3.44	4.99	8.03	10.41	0.096	0.059	0.057	0.135	0.058	0.056	1.080
T10(90ppm)	21.73	22.28	3.00	2.51	2.83	3.12	4.63	7.35	9.69	0.088	0.053	0.052	0.086	0.050	0.048	1.047
T11(100ppm)	20.72	21.43	2.93	2.38	2.62	2.71	4.55	6.91	9.28	0.087	0.052	0.050	0.080	0.048	0.047	1.031
SE (m)±	**0.582**	**0.746**	**0.151**	**0.199**	**0.233**	**0.254**	**0.391**	**0.460**	**0.712**	**0.0192**	**0.0023**	**0.0017**	**0.0031**	**0.0023**	**0.0017**	**0.049**
CD at 5%	**1.719**	**2.203**	**0.446**	**0.587**	**0.690**	**0.751**	**1.155**	**1.357**	**2.102**	**0.0566**	**0.0068**	**0.0049**	**0.0092**	**0.0067**	**0.0050**	**0.146**

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