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**Research article**

# Augmentation of Yield and Protein Content in Seeds of Chickpea (*Cicer arietinum* L.) Through $GA_3$ Spray Application at Phenological Stages of Crop Development

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## ABSTRACT

A experiment was conducted at Department of Botany, Aligarh Muslim University, Aligarh in the *'rabi'* season of 11th October, 2010 and harvest on the 30th March, 2011 to screening the effects of 4 levels of $GA_3$ spray (0, $10^{-7}$,$10^{-6}$ and $10^{-5}$M $GA_3$) at six spray stages of crop development on growth parameters viz., root length, root dry weight per plant; photosynthetic aspects like carbonic anhydrase (CA) activity, leaf chlorophyll (Chl) content; yield attributes, i.e., 100-seed weight, harvest index (HI), biological yield and seed yield per plant and seed protein content of chickpea (*Cicer arietinum* L.). The potted plants were then analyzed at 90 and 100 DAS for growth and photosynthetic aspects. The seed yield per plant and seed protein content were estimated at harvest. All parameters were found to be significantly stimulated by the application of $GA_3$, with maximum promotion being reported at the stage of 60-70 DAS with $10^{-6}$MGA.

**Key Words:** Biological yield, chickpea, carbonic anhydrase activity, dry weight, harvest index, seed yield,

**Abbreviations:** Chl, chlorophyll, CA, carbonic anhydrase activity, HI, harvest index, $GA_3$, gibberellic acid

## INTRODUCTION

The pulses make a major contribution to human diet in Asian countries where their nutritional contribution is of paramount significance. Chickpea is one of the legume crops cultivated by humans. It is of two types 'Desi' and 'Kabuli'. For production, chickpea stands the first position in India and third position at world level [1]. Chickpea is cultivated in arid and semi-arid areas around the world with an area of 11.1 million hectares adding 9.3 million tonnes of grain with an average productivity of 838 kg/ha. India is the largest producer and consumer in the world of chickpea. This crop is grown on 8.31 million hectares of our country with the annual production of 7.58 million tonnes and average productivity of 933 kg/ha. There has been a shift in chickpea area from cooler long duration, highly productive environment to warm, short duration, rainfed and less productive environment. Though chickpea is grown in our country in the largest area in comparison with the other countries of the world, but productivity at 911 kg/ha is much lower than the developed countries of world, such as 2833.3 kg/ha of China,1668.4 kg/ha of Canada and 1488.6 kg/ha of USA. During the period of 1990-2000, area has marginally declined and the productivity has steadily increased. There has been a major shift in the area of chickpea in the country. The expansion of irrigation facilities in northern India has led to replacement of chickpea with wheat and mustard in larger areas [2-3].

Moreover, there is limitation on increasing the acreage for cultivation, it is, therefore, highly logical to innovate ways that can improve its productivity. In this regard, an approach could be to make plants utilize fully the available resources leading to maximum harvesting of solar energy and subsequently enhancing the active sites. To attain such goal, the use of plant growth regulators (PGRs) may play an important role as they are regarded to affect many aspects of plant development, including photosynthetic rate ($P_N$), N-fixation, water and mineral uptake, HI [4]. Among PGRs, GA occupies a prominent position in mediating a variety of plant physiological processes including seed germination, leaf expansion, flower and fruit set, dry matter production, photosynthesis, translocation of food material and synthesis of mRNA coding for hydrolytic enzymes. The superiority of GA to the above mentioned PGRs has also been substantiated in the several preliminary studies.

Moreover, $GA_3$ enhance a number of physiological processes including activity of RuBPcase, breaking of seed and bud dormancy, cell-wall plasticity, cell elongation, flowering, $P_N$, protein-synthesis, phloem-loading, relative growth rate, stomatal aperture, senescence, stem-elongation, seed-germination, synthesis and secretion of hydrolyzing enzymes particularly α-amylase for promoting hydrolysis of storage-reserves, transpiration rate, transcription of messenger (m)-RNA and vernalization [5]. Keeping its prominent role in various physiological processes of plants, it is logical to exploit its potential by way of establishing its appropriate concentration and operational growth stage/s for foliar application. The author hypothesized that the spray levels of the $GA_3$ as well as spray stage/s will affect the response of chickpea in terms of seed yield and seed protein content of chickpea to a great extent.

## MATERIALS AND METHODS

A pot experiment was conducted during the *'rabi'* season of 2010-2011 on chickpea cultivar (DCP 92-3) in A M U, Aligarh. It is situated at 27.88 ˚N latitude 78.08˚E longitude and 180 m average altitude with an area of 3700.4 sq

km. The soil sample was analyzed in the Soil Testing Laboratory, Government Agriculture Farm, Quarsi, Aligarh for various physico-chemical properties. Before sowing, the earthen pots of equal size (25 cm height x 25 cm diameter) were filled with the homogenous mixture of soil and FYM in the ratio of 5:1 at the rate of 6 kg /pot. The required number of pots was arranged according to a factorial randomized design. Authentic seeds of the high yielding cultivar of chickpea, namely DCP 92-3 was obtained from the IIPR, Kanpur (Uttar Pradesh). The healthy seeds were soaked with double distilled water (DDW) for 2 h and then were surface sterilized with absolute ethyl alcohol followed by washing with DDW.

Prior to the foliar treatments, 100 milli-litre (Ml) stock solutions of $GA_3$ (SIGMA USA) at $10^{-3}$M were prepared. The amount of $GA_3$ was dissolved in 10 Ml ethyl alcohol and the final volume was made 100 Ml using DDW. Further dilutions of the stock solutions were made with DDW as per requirement. Four concentrations of aqueous solution of $GA_3$ for foliar spray treatment, viz. 0 (water), $10^{-7}$, $10^{-6}$ and $10^{-5}$M $GA_3$ and the six spray stages viz. 60, 70, 80, 60-70, 70-80 and 60-70-80 DAS. A uniform recommended basal dose of 17.9 mg N+13.4 mg P/kg soil was applied to all pots with the half dose of N and full dose of P giving at the time of sowing and the remaining half dose of N after 30 DAS. The remaining amount of N dose was compensated with urea. Finally, four plants per pot were maintained. A water-sprayed control was also included in the scheme of treatments. The experiment was performed according to a factorial randomized design with four replicates of each treatment. The performance of the crop was assessed with regard to root length, root dry weight, leaf Chl content, CA activity at 90 and 100 DAS and 100-seed weight, seed yield per plant, biological yield, HI and seed protein at harvest.

Length of root on per plant basis was determined separately with the help of a metre scale. The root of each plant was dried in a hot air oven at 80˚C for 24 h and their dry weight was obtained separately with the help of an electronic balance. The chlorophyll content was estimated in fresh leaves collected randomly from each replicate by the method [6]. The details are given below. The total chlorophyll content was calculated using the following formula:

Chlorophyll content = $\frac{20.2\times(OD645)+8.02\ (OD\ 663)\times V\times W}{1000}$ mg $g^{-1}$ (leaf fresh mass)

V= Volume of the extract in ml

W= Weight of the fresh leaves used for the extraction of the pigment in g.

Carbonic anhydrase (CA) activity was determined in fresh leaves collected randomly from each replicate. The enzyme CA catalyzes the reversible hydration of $CO_2$ to give the bicarbonate ion ($HCO_3^-$).

$$H_2O + CO_2 \overset{CA}{\rightleftharpoons} H^+ + HCO_3^-$$

The activity of the enzyme was estimated by adopting the method [7] and was calculated by the following formula:

$$\frac{0.5\times V\times N}{W\times T}$$ m mol (CO2) $mg^{-1}$ (leaf fresh mass)$min^{-1}$.

V= Difference in volume (ml) of HCl used in blank and test sample titration

N= Normality of HCl

W= Fresh weight of tissue in mg

T= Duration of the catalytic action of the enzyme (min.)

Finally, the activity of the enzyme was expressed in terms of mol $CO_2$ $kg^{-1}$(leaf fresh mass) $s^{-1}$.

The weight of 100 seeds was determined with the help of an electronic balance. The total seeds of two plants were threshed, cleaned and allowed to dry in the sun for some time and their weight was obtained with the help of an electronic balance, with expressing their weight on per plant basis. The biological yield was recorded before the threshing of plants. It was determined by weighing the dry mass of the two complete plants with the help of an electronic balance, with expressing the yield on per plant basis. The proportion of the biological yield representing the economic yield is called HI. The HI was computed by dividing the yield of a plant by the biological yield of the plant and expressed on percent basis. HI was calculated by the following formula:

$$HI = \frac{\text{Economic yield}}{\text{Biological yield}} \times 100$$

The total protein content in the dry seeds was estimated by adopting the methodology [8].

**Data analysis**

All data were analyzed statistically adopting the analysis of variance technique [9]. In applying the F test, the error due to replicates was also determined. When 'F' value was found to be significant at 5% level of probability, critical difference (CD) was calculated.

## RESULTS AND DISCUSSION

The results (Tables 1-7; Figs.1-2) are summarized below. The effect of various concentrations of leaf-applied GA and their application at different growth stages alone or in combination was found significant for all studied parameters. $F_{10^{-6}\,M\,GA}$ gave 48.94 and 38.75% higher value of root length at 90 and 100 DAS respectively than $F_W$. Foliar application stage $F_{60\text{-}70\ DAS}$ resulted in 13.12 and 15.40% higher value at 90 and 100 DAS respectively than $F_{80\ DAS}$. Interaction $F_{10^{-6}\,M\,GA} \times F_{60\text{-}70\ DAS}$ gave 104.82 and 74.91% higher value at 90 and 100 DAS respectively than the least value giving interaction $F_W \times F_{80\ DAS}$. Similarly, $F_{10^{-6}\,M\,GA}$ gave 122.40 and 71.19% higher value of root dry weight at 90 and 100 DAS respectively than $F_W$. $F_{60\text{-}70\ DAS}$ gave 9.34 and 32.68% higher value at 90 and 100 DAS respectively than $F_{80\ DAS}$ which gave the minimum value. $F_{10^{-6}\,M\,GA} \times F_{60\text{-}70\ DAS}$ gave 141.58 and 149.35% higher value at 90 and 100 DAS respectively than $F_W \times F_{80\ DAS}$ (Table 1-2).

In addition, $F_{10^{-6}\,M\,GA}$ gave 64.91 and 39.83% higher value of leaf Chl content at 90 and 100 DAS respectively than $F_W$. $F_{60\text{-}70\ DAS}$ gave 3.25 and 38.72 % higher value at 90 and 100 DAS respectively than $F_{80\ DAS}$. $F_{10^{-6}\,M\,GA} \times F_{60\text{-}70\ DAS}$ gave 69.24 and 100.30% higher value at 90 and 100 DAS respectively than $F_W \times F_{80\ DAS}$. Next in this series, $F_{10^{-6}\,M\,GA}$ gave 48.75and 38.17% higher value of CA activity also at 90 and 100 DAS respectively than $F_W$. $F_{60\text{-}70\ DAS}$ gave 12.11 and 18.07% higher value at 90 and 100 DAS respectively than $F_{80\ DAS}$. $F_{10^{-6}\,M\,GA} \times F_{60\text{-}70\ DAS}$ gave 68.90 and 117.54% higher value at 90 and 100 DAS respectively than the least value giving interaction $F_W \times F_{80\ DAS}$ (Table 3-4).

$F_{10^{-6}\,M\,GA}$ gave 38.13% higher value of 100-seed weight than $F_W$. $F_{60\text{-}70\ DAS}$ gave 16.37% higher value than $F_{80\ DAS}$. $F_{10^{-6}\,M\,GA} \times F_{60\text{-}70\ DAS}$ gave 75.27% higher value than $F_W \times F_{80\ DAS}$ (Table 5). $F_{10^{-6}\,M\,GA}$ gave 79.93% higher

value of seed yield per plant than $F_W$. $F_{60\text{-}70\ DAS}$ gave 8.29 % higher value than $F_{80\ DAS}$. $F_{10^{-6}M\ GA} \times F_{60\text{-}70\ DAS}$ gave 113.94% higher value than $F_W \times F_{80\ DAS}$ (Fig. 1). Also, $F_{10^{-6}M\ GA}$ gave 31.63% higher value of BY than $F_W$. Spray stage $F_{60\text{-}70\ DAS}$ gave 5.90 % higher value than $F_{80\ DAS}$. $F_{10^{-6}M\ GA} \times F_{60\text{-}70\ DAS}$ gave 53.21% higher value than $F_W \times F_{80\ DAS}$. $F_{10^{-6}M\ GA}$ gave 18.99% higher value of HI than $F_W$. Spray stage $F_{60\text{-}70\ DAS}$ gave 7.31% higher value than $F_{80DAS}$. $F_{10^{-6}M\ GA} \times F_{60\text{-}70\ DAS}$ gave 29.85% higher value than $F_W \times F_{80\ DAS}$ (Table 6-7). $F_{10^{-6}M\ GA}$ gave 24.42% higher value of seed protein content than $F_W$. $F_{60\text{-}70\ DAS}$ gave 7.05% higher value than $F_{80DAS}$. $F_{10^{-6}M\ GA} \times F_{60\text{-}70\ DAS}$ gave 48.57% higher value than $F_W \times F_{80\ DAS}$ (Fig. 2).

GA occupies a prominent position in mediating a variety of plant physiological processes including seed germination, leaf expansion, flower and fruit set, dry matter production, photosynthesis, translocation of food material and synthesis of mRNA coding for hydrolytic enzymes [10]. The vegetative and reproductive growth of plants depends mainly on their ability to fix C in organs having chloroplasts followed by the utilization of the photosynthates for sink organs. As the C fixing ability of plants is influenced by $GA_3$ among other factors, the availability of carbon with other macro-nutrients to chickpea affects production of dry matter and partitioning of photosynthates [11].

The enhancing effect of foliar application of GA ($10^{-6}$M $GA_3$) at 60-70 DAS over the water-sprayed control as well as its superior effect among the various other levels on root length can be traced to its various roles in plants. Earlier studies have reported that $GA_3$ as foliar spray on transplanted cutting increased plant height. Also, $GA_3$ foliar spray increased plant height and leaf length. An increase in growth parameters like shoot and root lengths, fresh and dry weights in plants sprayed with $GA_3$ in accordance with the known fact that exogenous application of PGRs evoke the intrinsic genetic potential of the plant causing increase in elongation of internodes as a consequence of cell division and cell wall extensibility [12].

For example, application of GA improves, among other processes, absorption and use efficiency of nutrients, activity of enzymes, cell division and cell enlargement, chlorophyll content, elongation of internode, membrane permeability, $P_N$, nucleic acid and protein synthesis, and transport of photosynthates [13]. Foliar application of GA could have led to the observed improvement in root length per plant of the treated plants. Thus, establish the superiority of foliar application of GA over water-sprayed control. These results broadly corroborate the findings of earlier workers [14, 15,16].

Improvement in root length and root dry weight of chickpea would have contributed in improving the ability of treated plants for nodule and biomass production [17]. This is manifested in the observed improvement in their dry weight is further confirmed by correlation studies emphasizing a significant and positive contribution towards the other growth parameters. Moreover, it contributes towards enhancing the capacity of the treated plants for biomass production as reflected in shoot and root dry weight of the plants. This enhancement could be the results of increased uptake of nutrients, enhanced photosynthesis and improved translocation of photosynthates and other metabolites to the reproductive parts [18, 19]. This sustained increase in the above mentioned parameters of the treated plants which is expected to culminate the maximization of seed yield and seed protein content.

The augmenting effect of leaf-applied GA over the water-sprayed control as also its superior effect at $10^{-6}$M on leaf Chl content and CA activity studied at 90 and 100 DAS is worth mentioning. The increase in leaf Chl and

CA activity can be attributes to the hormone-induced increase in transcription and/or translation of the gene that codes for CA and Chl and to its role in enhancing the permeability of membranes and absorption of nutrients [20]. These results are also in accordance with the data of earlier workers on CA activity and on leaf Chl content. Enhancement in leaf-nutrients, particularly N due to $GA_3$ application could be attributed to the compositional or chemical change in plants leading to alterations in N concentration. Presumably, increased uptake of nutrients enhanced photosynthesis and improved translocation of photosynthates and other metabolites to the sinks that might have contributed to the improved yield of $GA_3$ treated plants [21]. These findings are in accordance with data on $GA_3$ effects reported regarding plant nutrient elements [22, 23, 24].

This may also be attributed, as for growth characters, to its roles on one hand and compensation of the 'hidden hunger' for GA by its foliar application on the other. These results also corroborate the findings of [25, 26, 27] on CA activity, of [28] on Chl content. Enhanced rate of CA activity would have resulted in improving the $P_N$ and gs of treated plants (data unpublished). Such a response of the plants to the applied $GA_3$ is expected because this PGR has diverse role in the physiological processes and consequently improved the stomatal conductance that might have facilitated the diffusion of $CO_2$ into the stomata. In turn, the $CO_2$ might have been acted upon by CA [29]. Finally, $CO_2$ could be reduced by Rubisco in the chloroplast stroma. A probable reason for the enhancement of CA activity due to application of foliar spray of $GA_3$ might be the *de novo* synthesis of CA, which involves translation/transcription of the associated DNA. Enhancement in the CA activity I treated plants might have responsible for the enhanced rate of $CO_2$ fixation and hence have resulted in significant increase in fresh and dry weight of the treated plants [30].

Likewise, increased NR activity (data not published) might be responsible for increasing biosynthesis of Chl that in turn would have improved $P_N$ of treated plants. In fact, a number of studies have demonstrated an increased rate of $CO_2$ fixation in a variety of plant species by the application of nano-molar concentrations of $GA_3$ [31]. This proposition is further confirmed by correlation studies emphasizing a positive and significant correlation between these pairs of parameters. The increase in the number of pods per plant and 100-seed weight resulting from the foliar application of GA in comparison with the water-sprayed control as well as its superior effect at applied at $10^{-6}$ M on these parameters is worth mentioning.

The increase in the above yield attributes may be traced to its various roles mentioned in introduction leading to observed higher values for growth characters and, physiological and biochemical parameters of treated plants. Moreover, it mediates differentiation [32], leading to enhanced number of flowers which develop into pods. As stated that it plays role in cell division and cell enlargement [33], resulting in proper development of under-developed pods especially at the terminal end of branches [34, 4, 35]; CA supplying sufficient C skeleton; and membrane permeability and transport of photosynthates favouring partitioning hence higher values for the yield parameters of treated plants. These results broadly corroborate the findings of [36].

The augmenting effect of foliar treatment with $10^{-6}$M GA for 60-70 DAS over water-spray treatment on pods per plant and seeds per pod and also on 100-seed weight is understandable. This may be due to its roles mentioned in introduction for improving these parameters and offset of the 'hidden hunger' for GA by its foliar application. Similar results were also obtained by [4]. The increased yield attributing parameters of treated plants,

particularly pods per plant and 100-seed weight are likely to have contributed to the improved seed yield. This proposition is confirmed by correlation studies also wherein various yield characters may be noted to the positively and significantly correlated with seed yield. The observed increase in seed protein content due to foliar application of GA (Fig. 2) is not surprising. An improvement in protein synthesis may result from the foliar application of GA [37], hence higher value for seed protein content. These results broadly corroborate with the findings of [38, 39] on GA application.

## CONCLUSION

The interaction of GA spray concentration at $10^{-6}$M with spray stage 60-70 DAS ($10^{-6}$M GA x 60-70 DAS) gave the maximum values for most parameters and the least value giving interaction was found as water x 80 DAS.

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## REFERENCES

[1] Arnon, D.I. Copper enzymes in isolated chloroplasts. Polyphenol oxidase in *Beta vulgaris.* Plant Physiology. 24., 1949, 1-15.

[2] Lowry, O.H., Rosebrough, N.J., Farr, A.L. and Randall, R. J. Protein measurement with the Folin phenol reagent. Journal Biological Chemistry. 193., 1951, 265-275.

[3] Dwivedi, R.S. and Randhawa, N.S. Evaluation of rapid test for the hidden hunger of zinc in plants. Plant Soil. 40., 1974, 445-451.

[4] Gomez, K.A. and Gomez, A.A. (1984). *Statistical Procedures for Agricultural Research*. 2nd Ed. J. Wiley and Sons, New York.

[5] Hussein, M.M.M. Effect of gibberellic acid and chemical fertilizers on growth and chemical composition of *Cryptostegia grandiflora*, R. Br. plants. Journal of Horticultural Sciences of Ornamental Plants, 1., 2009, 27-38.

[6] Iqbal, H. F., Tahir, A., Khalid, M. N., I-ul-Haq and Ahmad, A.N. Response of chickpea (*Cicer arietinum* L.) growth towards the foliar application of gibberellic acid at different growth stages. Pakistan Journal of biological Sciences, 4., 2001, 433-434.

[7] Khan, T.A Mazid M, Azam A, Ansari, S.A, and Naeem, A. Zinc oxide Nanoparticles promotes the aggregation of Conconavalin. A: International Journal of Peptide Research and Therapeutics. 2012. 2(4): 23-29.

[8] Khan, T.A, Mazid, M and Quddusi, S. Role of organic and inorganic chemicals in plant-stress mitigation. Approaches to Plant Stress and their Management (Ed.).P.K.Gaur and P.Sharma. DOI-10.1007/978-81-322-1620-9-3. Springer, India, 2014. Pp. 39-52.

[9] Khan, T. A., and Mazid, M. Nutritional significance of sulphur in pulse cropping system. Biology and Medicine. 2011. 3 (2): 114-133.

[10] Khan,F Mazid, M., Khan, T.A. Patel, H .K, Rajiv. R. Chowdhury. Plant derived pesticides in control of Lepidopterian insects: Dictum and Directions. Research Journal of Biology. 2014: 2 (1): 1-10.

[11] Khan, T. *Studies on the Effect of Soil and Foliar Application of Nutrients on the Performance of Mustard*. Ph.D. thesis, Aligarh Muslim University, Aligarh, 1993, India.

[12] Jafri, N. *Study of the Effect of $GA_3$ Application on the Performance of Sunflower*. M.Phil. Dissertation, Aligarh Muslim University, Aligarh, 2009, India.

[13] Mazid, M. Application of spray and seed priming $GA_3$ with P and S ameliorate seed protein content by augmenting photosynthetic attributes, enzymes activities and leghemoglobin content of chickpea. International Journal of Basic and Applied Biology, 2014b: 1(2): 14-19.

[14] Kumar, S.P., Singh, R.P., Katiyar, C.P. and Khan, A.A.V. (1996). Beneficial effect of some plant growth regulators on aged seeds of okra (*Abelmoschus esculenthus* (L.) Moench) under field conditions. Seeds Research. 1996, 24: 11-14.

[15] Kumar, N., Khangarot, S.S. and Meena, R.P. Effect of sulphur and plant growth-regulators on yield and quality parameters of chickpea (*Cicerarietinum* L.). Annals of Agricultural Reserach. New Series. 2003, 24: 434-436.

[16] Mazid, M. Seed priming application of gibberellic acid on growth, biochemical, yield and protein status of Chickpea (Cicer arietinum L. cv. DCP 92-3). International Journal of Genetic Engineering and Biotechnology. 2014a, 5(1): 17-22.

[17] Liu P.B.W. and Loy, B. Action of gibberellic acid on cell proliferation in the sub-apical shoot meristem of watermelon seedlings. American Journal of Botany, 1976, 63: 700-704.

[18] Mazid, M., Khan, T.A., Mohammad, F. Medicinal Plants of rural India: A review of use by Indian folks. Indo Global Journal of Pharmaceutical Sciences. 2012, 2(3): 286-304.

[19] MacMillan. Occurrence of gibberellins in vascular plants, fungi and bacteria. Journal of Plant Growth Regulation. 2002, 20: 387-442.

[20] Mandavia, M.K., Karkar, C., Mandavia, C., and Khasiya, V. Effect of salicylic acid and brassinolide on yield and quality traits of chickpea seeds. Indian Journal of Agricultural Biochemistry. 2006, 19: 29-31.

[21 ] Ma, Q., Longnecker, N. and Atkins, C. Exogenous cytokinin and nitrogen do not increase grain yield in narrow-leafed lupins. Crop Sciences. 1998, 38: 717-721.

[22] Mazid, M., Ali, B., Hayat, S. and Ahmad, A. The effect of 4-chloro-3-indole-acetic acid on some growth parameters in mung bean under cadmium stress. Turkey Journal of Biology: 2010, 34: 9-13.

[23] Larque-Saavedra, A. Stomatal closure in response to acetyl salicyclic acid treatment. Z. Planzeophysiol. 1979, 93: 371-375.

[24] Mazid, M. Khan, T.A, Mohammad, F. Nooris, N. Physico-biochemical effects of pre-sowing seed treatment with gibberellic acid on Helianthus annus L.- National conference of Plant Physiology" Current Trends in Plant Biology Research": 895-896. Junagarh, 2013, Gujarat.

[25] Mazid, M and Khan, T. A. Molecules, Enzymes and Plant Productivity. Publication - APH Publishing Corporation Pvt. Ltd. Darya Ganj, 2014, New Delhi, INDIA.

[26] Khafagy, M.A. Effects of growth substances, biological boron and their combination on soybean plants under nitrogen levels. Journal of Agricultural Sciences of Mansoura University. 1995, 20: 4641–4658.

[27] Mazid, M and Naqvi, N. Key approaches of plant growth regulator application in searching of best time for enhancing nitrogen fixation capacity of chickpea cultivar DCP 92-3. Unique Journal Ayurvedic and Herbal Medicine. 2014a, 2(5):8-18.

[28] Mazid, M and Naqvi, N. Differential yield and quality response of four chickpea cultivars following the foliar spray of five selected plant growth regulators. Agricultural Science Digest. 2014b, 34 (4): 268-272.

[29] Mazid, M and Roychowdhury, R. Leaf N-P-K content as indicators of yield, total protein and sugar content of seeds of Bengal gram (*Cicer arietinum* L.). Unique Journal of Pharmaceutical and Biological Sciences. 2014, 2(5): 13-21.

[30] Shah, S.H. and Samiullah. Response of black cumin (*Nigella sativa* L.) to applied nitrogen with or without gibberellic acid spray. World Journal of Agricultural Sciences. 2007, 3: 153-158.

[31] Mok, M.C. Cytokinins and plant development- An overview. In: *Cytokinins: Chemistry, Activity and Function.* D.W.S. Mok and M.C. Mok (eds.). CRC Press, Boca Raton, FL, 1994, pp. 129-137.

[32] Moore, T.C. Biochemistry and Physiology of Plant Hormones. Springer-Verlag Inc,1989, New York.

[33] Mukhtar, F.B. Effect of some plant growth regulators on the growth and nutritional value of *Hibiscus sabdariffa* L. (red sorrel). International Journal of Pharmaceutics and Applied Sciences. 2008, 2 (3): 70-75.

[34] Mulligan, D.R. and Patrick, J.W. Gibberellic-acid-promoted transport of assimilates in stems of *Phaseolus vulgaris* L.: Localised versus remote site (s) of action. Planta, 1979, 145: 233-238.

[35] Muthuchelian, K., Murugan, C., Harigovindan, R., Nedunchezhian, N. and Kulandaivelu, G. Effect of triacontanol in flooded *Erythrina variegata* seedlings. 1. Changes in growth, photosynthetic pigments and biomass productivity. Photosynthetica, 1995, 31: 269-275.

[36] Naqvi, N. Khan, T.A, Mazid M, Khan, F. Quddusi, S. Roychowdhury, R. Phytoremediatory potential of Guava and Ashok tree at three different sites of Bareilly district-A case study: ARPN Journal of Agricultural and Biological Sciences. 2014, 9(3): 101-109.

[37] Quddasi, S, Khan, F, Mazid, M., Khan, T.A. Shakeel A. Arshad, M. Quality status of nutrients, vitamins and hormones under pathological threats in tomato: Basic scenario. Medicinal Chemistry and Analysis. 2014, 4(1):12-21.

[38] Mazid, M, Roychowdhury, R, Khan, F. Evaluation of chickpea cultivation approaches in terms of environmental resilience and future protein security. Current Agricultural Research. 2014, 2(2): 164-174.

[39] Hassanpourdagham, M.B, El- Amery, E.M.S and Mazid, M. Note on the enzyme activities, productivity and quality parameters of chickpea cultivars under influence of diverse synthetic plant growth promoters. Post har. Sci. Technol. 2014, 2(1): 23-38.

[40] Mazid, M and Khan, F. Analysis of response of chick-pea cultivars to various insecticides - A pot evaluation. Conceptual Framework and Innovations in Agro-Ecology and Food Sciences. 2015, 1(1): 68-72.

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**Table 1.Effect of concentrations of leaf-applied GA (C) and spray stages (F) on root length per plant (cm) of chickpea cultivar DCP 92-3 at two growth stages (mean of four replicates)**

| Foliar spray stages ($F_{DAS}$) | Foliar spray concentrations ($F_{M\ GA}$) | | | | Mean |
|---|---|---|---|---|---|
| | $F_W$ | $F_{10^{-7}M\ GA}$ | $F_{10^{-6}M\ GA}$ | $F_{10^{-5}M\ GA}$ | |
| | | | **90 DAS** | | |
| $F_{60\ DAS}$ | 14.30 | 20.72 | 22.40 | 16.35 | 18.44 |
| $F_{70\ DAS}$ | 12.40 | 15.28 | 19.31 | 17.80 | 16.20 |
| $F_{80\ DAS}$ | 11.40 | 17.80 | 19.43 | 18.21 | 16.71 |
| $F_{60\text{-}70\ DAS}$ | 15.30 | 18.23 | 23.35 | 18.70 | 18.90 |
| $F_{70\text{-}80\ DAS}$ | 14.80 | 15.30 | 16.45 | 15.90 | 15.61 |
| $F_{60\text{-}70\text{-}80\ DAS}$ | 13.80 | 19.40 | 21.20 | 18.70 | 18.13 |
| Mean | 13.67 | 17.79 | 20.36 | 17.51 | |
| C.D. at 5% | | C = 0.456 | F = 0.373 | C x F = 0.913 | |
| | | | **100 DAS** | | |
| $F_{60\ DAS}$ | 15.10 | 18.95 | 23.40 | 18.97 | 19.11 |
| $F_{70\ DAS}$ | 14.20 | 19.20 | 20.40 | 20.15 | 18.49 |
| $F_{80\ DAS}$ | 13.95 | 18.15 | 20.10 | 19.70 | 17.98 |
| $F_{60\text{-}70\ DAS}$ | 17.10 | 20.41 | 24.40 | 21.10 | 20.75 |
| $F_{70\text{-}80\ DAS}$ | 17.39 | 18.47 | 19.45 | 18.83 | 18.54 |
| $F_{60\text{-}70\text{-}80\ DAS}$ | 16.20 | 21.80 | 22.43 | 22.15 | 20.65 |
| Mean | 15.66 | 19.50 | 21.70 | 20.15 | |
| C.D. at 5% | | C = 0.499 | F = 0.408 | C x F = 0.999 | |

N.B.: A uniform basal dose of 40 kg N + 30 kg $P_2O_5$/ha was applied to all pots.

**Table 2.Effect of concentrations of leaf applied GA (C) and spray stages (F) on root dry weight per plant (g) of chickpea cultivar DCP 92-3 at two growth stages(mean of four replicates)**

| Foliar spray stages ($F_{DAS}$) | Foliar spray concentrations ($F_{M\ GA}$) | | | | Mean |
|---|---|---|---|---|---|
| | $F_W$ | $F_{10^{-7}M\ GA}$ | $F_{10^{-6}M\ GA}$ | $F_{10^{-5}M\ GA}$ | |
| | | | **90 DAS** | | |
| $F_{60\ DAS}$ | 0.195 | 0.372 | 0.447 | 0.405 | 0.355 |
| $F_{70\ DAS}$ | 0.187 | 0.369 | 0.411 | 0.403 | 0.343 |
| $F_{80\ DAS}$ | 0.190 | 0.351 | 0.400 | 0.387 | 0.332 |
| $F_{60\text{-}70\ DAS}$ | 0.192 | 0.397 | 0.459 | 0.403 | 0.363 |
| $F_{70\text{-}80\ DAS}$ | 0.189 | 0.354 | 0.404 | 0.389 | 0.334 |
| $F_{60\text{-}70\text{-}80\ DAS}$ | 0.198 | 0.372 | 0.442 | 0.397 | 0.352 |
| Mean | 0.192 | 0.369 | 0.427 | 0.397 | |
| C.D. at 5% | | C = 0.009 | F = 0.008 | C x F = 0.019 | |
| | | | **100 DAS** | | |
| $F_{60\ DAS}$ | 0.335 | 0.442 | 0.540 | 0.513 | 0.458 |
| $F_{70\ DAS}$ | 0.295 | 0.410 | 0.500 | 0.443 | 0.412 |
| $F_{80\ DAS}$ | 0.229 | 0.357 | 0.430 | 0.414 | 0.358 |
| $F_{60\text{-}70\ DAS}$ | 0.347 | 0.449 | 0.571 | 0.532 | 0.475 |
| $F_{70\text{-}80\ DAS}$ | 0.245 | 0.397 | 0.481 | 0.449 | 0.386 |
| $F_{60\text{-}70\text{-}80\ DAS}$ | 0.319 | 0.440 | 0.510 | 0.490 | 0.440 |
| Mean | 0.295 | 0.411 | 0.505 | 0.474 | |
| C.D. at 5% | | C = 0.011 | F = 0.009 | C x F = 0.022 | |

N.B.: A uniform basal dose of 40 kg N + 30 kg $P_2O_5$/ha was applied to all pots.

**Table 3. Effect of concentrations of leaf applied GA (C) and spray stages (F) on chlorophyll content [mg $g^{-1}$ (leaf fresh mass)] of chickpea cultivar DCP 92-3 at two growth stages (mean of four replicates)**

| Foliar spray stages ($F_{DAS}$) | Foliar spray concentrations ($F_{M\ GA}$) | | | | Mean |
|---|---|---|---|---|---|
| | $F_W$ | $F_{10^{-7}M\ GA}$ | $F_{10^{-6}M\ GA}$ | $F_{10^{-5}MGA}$ | |
| | | | **90 DAS** | | |
| $F_{60\ DAS}$ | 1.811 | 2.524 | 2.920 | 2.613 | 2.467 |
| $F_{70\ DAS}$ | 1.620 | 2.794 | 2.911 | 2.859 | 2.546 |
| $F_{80\ DAS}$ | 1.720 | 2.511 | 2.810 | 2.791 | 2.458 |
| $F_{60\text{-}70\ DAS}$ | 1.771 | 2.673 | 2.910 | 2.797 | 2.538 |
| $F_{70\text{-}80\ DAS}$ | 1.820 | 2.411 | 2.892 | 2.521 | 2.411 |
| $F_{60\text{-}70\text{-}80\ DAS}$ | 1.744 | 2.556 | 2.876 | 2.706 | |
| Mean | | | | | |
| C.D. at 5% | | C = 0.065 | F = 0.053 | C x F = 0.130 | |
| | | | **100 DAS** | | |
| $F_{60\ DAS}$ | 2.212 | 2.794 | 2.922 | 2.897 | 2.706 |
| $F_{70\ DAS}$ | 1.923 | 2.121 | 2.523 | 2.124 | 2.173 |
| $F_{80\ DAS}$ | 1.993 | 2.135 | 2.821 | 2.110 | 2.265 |
| $F_{60\text{-}70\ DAS}$ | 2.423 | 2.741 | 3.992 | 3.412 | 3.142 |
| $F_{70\text{-}80\ DAS}$ | 2.104 | 2.823 | 3.112 | 3.104 | 2.786 |
| $F_{60\text{-}70\text{-}80\ DAS}$ | 2.121 | 2.821 | 3.492 | 2.112 | 2.387 |
| Mean | 2.129 | 2.573 | 2.977 | 2.627 | |
| C.D. at 5% | | C = 0.068 | F = 0.056 | C x F = 0.136 | |

N.B.: A uniform basal dose of 40 kg N + 30 kg $P_2O_5$ /ha was applied to all pots.

**Table 4.Effect of concentrations of leaf applied GA (C) and spray stages (F) on carbonic anhydrase activity [mol $CO_2$ $kg^{-1}$(leaf fresh mass) $s^{-1}$] of chickpea cultivar DCP 92-3 at two growth stages (mean of four replicates)**

| Foliar spray stages ($F_{DAS}$) | Foliar spray concentrations ($F_{M\ GA}$) | | | | Mean |
|---|---|---|---|---|---|
| | $F_W$ | $F_{10\text{-}7M\ GA}$ | $F_{10\text{-}6M\ GA}$ | $F_{10\text{-}5M\ GA}$ | |
| | | | **90 DAS** | | |
| $F_{60\ DAS}$ | 41.88 | 63.71 | 64.01 | 58.70 | 57.07 |
| $F_{70\ DAS}$ | 40.81 | 57.36 | 59.18 | 56.86 | 53.55 |
| $F_{80\ DAS}$ | 39.06 | 56.85 | 56.45 | 54.06 | 51.60 |
| $F_{60\text{-}70\ DAS}$ | 41.53 | 64.05 | 65.98 | 59.86 | 57.85 |
| $F_{70\text{-}80\ DAS}$ | 39.51 | 58.73 | 56.85 | 55.90 | 52.74 |
| $F_{60\text{-}70\text{-}80\ DAS}$ | 41.85 | 59.01 | 61.53 | 57.05 | 54.86 |
| Mean | 40.77 | 59.01 | 60.66 | 57.07 | |
| C.D. at 5% | | C = 1.433 | F = 1.183 | C x F = 2.884 | |
| | | | **100 DAS** | | |
| $F_{60\ DAS}$ | 57.95 | 68.71 | 78.48 | 71.58 | 69.18 |
| $F_{70\ DAS}$ | 52.11 | 66.61 | 73.65 | 71.61 | 65.99 |
| $F_{80\ DAS}$ | 36.86 | 61.93 | 68.38 | 66.68 | 58.46 |
| $F_{60\text{-}70\ DAS}$ | 58.53 | 65.38 | 80.20 | 72.03 | 69.03 |
| $F_{70\text{-}80\ DAS}$ | 57.05 | 63.61 | 70.18 | 69.86 | 65.17 |
| $F_{60\text{-}70\text{-}80\ DAS}$ | 60.38 | 65.40 | 75.05 | 69.95 | 67.69 |
| Mean | 53.81 | 65.40 | 74.32 | 70.28 | |
| C.D. at 5% | | C = 1.716 | F = 1.400 | C x F = 3.417 | |

**Table 5.Effect of concentrations of leaf-applied GA (C) and spray stages (F) on100-seed weight (g) of chickpea cultivar DCP 92-3 at harvest (mean of four replicates)**

| Foliar spray stages ($F_{DAS}$) | Foliar spray concentrations ($F_{M\ GA}$) | | | | Mean |
|---|---|---|---|---|---|
| | $F_W$ | $F_{10^{-7}M\ GA}$ | $F_{10^{-6}M\ GA}$ | $F_{10^{-5}M\ GA}$ | |
| $F_{60\ DAS}$ | 16.81 | 21.70 | 23.20 | 20.45 | 20.54 |
| $F_{70\ DAS}$ | 18.10 | 20.30 | 21.20 | 19.95 | 20.01 |
| $F_{80\ DAS}$ | 13.75 | 19.10 | 20.40 | 18.35 | 17.90 |
| $F_{60\text{-}70\ DAS}$ | 15.21 | 22.30 | 24.10 | 21.70 | 20.83 |
| $F_{70\text{-}80\ DAS}$ | 18.23 | 21.50 | 20.80 | 20.30 | 20.21 |
| $F_{60\text{-}70\text{-}80\ DAS}$ | 14.40 | 21.10 | 22.80 | 20.84 | 19.79 |
| Mean | 16.05 | 21.00 | 22.17 | 20.27 | |
| C.D. at 5% | | C = 0.518 | F = 0.423 | C x F = 1.035 | |

**Table 6.Effect of concentrations of leaf-applied GA (C) and spray stages (F) on harvest index (%) of chickpea cultivar DCP 92-3 at harvest (mean of four replicates)**

| Foliar spray stages ($F_{DAS}$) | Foliar spray concentrations ( $F_{M\ GA}$) | | | | Mean |
|---|---|---|---|---|---|
| | $F_W$ | $F_{10^{-7}M\ GA}$ | $F_{10^{-6}M\ GA}$ | $F_{10^{-5}M\ GA}$ | |
| $F_{60\ DAS}$ | 40.12 | 44.11 | 47.70 | 45.72 | 44.41 |
| $F_{70\ DAS}$ | 39.23 | 43.10 | 47.80 | 43.10 | 43.31 |
| $F_{80\ DAS}$ | 37.12 | 38.44 | 45.10 | 41.80 | 40.62 |
| $F_{60\text{-}70\ DAS}$ | 38.44 | 41.80 | 48.20 | 45.92 | 43.59 |
| $F_{70\text{-}80\ DAS}$ | 40.11 | 44.20 | 45.90 | 44.12 | 43.58 |
| $F_{60\text{-}70\text{-}80\ DAS}$ | 42.13 | 44.10 | 47.52 | 46.23 | 45.00 |
| Mean | 39.53 | 42.63 | 47.04 | 44.48 | |
| C.D. at 5% | | C = 0.115 | F = 0.910 | C x F = 2.229 | |

N.B.: A uniform basal dose of 40 kg N + 30 kg $P_2O_5$ /ha was applied to all pots.

**Table 7. Effect of concentrations of leaf-applied GA (C) and spray stages (F) on biological yield per plant (g) of chickpea cultivar DCP 92-3 at harvest (mean of four replicates)**

| Foliar spray stages ($F_{DAS}$) | Foliar spray concentrations ($F_{M\ GA}$) | | | | Mean |
|---|---|---|---|---|---|
| | $F_W$ | $F_{10^{-7}M\ GA}$ | $F_{10^{-6}M\ GA}$ | $F_{10^{-5}M\ GA}$ | |
| $F_{60\ DAS}$ | 6.492 | 8.571 | 8.870 | 8.485 | 8.105 |
| $F_{70\ DAS}$ | 6.420 | 7.725 | 7.923 | 7.621 | 7.422 |
| $F_{80\ DAS}$ | 5.824 | 7.811 | 7.822 | 7.724 | 7.295 |
| $F_{60\text{-}70\ DAS}$ | 6.129 | 8.422 | 8.923 | 7.428 | 7.726 |
| $F_{70\text{-}80\ DAS}$ | 6.501 | 7.970 | 8.210 | 7.979 | 7.665 |
| $F_{60\text{-}70\text{-}80\ DAS}$ | 6.520 | 7.421 | 8.120 | 7.745 | 7.452 |
| Mean | 6.314 | 7.987 | 8.311 | 7.830 | |
| C.D. at 5% | | C = 0.198 | F = 0.162 | C x F = 0.396 | |

N.B.: A uniform basal dose of 40 kg N + 30 kg $P_2O_5$/ ha was applied to all pots.

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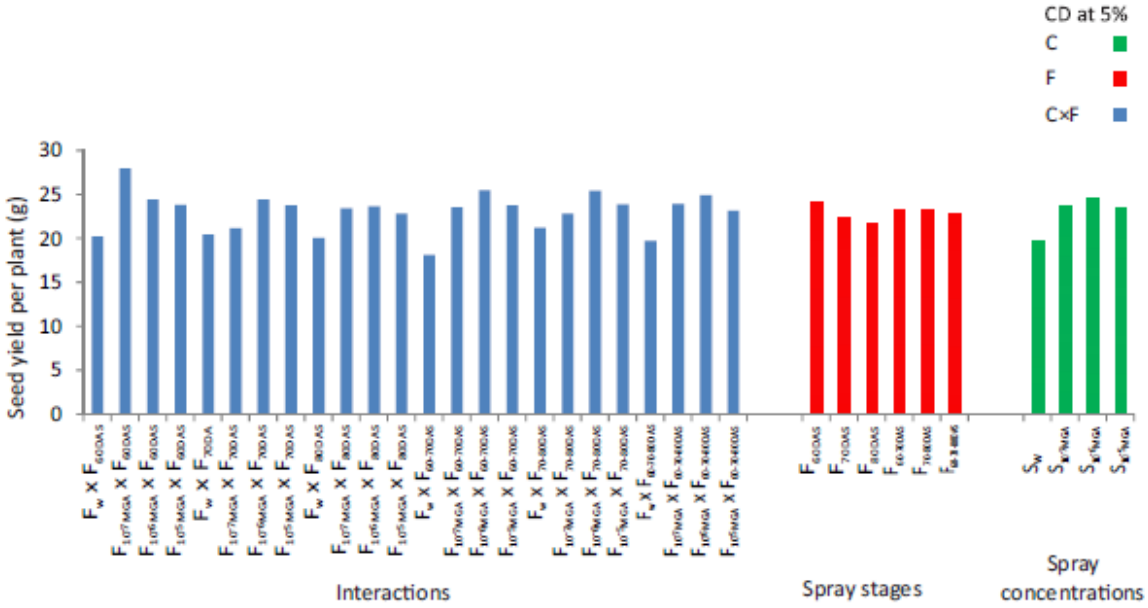


**Fig. 1. Effect of concentrations of leaf-applied GA and spray stages on seed yield per plant of cultivar DCP 92-3 of chickpea**

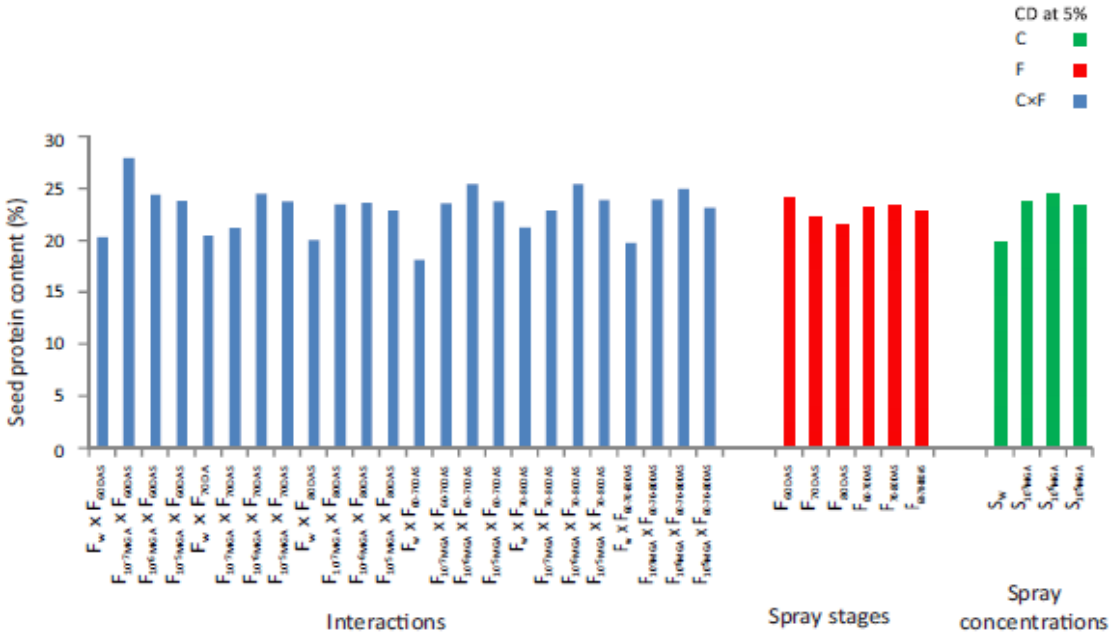


**Fig. 2. Effect of concentrations of leaf-applied GA and spray stages on seed protein content of cultivar DCP 92-3 of chickpea.**